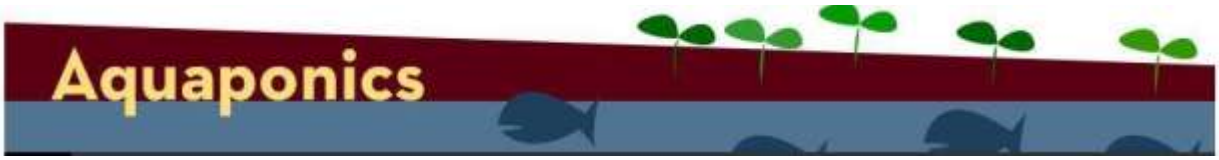


Identifying Aquaponics Information Gaps: An Examination of Educational Resources Available to Home Hobbyists in Minneapolis Garden Center Sites

Natalie Campbell
Environmental Sciences, Policy, and Management

Lindsey Miller
Horticulture Science, UMN Department of Horticulture

Abigail Reynolds
Horticulture Science, UMN Department of Horticulture

May 11, 2015

EXECUTIVE SUMMARY

The majority of aquaponics home hobbyists personally design and build their system. It is likely that while building systems, they will visit retail garden center sites in their geographic area to source materials and gather information. Yet, the degree of aquaponics information and training available at these garden center sites is unknown.

This research addresses three questions.

- What aquaponics information is available at Minneapolis garden centers?
- Is there a difference between small independent garden centers and big box garden centers?
- What are common gaps in aquaponics information at Minneapolis garden centers?

We surveyed 75% of the garden centers in Minneapolis to evaluate the level of familiarity and comfort managers and employees have regarding aquaponics. Overall, there is a lack of aquaponics information at study garden center sites; big box stores show a higher level of familiarity and comfort than small independent businesses. Additionally, these potential information nodes in an aquaponics network are disappearing as small independent garden centers go out of business.

Given these findings, three recommendations were made to increase the level of familiarity with and available information to Minneapolis home hobbyists about aquaponics.

- Educate key managerial staff on the basics of aquaponics and identify currently stocked merchandise that can be utilized in aquaponics systems.
- Identify several staff members as aquaponics reference points for staff. This could also include training employees about where to direct customers when the store does not supply what they're looking for.
- Develop and implement educational programs and/or outreach materials for customers about aquaponics and other products sold at small independent garden centers.

Table of Contents

INTRODUCTION

Issue Description

Customers utilizing a new technology must seek information from a variety of sources; therefore, it is important to understand the level of information available at relevant retail garden center sites. In this study we focus on aquaponics: an emerging technology that allows individuals to sustainably produce plants and fish in the home year-round. Many sources can provide information and training to customers interested in aquaponics, but little is known about if and how they are doing it. The degree of aquaponics information available to customers at retail garden center sites is currently unknown.

Home aquaponic systems are often designed specifically for a site, meaning physical and biological components in one home system will differ from those in another; therefore, customers installing aquaponics technology in their home (e.g. aquaponics home hobbyists) will require a wide variety of information regarding physical and biological components (Bernstein, 2011). It is likely that hobbyists who personally design and construct home aquaponic systems will be more satisfied with the end result if they receive sufficient information and training during construction. Satisfied home hobbyists can ultimately aid in the diffusion of this technology to others considering home systems thus expanding the aquaponics network.

Garden centers may be an important source of information and/or training, especially those that sell plants and aquatic organisms as well as the physical materials for the system. For example, interactions between garden center personnel and home hobbyists will occur as hobbyists consider plant species for their system. These interactions are especially important because they are likely take place for every hobbyist. Therefore, we seek to evaluate small and big box garden center sites regarding the level of relevant information each can provide a customer interested in a home aquaponics system. Study findings will inform garden center management in their efforts to close common information and training gaps, thereby strengthening interactions between garden center personnel and home hobbyists.

Literature Review

Customers have shown an expanding interest in technologies that reduce negative effects from their daily behaviors and routines. This trend takes place in response to a growing public awareness of issues facing the health of the planet and the well being of people in society. Vermeir and Verbeke evaluated this phenomenon and described the emergence of “the ethical consumer” (2006). They define these consumers as those “who perceive a more direct link between what is consumed and the social issue itself” (Vermeir & Verbeke, 2006, p. 2). In addition, they assert that these consumers are increasing their focus on the ethical consequences of their behaviors.

Aquaponics is a recent technology that could have a strong appeal for the ethical consumer. In brief, it is defined as “the cultivation of fish and plants together in a constructed, recirculating

ecosystem" (Bernstein, 2011, p. 1). In the U.S., the first of these systems began to appear in the mid-1970s; yet a recent online survey administered to aquaponics users concluded that the median year respondents began to construct and use aquaponics systems was 2010 (Love, et al., 2015). As is the case with any new technology, those utilizing these systems seek out ways to connect with each other, especially among the home hobbyists who are more dispersed and generalists when it comes to production systems of this type.

Another recent study conducted by Love, et al. (2014) describes aquaponics as a "rapidly growing field with respondents who are actively experimenting with and adopting new technologies" (p. 1). The authors found that 83% of aquaponics systems were personally designed by survey respondents, 60% of systems are kept in the home, and 84% of those working with aquaponic systems consider it a hobby. Furthermore, Love, et al. (2014) determined that of the 84% who claim to be hobbyist aquaponics users, 51% gave tours of their system and educated others in the community about this technology. These hobbyists must purchase construction and biological materials from relevant retail sites, making relationships and interactions between hobbyists and personnel at these sites an aquaponics social network.

One way to evaluate the properties of an emergent social network is through the use of social network theory. Social network research examines a set of people, or nodes, and the relationships (ties) that relate them (Kadushin, 2012). In the context of our research, nodes are the set of individuals communicating about aquaponics (home hobbyists and garden center personnel), and ties are the interactions and experiences they share. To understand the structure of a social network each tie between individuals can be defined as strong or weak**.** The difference between strong and weak ties is based on three criteria: the amount of time individuals spend together, the emotional intensity shared by individuals during that time, and the services exchanged by either party. In a weak tie relationship it is unlikely that the individuals have many common contacts, and in a strong tie relationship there are many common contacts (Michelfelder & Kratzer, 2013). Weak ties are said to "foster idea generation and exploration of new innovative opportunities" (p. 2) between different individuals. Alternately, strong ties are necessary in order to "take action, transfer complex knowledge, implement ideas and exploit them" (p. 2) among individuals spending a lot of time together (Ahuja, 2011).

For new technologies and ideas to be successful a social network with both strong and weak ties is necessary (Michelfelder & Kratzer, 2013). Bridging ties, or weak ties, can be used to bring two different social individuals or groups together allowing for an even greater exchange of knowledge (Bodin & Crona, 2009). We assume ties between aquaponic home hobbyists and garden center personnel are weak due to infrequent interactions, but result in the generation of new and innovative ideas for how to create and operate a home aquaponic system. As ties between garden center personnel and home hobbyists strengthen, each node could begin to explore complex ideas and take actions, allowing aquaponics technology to be shared and diffuse through a broad network of aquaponics input suppliers and aquaponics home hobbyists.

An emerging trend in market sites is in-store customer training; such trainings are an example of ties being used. Stores are facilitating and expanding their use of interactive training sessions

as products available to customers become more complicated. Fang & Xu (2011) found that if a manufacturer can "effectively and cost efficiently 'train customers' then optional training can make the product more attractive and improve the manufacturer's net gains" (p. 1). In addition, they point out that when education was offered with the purchase of a product, the price of the product could be raised (Fang & Xu, 2011). Although the previously mentioned study was based on a customer's relationship with cellular phone technology, the idea of training customers can be applied to many different products.

Not only is customer training a growing trend; it is also becoming more common for specialized employees to have additional training about a specific topic. In a study done by Czapar, et al. (2007), 936 retail stores were surveyed to evaluate how pest management recommendations were made. One critical finding was that 72% of small independent lawn and garden centers had assigned specific employees to make recommendations pertaining to pest management. This percentage was much higher than in large businesses (a business with more than two branches) where only 39% had a specific person to answer pest management questions. As employees gained more knowledge they were able to sell more products for the proper use of pesticides, which ultimately increased consumer safety (Czapar et al., 2007).

In a competitive market place, retail garden center sites may differentiate themselves when they begin to provide information and supplies for aquaponics systems; this can be interpreted in Everett Rogers' "Diffusion of Innovation" theory (2003). Rogers outlines a pattern of idea adoption that may explain how quickly different garden centers (network nodes) adopt aquaponics technology and ideas. Rogers breaks down societal adoption of an idea into five distinct categories: Innovators, Early Adopters, Early Majority, Late Majority, and Laggards (Figure 1). Innovators are willing to take risks, usually have financial liquidity and have close contact to scientific sources and interaction with other innovators. Early Adopters usually have financial liquidity and advanced education but are more discreet in adoption choices than innovators. Early Majority adopt an innovation or idea after a varying degree of time, but later than Innovators and Early Adopters. The Late Majority adopt an innovation after most of society has adopted it. They have a high degree of skepticism and usually a small amount of financial liquidity. Laggards are the last to adopt an innovation. These individuals usually have an aversion to change, are typically more focused on traditional methods of doing things, and have the lowest financial liquidity. These categories represent different behavioral patterns of individuals or organizations in responses to a new idea. This idea could be a product, service, way of thought, or new technology (Rogers, 2003). This theory may explain any differentiation that occurs between small independent and big box garden centers, or among the garden centers in general.

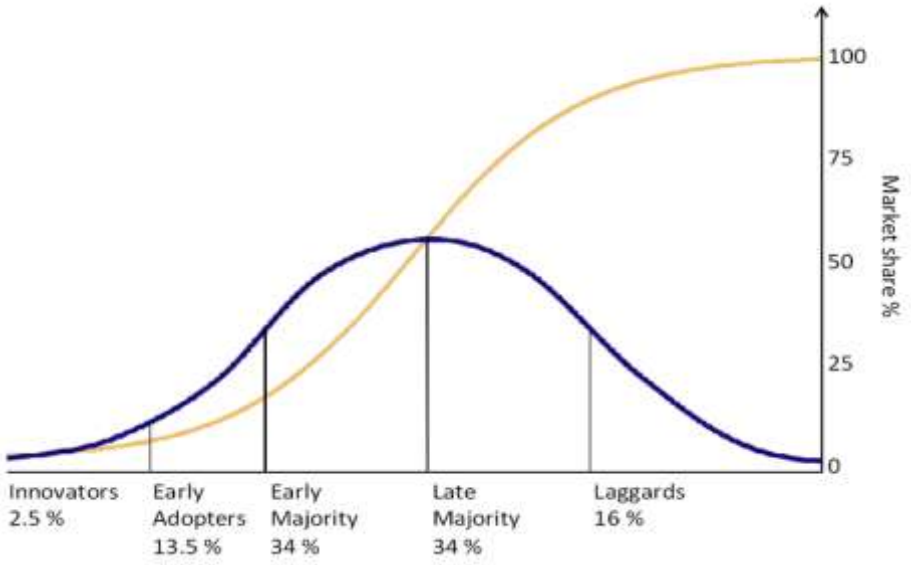


Figure 1: Rogers' Diffusion of Innovation illustrates how an idea makes its way to a consumer base. (Source: Havassing (2012), adapted from Diffusion of Innovations by Everett M. Rogers, 2003.)

We argue that in-store information and training about aquaponics could develop social networks among garden center representatives and home hobbyists. Development of these networks could then result in an exchange of new ideas and improved knowledge about aquaponics, eventually differentiating garden centers in the market place. As the popularity of aquaponics grows, customers will be contacting their small independent and big box garden centers on a more frequent basis. Many of these stores already offer customer training about the use of products sold in the establishment; because aquaponic systems use complicated technologies, thorough customer training sessions for these systems could be both helpful and profitable. To-date no research has been done to examine the current state of aquaponics information exchange and training at retail garden center sites or what aquaponics information is missing at the employee level.

Aquaponics is an emerging technology; it is therefore likely that critical information gaps among home hobbyists building aquaponics systems and garden center personnel selling supplies exist. By creating social networks through garden center sites, improved information can spread and the emerging technology will have a better chance of diffusing across ethical consumers and a diversity of users. By examining the current level of information and existing relationships (ties) with garden center sites, we hope to strengthen ties between aquaponics home hobbyists and garden center representatives, to the advantage of both parties and the aquaponics network as a whole.

Series Goals

A comprehensive, informational library is compiled through student research as part of an ongoing research project at the University of Minnesota in HORT 4601: Aquaponics: Integrated

Fish and Plant Food Systems. The series mission is to supply interested parties with valuable information regarding aquaponics to expand the field and help provide sustainable, safe, healthy, and reliable products. These products may be physical, educational, or value based.

Chapter Goals

Through this research we attempt to evaluate the level of relevant information available to customers interested in a home aquaponic system at small independent and big box retail garden center sites in Minneapolis. The findings and recommendations are meant to inform garden center management about closing common information and training gaps. Doing so will strengthen the relationships (ties) between garden center personnel and home hobbyists.

Objectives

Through this research we work to achieve the following objectives:

1. Assess the availability and content of aquaponics information present at Minneapolis garden center sites, placing specific focus on the availability of physical and biological system information.
2. Conduct a comparison of small independent and big box garden centers supplying local home hobbyists with system components.
3. Identify aquaponics information gaps and recommend ways to address them.

Research Questions Tested

Through this project we addressed the following research questions:

1. What aquaponics information and assistance is available at retail garden center sites for home hobbyists in Minneapolis?
2. Is there a difference between small independent garden centers versus big box store garden centers and if so, how do they differ?
3. What are the common gaps in aquaponics information at these potential assistance and diffusion sites in the aquaponics network?

To answer these questions we used management staff at small independent and big box garden centers as key informants about their business and the level of interest in aquaponics shown by their customers. Specifically, we focused on management and employee understanding of the physical and biological components of home aquaponic systems, and on the level of aquaponic training offered at each establishment.

METHODS

Site Description

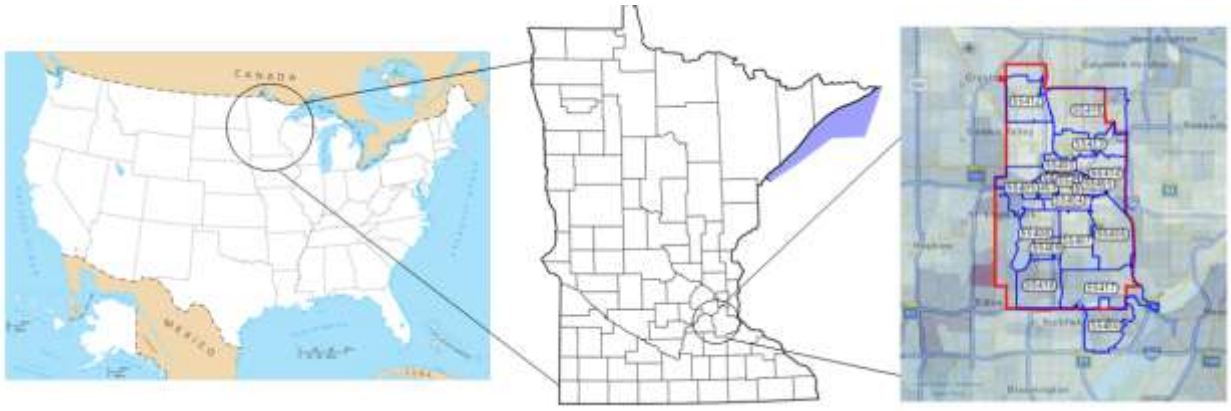
This study was done in collaboration with other project groups; six teams performed research in an aquaponic greenhouse environment. See Appendix A for the site description of the greenhouse and maintenance instructions for this location.

Our research site was the City of Minneapolis, Minnesota (USA) which is in the north-central region of the United States between latitude 44°58′47″ N and longitude 93°15′49″ W (Figure 1). Minneapolis is a large metropolitan area spanning 53.97 square miles, with 400,070 residents (Citi-Data, 2013). Its inhabitants enjoy the many lakes located within and around its borders, and the extensive urban forest that transitions into developed areas.

Minneapolis is located in a temperate continental climate, with four main seasons. Winter (November through February) has an average low temperature of 14.75°F (-9.58°C) and an average high temperature of 30.25°F (-0.97°C). The growing season in Minnesota usually lasts from April through the end of September and sometimes into early October. The average high temperature for those months is 73.5°F (23.1°C) and the average low temperature is 58.83°F (14.91°C) (Climate Data, 2015).

Most Minneapolis residents live in owner-occupied, single-family homes or apartments. Owner-occupied homes in Minneapolis have an average of 6.1 rooms in total, while owner-occupied apartments have an average of 3.2 rooms in total. Little is known about where aquaponics home hobbyists in the area construct systems, but it can be assumed that the majority of systems built in Minneapolis are housed indoors due to unfavorable outdoor conditions during winter months.

Small independent garden centers surveyed for this study were located within 19 postal zip code areas that most closely comprise the City of Minneapolis (Figure 2; Appendix B). Two big box garden centers from just outside city limits were also surveyed since these are the large retail sites used by Minneapolis residents.



a. b. c.

Figure 2: a) Minnesota located within United States of America, b) Map of the state of Minnesota including county borders, c) The City of Minneapolis boundaries (red border) and designated city zip codes (blue border).

Research Techniques

Study Design

Common terms were defined for this study. Small independent garden centers were defined as those having fewer than three locations, all of which were located in the state of Minnesota. Big box garden centers were defined as those found inside a large retail store, having more than five locations in more than two states. Additionally, retail sites were defined as those having a physical walk-in space where consumers could view and purchase merchandise.

Study population for this research included all relevant retail garden center sites within the Minneapolis postal zip code areas (Figure 2). Within these designated zip codes (Appendix B) establishments termed “garden center” were located through YellowPages.com; in total, 27 small independent garden centers were identified. In an effort to round out study findings and increase the validity of recommendations, two big box garden centers that serve the Minneapolis area were also selected; these businesses are located in suburbs adjacent to Minneapolis.

The total population of retail sites in the study area was 27 small independent, and two big box garden centers. After initial attempts to contact the small independent sites, the population was reduced from 27 to 21 as four stores had recently closed, one had a phone number that was no longer in service, and one had not yet opened for business. Ten additional stores did not fall into our definition of retail site, as five were only available by appointment or did not have a storefront, and five were landscaping companies. Additionally, one small independent garden center had recently merged with another. These small independent businesses were removed from the sample, leaving a total population of ten small independent and two big box garden centers with a retail site.

We first called each site to verify hours and inquire about an appropriate time for a visit. If a specific time was given we went at that time. If there was no answer or no time given, we visited the store during normal business hours. At each site we asked for the manager, who was considered the key informant for the business. These were the main points of contact, unless someone else was suggested by our initial contact.

Each small independent and big box garden center was contacted up to four times in an effort to get a response from the business. The first contact was made by phone; a message was left if there was no answer and a way was provided to do so. During the second contact, surveys were left with management personnel; in some cases individuals completed the survey during this visit. A third contact was made in an effort to pick up completed surveys from those who asked us to return at a later time, and if necessary, a fourth contact was made for the same purpose. The survey was delivered to thirteen garden center sites and was successfully retrieved from seven for a response rate of 58%; out of these respondents, five were small independent and two were big box garden centers.

When administering each survey, we provided an informational handout describing the study to the respondent (Appendix C). This handout informed respondents that the survey was voluntary and they could decline to answer any questions. It also explained that the data collected would in no way identify surveyed individuals or their company, and that filling out the survey and returning it to researchers acted as consent for participation. Finally, the form provided very basic information about aquaponics and how to get in contact with researchers after the study.

The survey took on average ten minutes to complete. Survey themes included: respondent sociodemographic factors, general goals of the company, familiarity with aquaponics, level of management and employee comfort in explaining specific aspects of aquaponics, and educational resources provided by the company to customers (Table 1; Appendix C). The survey contained 11 main questions, some with additional sub questions. In all, five questions were open-ended and 17 were closed-ended. Respondents were given space to comment after most questions.

Data Analysis

Categorical data was analyzed through use of averages, percentages, or by the number of respondents that selected each variable. Graphical representations of relevant data were made in order to display common trends and gaps in available information. Survey questions requiring a written response were analyzed through examination of common patterns in the text and frequency of response.

FINDINGS

A total of five small independent and two big box garden centers participated in the study (n=7). Surveyed individuals had an average of 10.6 years of experience working at respective garden centers, and 86% of respondents were male. Forty-three percent of surveyed individuals listed manager as their primary role in the company. Remaining individuals listed president, principal, garden center specialist, and garden center sales associate as their job title, with 14% of the population falling into each category.

Degree of Information Available at Garden Centers

Surveyed individuals had a moderate level of familiarity with aquaponics but were less comfortable sharing this knowledge with others (Figure 3). During the survey, respondents were asked to rate their level of familiarity with aquaponics on a scale of one to five; here, one was defined as "not familiar" and five was defined as "very familiar". When rating a personal level of familiarity with aquaponics in this way, no participant in the study responded one, meaning "not familiar". In addition, respondents were asked to rate the level of personal and employee comfort when explaining aquaponics related structural components, fish and plant materials, and nutrient cycling. The scale again ranged from one to five, with one defined as "not comfortable" and five defined as "very comfortable". The word comfort was defined on the survey as "having knowledge of the component and finding it easy to share this knowledge with others". Here, 64% of respondents claimed they were not comfortable sharing information about aquaponic structural components and 50% of respondents claimed they were not comfortable sharing information about nutrient cycling, or fish and plant components.

Question number	Survey question	Response codes
1	What is your role at this establishment? *Please respond with your title and primary duties.*	Text from survey
2	How long have you been with the company___# years	Number of years
3	Please provide a brief statement describing the organization's general goals.	Text from survey
4	How familiar are you with aquaponics? *Circle one response.*	Scale 1-5 (1=not familiar/5=very familiar)
5	Have you been asked by customers about aquaponics? *Circle one response.*	Yes or no
5a	*If yes:* How often do you get inquiries about aquaponics? *Circle one response.*	Weekly, monthly, yearly, seasonally (if seasonally what season)
5b	Have you observed an increase in customer inquires about aquaponics? *Circle on response.*	Yes or no
5c	If a customer asks about aquaponics do you refer them to other sources of information? *Circle one response.*	Yes or no
5d	*If yes,* please list the sources you recommend	Text from survey
6	For the average consumer, how capable are they of creating a home aquaponics system? *Circle one response.*	Scale (1=not capable/5=very capable)
6a	Please Comment	Text from survey
7	How comfortable would you be describing the following components of an aquaponics system to a customer?	Scale (1=not comfortable/5 very comfortable)
7a	Structural Components	Scale (1=not comfortable/5 very comfortable)
7b	Fish and Plants	Scale (1=not comfortable/5 very comfortable)

7c	Nutrient Cycling	Scale (1=not comfortable/5 very comfortable)
7d	Please comment	Text from survey
8	How comfortable would your employees be describing the following components of an aquaponics system to a customer:	Scale (1=not comfortable/5 very comfortable)
8a	Structural Components	Scale (1=not comfortable/5 very comfortable)
8b	Fish and Plants	Scale (1=not comfortable/5 very comfortable)
8c	Nutrient Cycling	Scale (1=not comfortable/5 very comfortable)
8d	Please comment	Text from survey
9a	Does your organization use education and training to support the customers who purchase products from your store? *For example, shade garden design, deck building or other relevant topics. Circle one response.*	Yes or no
9b	*If no:* why not? *Briefly explain.*	Text from survey
9c	*If Yes:* Where and how do people receive this training	Text from survey
9c.1	*If Other:* Please describe	Text from survey
9c.1	Do you conduct these trainings	Yes or no
9c.2	In general, how long are the sessions	Hours and times per year
9d	Does your organization offer aquaponics related training?	Yes or no
9d.1	If yes, what types	Text from survey
10	What would you like to know about aquaponics	Text from survey

Table 1: Research questions asked on survey distributed to big box stores and small independent garden centers.

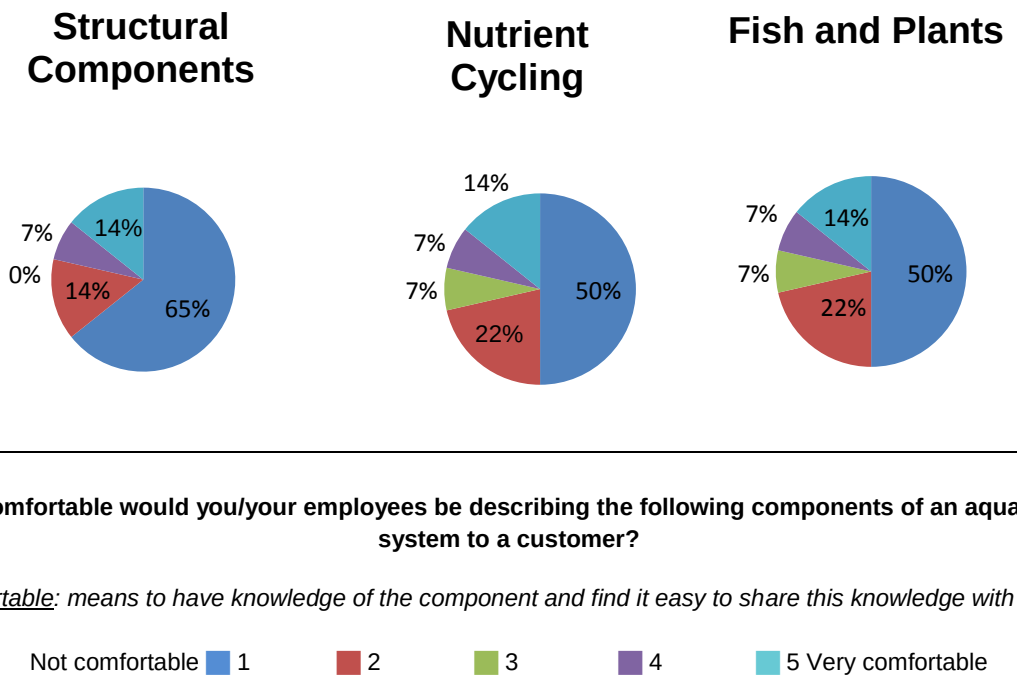


Figure 3: Manager ranking the level of personal and employee comfort regarding the following aspects of a home aquaponics system: structural components, nutrient cycling, and fish and plant components.

Difference Between Small Independent and Big Box Network Nodes

Despite relatively low knowledge and assistance across the sample, more information and assistance was available at big box stores than was available at small independent garden centers (Figure 4). When asked to rate a personal level of familiarity with aquaponics on a scale of one to five (where one was defined as “not familiar and five was defined as “very familiar) survey participants at big box stores responded 4 on average; survey respondents at small independent garden centers, however, responded 2.6 on average. Participants were also asked to rate the level of employee comfort when explaining aquaponics structural components, nutrient cycling, and fish and plant materials to a customer. The scale again ranged from one to five, where one was defined as “not comfortable” and five was defined as “very comfortable”; the word comfort was also defined on the survey as “having knowledge of the component and finding it easy to share this knowledge with others”. In response to this question, big box participants rated employee comfort at 4.5 on average, while small independent participants rated employee comfort at 1.2 on average.

Respondents were left space and asked to provide comments after each question. When responding to the level of employee comfort in explaining aquaponics components, small independent garden center participants provided diverse comments, noting, “we have every level of expertise with numerous interest areas, so hard to average out” and “(employees) would need a lot of education”; and “we don’t sell anything related to aquaponics so (employees) don’t have to know about it.” These comments help explain relatively low ratings of employee comfort with aquaponics at small independent garden centers. A respondent from one big box garden center indicated that employees would be comfortable with the topic at their establishment explaining, “we offer product knowledge (PK) classes for new products coming into our store/department. (PK classes) are mandatory class offerings.” This statement suggests confidence in the ability of employees to develop product knowledge at this site.

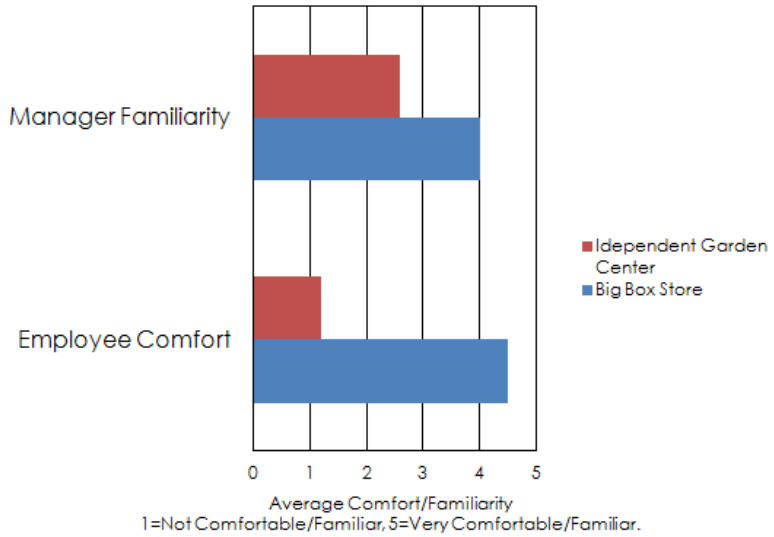


Figure 4: Average ranking of manager familiarity and employee comfort at big box stores versus small independent garden centers, Minneapolis, 2015.

Big box and small independent participants had an obvious difference in attitude on the subject of aquaponics; big box personnel had a more open and positive attitude when approached about this technology, whereas, small independent personnel did not appear interested in engaging in conversation about the topic. The survey given to respondents ended with questions regarding what participants would like to know about aquaponics and what questions they had for us. Twenty-nine percent of small independent garden center participants chose not to respond to these questions. Those responding made comments such as: “the principal of aquaponics sounds good but I doubt its practicality in a retail setting” or “more interested in how aquaponics can serve a roll in our plant production vs. retail to consumers,” and finally, “the amount of inventory to stock and lack of turns in the allotted space on the sales floor would deter me from stocking it.” These statements were made by individuals who rated themselves low on the scale of familiarity with aquaponics. These individuals were not open to aquaponics retail possibilities.

Big box garden center participants, on the other hand, responded to questions about things they would like to know 100% of the time. One participant commented that “as (aquaponics) is becoming more prevalent and readily available any and all information would be helpful”; and later wrote, “is there any literature for us to learn from and what sources would be most beneficial to associates?” Another big box representative responded with a list of questions for our team. Some examples of these questions include, “(are) there other uses for fish than the local restaurant industry?”; “is the water useable for other sources?”; and “is aquaponics economically realistic given the cost of transport versus the cost of construction of an enclosed system?”. These statements were made by individuals that rated themselves high on the scale of familiarity with aquaponics. Big box respondents’ comments, suggest they desire more information on the topic of aquaponics despite an already high level of familiarity.

Network Relationships and Information Exchange

Finally, in this 2015 study, we found fewer operating small independent garden centers than were identified using Yellowpages.com, a site last updated in 2014 (Figure 5). Using the original study criteria, a total of 17 small independent garden centers were identified; of these, four had recently closed resulting in a 25% decrease in small independent garden centers in the City of Minneapolis. The consequence of this is a loss of potential network nodes and relationships that foster learning and support the diffusion of aquaponics.

The majority of remaining small independent garden centers were located on main streets within small shopping areas, embedded within residential areas. This type of location gives stores a close proximity to customers, and allows them to create a sense of community within the neighborhood. Being in close proximity to customers also builds reciprocity and shared interests among residents and businesses. Big box garden centers in the study were located on major highways near or in large shopping complexes. This type of location allows stores to cater to a broad range of customers, but does not assist them in forming close community ties.

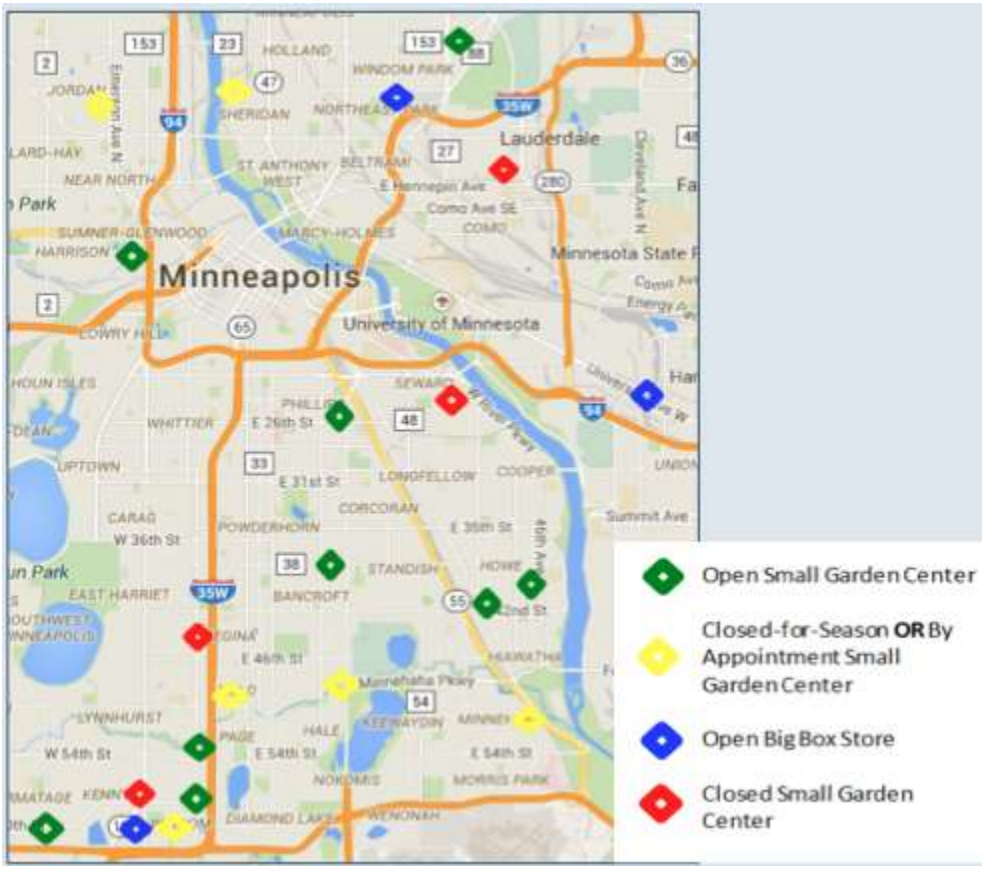


Figure 5: Map of all big box and small independent garden centers in Minneapolis zip codes included in the study population, 2015. (N=22)

Retail garden center sites could enhance the level of information available to customers through on-site or web-based aquaponics training; however, no garden center in the study currently

offers on-site aquaponics training or topical information on the business websites. One big box garden center offered a pamphlet that described aquarium components; no site in the study provided workshop training or pamphlets related to aquaponics.

Yet, seventy-one percent of surveyed garden center sites offer nonaquaponic product training to their customers. Among those offering training 80% conduct sessions on-site and 80% provide training resources on the company website. Seventy-five percent of businesses offering on-site training utilized informational handouts and hosted workshops to educate customers on product offerings. Survey respondents also described two "other" types of on-site training: "classroom training at the store/on the floor", and "on-site design consultations/ coaching." On-site trainings are held three times per year and last 2.5 hours on average. Additionally, workshop, classroom, and consultation style training was personally conducted by the survey respondent 80% of the time.

Businesses offering on-line training utilize informational web videos 50% of the time and refer customers to related websites 25% of the time. Fifty percent of garden centers offer "other" types of training on the web; respondents described these offerings as "social media/inspirational content" and "monthly e-newsletters."

DISCUSSION

Degree of Information Available at Garden Centers

Managerial staff and employees at garden center sites in Minneapolis are in general more familiar with aquaponics than they are comfortable describing it; this overall lack of familiarity with, and comfort describing aquaponics leads to weak ties between Minneapolis garden center personnel and home hobbyists. The existence of weak ties in the aquaponics network should lead to idea generation and allow nodes to explore new innovative opportunities; however, a lack of familiarity and comfort with the topic at garden center nodes may inhibit these garden center employees from performing an important role in the network. Garden center personnel will need to familiarize themselves with the topic of aquaponics in order for new and innovative ideas to be exchanged.

Not only is garden center management staff uncomfortable describing aquaponics to customers, they are also unaware of currently stocked merchandise that could benefit home hobbyists. During initial interactions with surveyors, many respondents claimed they had nothing of use to aquaponics home hobbyists at their garden center site. However, traditionally stocked plants, such as basil or salad greens are commonly used in home aquaponics systems. Other items such as growing media, potting containers, and rock materials are also used in home systems on a regular basis and are commonly stocked at garden center retail sites (Bernstein, 2011). By identifying currently stocked merchandise that satisfies the needs of home hobbyists, management personnel could significantly strengthen their ties with these customers.

Difference Between Small Independent and Big Box Network Nodes

The difference in rating of familiarity between big box and small independent garden centers may indicate fundamental differences at these sites. There is a possibility that these owners and managers differ in their overall interest in aquaponics. In small independent garden centers, they are most likely gardeners with interests in subjects such as flower gardens, vegetable gardens, and home décor. The types of products sold at the small independent garden centers, visited in this study, were mainly traditional gardening, home decoration, and gift items. Big box stores have more employees and a broader range of products available for many types of home improvement; many employees are hired for specific sections of the store so they can share their expertise with customers. Because of this, big-box employees might be more interested in ideas posed by customers that combine the skill sets of multiple different big box store sections proposed. An example of this is aquaponics which has multiple system components. We encountered a higher level of general interest about aquaponics at big box stores than at small independent garden centers. More research should be done to determine employee interest aquaponics and how it correlates to their knowledge about aquaponics systems.

Big box stores had a higher average than small independent garden centers when rating the comfort level of employees answering customer questions about aquaponics; there are a number of interpretations as to why. Small garden center owners/managers may feel employee jobs should revolve around traditional gardening topics and methods, rather than new technologies. Whereas, big box stores may trust the level of employee confidence more than small independent garden centers.

Based on Rogers' "Diffusion of Innovations" theory (2003), we found aquaponics technologies in general are still in the Innovation Stage of adoption. Aquaponics is not widely adopted by the general public (Love et. al, 2015) and we found few relevant garden center sites as network nodes that understood much about it. The data gathered in this study suggests big box stores would most likely fall into the category of Innovator; they showed more knowledge and acceptance of the idea overall. Big box stores also have more financial liquidity than small independent garden centers, another trait common in the Innovator category. In the future small independent garden centers might fall into the Early Adopter or Early Majority category.

Further investigation of this topic could be helpful in figuring out why smaller independent garden centers seemed to lack interest in the topic of aquaponics. Some possibilities may include their limited floor space, sticking to products and strategies that have worked for them in the past, or even just simply not enough interest from their current consumer base. For now, it can be assumed that big box store's interest in this emerging technology gives them a competitive edge.

Loss of Network Nodes

Twenty-five percent of small independent garden centers within Minneapolis zip codes closed in the past year. There are a variety of possible reasons for this trend. Dr. Neil Anderson, a

professor in the Department of Horticultural Science at the University of Minnesota-Twin Cities, noted that it is difficult for small independent garden centers to compete with the low prices found at big box stores. He also mentioned that small independent garden centers tend to have limited resources, which prevent them from training employees who specialize in specific topics. Because of this it is often necessary for all staff to have general knowledge about the products sold in the store.

With each store closure a potential aquaponics network node is lost; when such nodes are lost less information is shared and the diversity of knowledge decreases (Ahuja, 2000). Diverse network nodes are vital for diffusing new technologies, as they create a way to gain knowledge and transfer information (Kadushin, 2012). Small independent garden center network nodes are imperative in the creation of an aquaponics network. These retail sites would benefit from enhancing the level of information available to new and emergent customers such as aquaponics home hobbyists.

Customer training programs administered at garden center sites and surrounding the topic of aquaponics are currently underrepresented in the Minneapolis area. Taking a lead role in developing this type of training could offer small independent garden centers a competitive edge in the aquaponics network. Delivering aquaponics information to customers through on-site trainings/workshops can make merchandise used in these systems more attractive to customers and increase manufacturer and supplier net gains (Fang & Xu, 2011). Administering aquaponics training would require key employees to gain knowledge on the topic of aquaponics. As employees obtain this knowledge they will sell more products for proper use in aquaponics systems (Czapar, et al., 2007). In turn, customers successfully utilizing store merchandise in home systems will be more satisfied with their purchase and more likely to return the purchasing site.

Study Limitations and Future Research

From this study came three important findings. First, study participants had a moderate degree of general knowledge about aquaponics, but they were not confident sharing this knowledge with others. Second, big box garden centers had more written information about aquaponics and employees at these establishments were more familiar with the subject than at small independent garden centers. And finally, small independent garden centers are going out of business at a much faster rate than big box garden centers, thus reducing the opportunities for home hobbyists to learn through an expanded aquaponics network.

The results of this study were limited by the season in which it was conducted, sample size, region, and study criteria. Seasonally, our research was conducted between the months of February and May, a time of year considered late winter-early spring in Minneapolis. Because of this, some garden centers that met the criteria had not yet opened. Additionally, staff members at open garden centers were busy preparing for the upcoming growing season, which caused some personnel to decline participation in the study. Similar research should consider the most appropriate time of year for administering surveys in the study region, or allow for a long period of time to complete the survey in a busy retail season.

The findings of this study are most generalizable to aquaponics network nodes such as home hobbyists and garden center staff, residing or working in urban areas similar to the City of Minneapolis. The study considered only garden centers that are in, or serve residents this city, and therefore, the results may not be generalizable to other regions or markets. Future research could expand this line of research, for example, by investigating aquaponics information gaps in rural and suburban areas.

Although this research was not without limitations, the trends observed among garden centers in Minneapolis were relatively consistent among small independent versus big box garden centers. It is therefore reasonable for garden center personnel and aquaponics home hobbyists in the area to consider the findings of this study as the interest in aquaponics systems, and thus the aquaponics network, continues to develop locally.

RECOMMENDATIONS

Interest in aquaponics will continue to grow and has the ability to create new opportunities for retail garden center sites. Due to the current lack of information available at these retail sites in Minneapolis, it is necessary that management and staff at these establishments consider future training on the topic of aquaponics. After doing so, garden center sites can aid in the diffusion of aquaponics technology by offering a range of training opportunities for customers interested in building home systems.

Educate a few key managerial staff on the basics of aquaponics and identify currently stocked merchandise that can be utilized in aquaponics systems

Minneapolis garden centers can educate key managerial staff on the basics of aquaponics, and identify already stocked merchandise that can be utilized in aquaponics systems. Doing so would enhance both the level of familiarity with aquaponics and comfort when describing these systems to staff or customers at each garden center site. Managerial aquaponics training should be considered a priority, as Fang and Xu (2011) have shown that increasing the level of topical information and education available to customer can lead to an increase of the price of relevant merchandise. Additionally, management staff miss key opportunities to increase sales if they are unaware of in-stock merchandise that could satisfy the needs of aquaponics home hobbyists.

Gaining information about aquaponics can begin with searching relevant websites. This approach to self-training by managers is flexible based on an individual's interests and does not require a large investment of time. Additional development could then include reading how-to texts or training manuals on diverse aquaponics topics and/or attending local aquaponics conferences. By developing an understanding of aquaponics systems and identifying currently stocked merchandise for use by home hobbyists, managerial staff increase the level of information available to consumers and ultimately increase profitability at their retail site.

Identify several staff members as reference points for the rest of staff. This could also include training employees about where to direct customers when the store does not supply what they're looking for.

Once managerial staff understand the basics of aquaponics key staff members can learn more about the topic. Providing many immediate sources of information for customers interested in aquaponics will strengthen ties between garden center personnel and home hobbyists. Educating key staff about aquaponics will also ensure home hobbyists have timely access to this information when visiting a site. Increasing customer satisfaction in this way can ultimately increase sales of aquaponics related merchandise.

Key staff members being educated about aquaponics should have a general interest in the subject, or in problem-solving or new technologies when possible. Fueling this interest and enhancing employee knowledge will cause these individuals to feel more connected to the company, and may ultimately increase employee retention. Once key staff have been identified, management personnel can utilize educational materials that are similar or identical to the material used in their own training; ensuring consistency of information among management staff and employees will help maximize the diffusion of aquaponics information to home hobbyists.

Many sources of aquaponics information exist, and by utilizing a variety of these sources garden center staff will gain a broad knowledge of the topic. Website information is the easiest to access and allows individuals flexibility where time is concerned. Management and staff utilizing the web for aquaponics information should visit a variety of sites including aquaponics related blogs, published journal articles, and how-to videos. It would be easy for management to track websites they find most helpful and pass a list of these sites to key staff members. Other sources of aquaponics information include aquaponics textbooks and conferences. Providing textbooks to employees on-site would allow access to information should unforeseen requests arise, and would also allow staff to continue their education during slow business hours. Sending key staff to aquaponics conferences would increase the level of information these individuals have on the topic and provide a team-building environment. Key staff could relay conference information to management, saving management staff time during busy seasons, ultimately increasing the level of comfort key staff has when describing aquaponic systems to others.

In order for the business to respond to customer interests, it will be important for employees and managerial staff to maintain communication about the topic. This will help garden center sites adjust product offerings and information based on customer inquiries/needs. Discussion sessions regarding questions posed by customers, or newly identified sources of aquaponics information could be held a few times per season in an effort to keep the learning process active and ongoing. These discussions between employees and managerial staff will further increase the level of comfort each has with aquaponics, making both parties more comfortable when discussing the topic with customers.

Create in-store learning events in order to reduce loss of network nodes

To reduce the loss of potential aquaponics network nodes, it is necessary for small independent garden centers to remain open. This will allow retail sites to be a place where ideas can be exchanged between garden center staff and home hobbyists. One way for small independent garden centers to remain open is to fill a unique niche. Some small independent garden centers are already doing this by focusing on native plants, organic gardening, sustainable planting systems, etc. Aquaponics focused products—plants, fish, and necessary hardware—is a relatively unexplored niche that small independent garden centers have the potential to fill.

In addition to offering aquaponics related products; small independent garden centers could conduct on-site aquaponics training/workshops. Providing product information to customers interested in aquaponics would aid in building positive relationships between these individuals and garden center staff, and increase the likelihood that a customer returns. Studies have shown that customers are more likely to be satisfied with products they have purchased when they are able to use them correctly. By providing customers with training and educational materials the chances of them succeeding and being happy with their purchases will increase (Fang & Xu, 2011). Providing on-site aquaponics workshops would create stronger network ties, and support the diffusion of aquaponics in Minneapolis.

Small independent garden centers could create informational pamphlets or webpages related to aquaponics; both would aid in customer learning and are relatively easy to implement. Informational pamphlets could feature in-store merchandise useful for aquaponic systems, giving customers a take-away source of information that would keep them coming back to a specific establishment. Aquaponics related webpages could lead customers interested in aquaponics to a garden center that provides topical information. These sites could offer a fluid range of information by adjusting the material offered here, as new merchandise is available on-site. Alerting customers about new possibilities for aquaponic friendly plants or structural components is another way small independent garden centers can draw continued business. Providing this type of information to customers ultimately allows for the creation of new and mutually beneficial social networks ties between home hobbies and garden center retail sites in Minneapolis.

CONCLUSION

Aquaponics technology is a growing interest in Minneapolis as it has the potential to provide year-round local food, and is considered a sustainable alternative to conventional agriculture. Aquaponic systems are unique because they are specifically built for a space. This allows people building systems to be creative in their design. As each unique system is designed customers will interact with others in the community, and relevant business representatives. The process of building a system will ultimately engaging a wide variety of community members in learning about this technology.

Aquaponics technology appeals to customers who “perceive a direct link between what is consumed and (a) social issue”, or ethical consumers (Vermeir & Verbeke, 2006, p. 2). Aquaponics home hobbyists fall into this group, and will likely visit local retail sites to inquire about system components during construction. Many sources can provide information and training to customers interested in aquaponics, but little is known about if and how they are doing it. The degree of aquaponics information available to customers at retail garden center sites is currently unknown. By determining common gaps in available information at garden center retail sites we create an opportunity to improve the diffusion of this technology to home hobbyists in Minnesota.

Study findings demonstrated that there is an overall lack of aquaponics information available to home hobbyists at garden center sites in the City of Minneapolis; however, big box garden centers show a higher level of familiarity and comfort than small independent garden centers. Additionally, potential information nodes in the aquaponics network are disappearing as small independent garden centers in Minneapolis go out of business.

ACKNOWLEDGEMENTS

Funding for this research was funded, in part, by the Minnesota Agricultural Experiment Station and a grant from the College of Food, Agricultural and Natural Resource Sciences Program for Creation of New or Revised Courses and Programs for Experiential and Interdisciplinary Education, entitled “Aquaponics: To fish and plant…*for life!”* We would also like to thank University of Minnesota faculty advisor Dr. Kristen Nelson for guiding us in the research process.

REFERENCES

Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly* 45 (3), 425–455.

Anderson, N.O., Annis, J., Buchholz, M., Cutting, J., Heuring, E., Jankila, E., McCrumb, M., Nelson, N., Pehoski, M., Piepho, K., Price, V., & Russell, V. (2011). Undergraduate sustainable learning: Effects of sustainable soilless media on production and sensory evaluation of cucumbers, basil, parsley, and lettuce. In: Murphy , K. (Ed.). *Plant Breeding for Sustainable Agriculture. Special Issue of Sustainability,* 3(9):1381-1398.

Bernstein, S. (2011). *Aquaponic Gardening: A Step-by-Step Guide to Raising Vegetables and Fish Together*. Gabriola Island, BC V0R 1X0, Canada: Ninth Printing.

"City of Minneapolis." *Official Website of the City of Minneapolis*. N.p., 2015. Web. 12 Mar. 2015.

“Climate Minneapolis.” *United States Climate Data.* N.p., 2015. Web. 12 Mar. 2015

Czapar, G.F., Curry, M.P., Cloyd, R.A. (2007). Educational needs and customer service practices of retail stores that sell pesticides in Illinois. *HortTechnology*, 17(1):115-119.

Fang, F., Xu, X. (2011). An analysis of consumer training for feature rich products. *Decision Support Systems*, 52(1):169-177.

"Geographic Coordinates of Minneapolis, Minnesota, USA." *Latitude, Longitude, and Elevation above Sea Level of Minneapolis*. Date and Time, 2011. Web. 12 Mar. 2015.

Kadushin, Charles. "Ch. 2Some Basic Network Concepts and Propositions." *Understanding Social Networks: Theories, Concepts, and Findings*. New York: Oxford UP, 2012.

Love, D. C., Fry, J. P., Genello, L., Hill, E. S., Frederick, J. A., Li, X., Semmens, K. (2014). An International Survey of Aquaponics Practitioners, *PLoS ONE* 9(7): e102662.

Love, D.C., Fry, J. P., Li, X., Hill, E. S., Genello, L. Semmens, K., Thompson, R. E. (2015). Commercial aquaponics production and profitability: Findings from an international survey. *Elsevier Life Sciences: Aquaculture*, 435:67-74.

Michelfelder, I., Kratzer, J. (2013) Why and how combining strong and weak ties within a single interorganizational R&D collaboration outperforms other collaboration structures. *Journal of Product Innovation Management*, 30(6):1159-1177.

"Minneapolis, Minnesota (MN) Zip Code Map - Locations, Demographics." - *List of Zip Codes*. Citi-Data, 2013. Web. 12 Mar. 2015.

Rogers, E. M. (2003). *Diffusion of innovations*. New York: Free Press.

Vermeir, I., Verbeke, W. (2006). Sustainable food consumption: Exploring the consumer “attitude-behavioral intention” gap. *Journal of Agriculture and Environmental Ethics*. 19:169-194.

APPENDIX A: A SITE DESCRIPTION OF GREENHOUSE CONDITIONS AND GREENHOUSE MAINTENANCE

The following Site Description contains the greenhouse conditions under which the 2015 University of Minnesota HORT 4601 (Aquaponics) Spring Semester class conducted research. The only exception(s) to this are Chapter(s) that indicate(s) otherwise in their Study Design. The location for aquaponics research was in the Minneapolis – Saint Paul Metropolitan area, State of Minnesota, U.S.A., specifically located at the St. Paul Campus of the University of Minnesota (44°59'17.8" N lat., -93°10'51.6" W long.). Plant seeds were sown in 288 plug trays with a pasteurized Berger BM2 Germination Mix (Berger Peat Moss, Saint-Modeste, Quebec, Canada). For seed germination, a mist system in a greenhouse was used from sowing to germination (21±0.8/21±0.7°C, day/night, 16 hrs (0600–2200 HR) lighting at a minimum setpoint of 150 µmol m^{-2} s^{-1}, a mist frequency of 10 min. intervals (mist nozzles, reverse osmosis water) during 0600-2200 HR with a 7 sec. duration (Anderson, et al., 2011). After germination until the true leaf stage, plug trays were moved from the mist greenhouse to capillary mats; the environmental conditions in this greenhouse were 24.4±3.0/18.3±1.5°C day/night and 16 hrs (0600–2200 HR) lighting at a minimum of 150 µmol m^{-2} s^{-1}. Greenhouses used for aquaponics experimentation were located in the Plant Growth Facilities, House Nos. 369-C2 and 369-C4. Greenhouse No. 369-C2 had 23.6±0.8°C (daily integral) whereas No. 369-C4 was at 21.7±0.4°C. Temperature setpoints were 23.5°C and 21.5°C for 369-C2 and 369-C4, respectively, while the photoperiod was long days (0600–220 HR) with supplemental lighting supplied by metal halide high intensity discharge (HID) lamps at a maxima of 1377 µmol m^{-2} s^{-1}; electrical generators served as the electrical power backup system. Both greenhouses were adjacent, A-frame even-span construction sharing one inner wall; the roof, shared inner wall and interior wall adjoining the service walkway were glazed with double-strength float glass whereas the exterior walls had chambered acrylic (Exolite®; Cyro Industries, Mt. Arlington, NJ) glazing. Heating was delivered via hot water in perimeter pipes with galvanized fins for enhanced heat exchange. All environmental settings were controlled via an Argus Control Systems Ltd. computer (Surrey, British Columbia, Canada).

The aquaponics system in greenhouse No. 369-C2 consisted of eight aluminum tanks (193x77.5x75 cm, length x width x height; 6.5 cm thick walls) with a floating raft system (2/tank; 60x60x5.5 cm, Owens Corning FOAMULAR 150, R-10 insulation sheathing; Owens Corning Co., Toledo, OH); the water volume in each tank was ~550 L or 0.55 m^3. Two plastic, hemispherical tanks (68x47x26 cm) were connected to each fish tank and served as the biofilters. Each biofilter was filled with 8-10 cm dia. gravel (D-Rock Center, New Brighton, MN). In greenhouse 369-C2, ammonium chloride (1 g/biofilter; Hawkins Chemical Co., Roseville, MN) was used to start the biological filter or biofilter in 8-10 cm dia. lava rock (D-Rock Center, New Brighton, MN) to produce ~1 mg/L ammonia with an initial start of *Carassius auratus* (goldfish) whereas ammonium carbonate was used in 369-C4. Two plastic, hemicylindrical tanks (68x47x26 cm) were mounted above one end of each fish tank and served as the biofilters. Each biofilter was filled with 2 cm dia. granite gravel (Hedberg Aggregates, Stillwater, MN). A low density (approx. 25-30 fish / tank) of *Carassius auratus* was used to start the biological filter in the gravel.. Water was lifted to the biofilter tanks by a Danner Supreme 700 GPH mag drive pump. The outflow was valved and split between the two biofilter tanks and a third outlet which discharged directly to the fish tank for added aeration and circulation. Each biofilter received approximately 4 l/min. An automatic bell siphon in each of the biofilter tanks allowed the water level to rise in the

gravel from a low point of approximately 2 cm depth to a high of around 15 cm. At the high point the siphon would start and the water would draw down (returning to the fish tank), creating an ebb and flow in the gravel. Potential plant spacing on each raft could be a max. of 16 plants in a 4x4 grid, each plant could be grown in a 12cm dia. Net Cup (Hydrofarm Central, Grand Prairie, TX) filled with Trock rockwool (medium grade, 4CF, 30/PL; Therm-O-Rock East, Inc., New Eagle, PA). Water quality was monitored daily (5/wk excluding weekends) and fish measurements were sampled weekly by students and recorded in an interactive Google Doc® file. The measurements and safety protocols are detailed in Appendix A. Temperature measurements averaged 22.3±0.9°C and closely approximated the air temperature setpoint. Fish species grown in this house were *Oreochromis* spp. (tilapia) and *Perca flavescens* (yellow perch) at varying densities, depending on age.
The aquaponics system in greenhouse No. 369-C4 consisted of four aluminum tanks (identical specifications as for No. 369-C2) with two tanks used for a two galvanized steel framed, adjustable shelving rack system; there were two shelves/rack. The same measurements and safety protocols (Appendix A) used in greenhouse No. 369-C2 were used. Temperature measurements averaged xx±xx°C and approximated the air temperature setpoint. Fish species grown in this house were *Perca flavescens* (yellow perch) and *Carassius auratus* (goldfish) at varying densities, depending on fish age. One plastic, rectangular tub (123x186x18 cm; Polytank Co., Litchfield, MN) served as a biofilter for each rack system, was filled with 3-4 cm dia. lava rock (D-Rock Center, New Brighton, MN) and located on the concrete floor underneath the lowest shelf of each shelving rack system. Two tubs/shelf (123x94x18 cm; Polytank Co., Litchfield, MN) were fitted with six web flats, each of which could hold a 50.8x25.4 cm plug growing tray (variable plug diameters) of plants. The top shelf of each rack system was exposed to natural and supplemental lighting (metal halide HID lights) whereas the second shelf had supplemental light emitting diode (LED) lighting supplied by either Sunshine Systems GrowPan (450-470, 630 nm; 300 Watt; Sunshine Systems, LLC, Wheeling, IL) or Green Power LED (450-470, 660 nm; 300 Watt; 152x12 cm; 110v strips; Royal Philips N.V., Andover, MA). To start the biofilter, ammonium carbonate (Hawkins Chemical Co., Roseville, MN) was added as needed to maintain ~1 mg/L ammonia while the nitrifying bacteria populations were established. Airlift pumps moved the water from the fish tank to the biofilter, where a float level control would allow the water depth to cycle between approximately 2 cm and 23 cm. At the high point, a Danner Supreme 700 GPH mag drive pump lifted the water from the biofilter to the plant beds on the two shelves above, from which point it would drain back to the fish tank.

Greenhouse Maintenance Instructions

- Wash your hands thoroughly prior to entering and after leaving each Aquaponics greenhouse (in accordance with the posting on the greenhouse doors).
- No food or drink in the greenhouses as well as no eating or drinking therein! Greenhouse water is NOT potable.
- Make sure that the water is flowing and being aerated. Water is pumped from each tank into the biofilters flows back into the tank via gravity. Aeration is via an air pump next to the window (one per room). Water should be flowing and aerated 24/7. If not, call Jay Maher IMMEDIATELY (his number is at the end of this document and posted outside of C2)! Stop feeding! Until help arrives, monitor the fish/water quality and mechanically aerate or exchange the water if necessary.

- Check the plants for visible growth issues. The plants will NOT require watering, but any pale green leaves may signal a lack of N. Watch for these signs or anything else that may seem abnormal. Report them to an instructor when these are noted.
- Measure water quality in half of the tanks each morning (even tanks on even days, odd tanks on odd days). Take these measurements PRIOR to feeding or measuring fish. We are interested in temperature, oxygen, pH, nitrite, ammonia, and alkalinity. Take all measurements/water samples from the front of each tank (i.e., the end of the tank that is closest to the center aisle). If a result is puzzling, take another measurement. If the result persists then record it and alert an instructor. If you break a glass sample tube, sweep up the area and put all glass in the sharps container.
    - Temperature should be close to ambient (23^{o}C) unless the water is being experimentally heated: Turn on the temperature/pH probe and submerge the sensor end in the water (avoid getting the plastic housing wet). Record the equilibrium temperature in ^{o}C. When you are done, rinse the probe off in tap water, top up the storage solution inside of the cap well, and place the cap on the probe. Store upright.
    - Oxygen (should be >6 ppm): Turn on the probe, remove the protective cap, and submerge the probe into the water up to the wire. Move the probe in a small circle (approximately the diameter of a penny) until the reading equilibrates. Record the oxygen concentration, rinse the probe off in tap water, and replace the cap.
    - pH (should be 6.5-7.5): As per temperature.
    - Nitrite (should be <0.75 ppm): Collect 5 ml of tank water in a small sample tube. Add 5 drops of the appropriate solution to the beaker. Cap/stopper and shake. After 5 minutes, use the color card to determine the approximate nitrite level (it is okay to sub-divide a category). Dispose of the solution in the sink in hall C and rinse both the cap/stopper and tube with tap water.
    - Ammonia (should be <0.75 ppm): As per nitrite except that you add 8 drops from one bottle and 8 drops from another.
    - Alkalinity (should be 3-4 drops): Collect 5 ml of tank water in a small sample tube. Add one drop of the appropriate solution, cap/stopper and shake for ~2 seconds. Repeat until the blue solution turns yellow. Record the number of drops that you added. Dispose of the solution and clean the tube as per the nitrite protocol.
- Clean the pump filters in each of your tanks after sampling water quality. Lift the pump out of the water (don't be alarmed by the gurgling), slide the sponge filter off of the pump, and put the pump back into the water (so that it doesn't burn out). Then wring the filter out under running water in the hallway sink until clean and replace the filter. Do not swap filters among tanks.
- Feed the fish and check for pain/distress. Feed the fish in all tanks each morning (~8-9 a.m.) and afternoon (~3-4 p.m.) according to the rates and instructions from Jay Maher. There is fish feed in each greenhouse. Take this opportunity to check for pain/distress. Clinical signs are reduced or increased breathing (movement of the mouth and gill covering), darkening of the skin, altered swimming behavior (listlessness, surface

breathing, loss of equilibrium), aggression, reduced feeding, and (in the case of an infection) sores. Report any dead fish to Jay Maher. Place them in a Ziplock bag and place the bag on the utility table; Jay will take care of disposal.

- Measure fish growth (and check for pain/distress) in four tanks once per week. Add tank water to a Green bucket and place the bucket on a scale. Zero the scale. Obtain 5 fish from a given tank as follows. First, gain access to the tank by placing the floating rafts on the biofilter and removing the air stones. If there is a tank heater attached to one of the air stones then turn off the heater and wait 10-15 minutes for the element to cool before removing the last air stone (the element can overheat very quickly if exposed to air). Then unplug the pump and place both the pump and weighted bucket on the floor. Second, use the PVC gate to concentrate fish at either the front or back of the tank. Be careful not to injure any fish during this procedure. Use the dip net for that tank to remove 5 fish from a given tank. Place these fish in the tared bucket and report mean mass in grams (mass of the fish in the bucket divided by number of fish in the bucket). Then transfer individual fish to the measuring board so that you can measure total length in mm. Return the fish to its original tank. When all fish have been processed, return the water to the tank and report mean fish length. Handle the fish gently and watch for any signs of pain/distress (see previous bullet). Before moving on to the next tank, wash the PVC gate, buckets, and measuring board.
- Clean up at the end of each day. Place any large plant parts (e.g., leaves/stems) that may have fallen onto the floors into the Orange bucket and then transfer them to the compost wheelbarrow. Sweep the floors clean. Properly store all equipment related to fish feeding/measuring and water quality.
- Complete the Maintenance Checklist and then report results via the Google sheet '4601.15 Aquaponics data record'.
- Color-coded buckets in the houses: Green buckets are for water/fish use only; Orange buckets are for compost plant materials; White buckets are for cleaning and disinfecting. Clear plastic bins are for plant harvest. Ziplock plastic bags are for any dead fish.
- In case of emergency
    - For greenhouse emergencies: Contact Roger Meissner xxx-xxx-xxx
    - For water pump failure or fish-related issues: Contact Jay Maher xxx-xxx-xxxx or Paul Venturelli xxx-xxx-xxx
    - For plant-related issues: Contact Neil Anderson xxx-xxx-xxxx

APPENDIX B: CONSENT FORM LEFT WITH SURVEY RESPONDENTS

Examining Local Resources for the Aquaponics Home Hobbyist

By completing this survey you agree to participate in a research study sponsored by the University of Minnesota evaluating knowledge gaps in aquaponics. We request that you read this form and ask any questions you may have before beginning the survey.

Background Information
This study is conducted by student researchers from the Aquaponics (HORT 4601) course at the University of Minnesota. Our goal is to identify knowledge gaps currently existing on the subject of aquaponics at both small and big box garden centers in Minneapolis. Through surveying you about your organization's basic knowledge of aquaponics, we will assess what educational offerings should be enhanced to make garden centers in Minneapolis competitive in their service to aquaponics home hobbyists.

Procedures
If you agree to participate in this study, we will ask you to complete a short questionnaire about what types of knowledge your establishment offers local aquaponics home hobbyists.

Risks and Benefits of Participating in the Study
The potential benefit of participating in this study is a greater knowledge of how your business can offer help to aquaponics home hobbyists. As aquaponics is a rising trend among these hobbyists, knowing how to assist them can make your business more competitive. There are no expected risks for participating.

Confidentiality:
The information collected in this interview will be kept private. Any published reports will focus on community level issues not individuals. Research records will be kept in a locked file; only researchers will have access to the records.

Voluntary Nature of the Study:
Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota. If you decide to participate, you are free to withdraw at any time without affecting those relationships.

Contacts and Questions:
The researchers conducting this study are Dr. Kristen Nelson, Abigail Reynolds, Lindsey Miller, and Natalie Campbell. You may ask any questions you have now. If you have questions later, you may contact Kristen Nelson at (612) 624-1277. You may also write me at 115 Green Hall, 1530 Cleveland Avenue North, Saint Paul, MN 55108-6112.

Keep this form for your records

APPENDIX C: SURVEY GIVEN TO RESPONDENTS

Examining Local Resources for the Aquaponics Home Hobbyist

In this survey we are interested in learning about the types of information available to aquaponics home hobbyists in Minneapolis. The survey begins by asking a few questions about experiences related to consumer interest in aquaponics and finishes with broad questions about programs and training offered to consumers through your organization. All the responses will be kept confidential and only aggregated data will be used in the research paper.

First, a little about you and your organization:

1. **What is your role at this establishment?**

   Please respond with your title and primary duties.

2. **How long have you been with the company? _____# years**

3. **Please provide a brief statement describing the organization's general goals.**

4. **How familiar are you with aquaponics?** *Circle one response.*

1 2 3 4 5

Next, a little about your customers:

5. **Have you been asked by customers about aquaponics?** *Circle one response.*

YES NO

If yes: **How often do you get inquiries about aquaponics?** *Check one response.*

□ **Weekly** □ **Yearly**

□ **Monthly** □ **Seasonally (***When? Circle all that apply.)*

b. **Have you observed an increase in customer inquires about aquaponics?** *Circle one response.*

YES NO

c. If a customer asks about aquaponics do you refer them to other sources of information? *Circle one response.*

YES **NO**

If yes: **Please list the sources you recommend:**

6. For the average consumer, how capable are they of creating a home aquaponic system? *Circle one response.*

1 **2** **3** **4** **5**

Please comment:

Next we delve into employee knowledge about aquaponic systems:

7. How comfortable would you be describing the following components of an aquaponics system to a customer:

Comfortable: means to have knowledge of the component and find it easy to share this knowledge with others. 1= Not comfortable 5 =Very comfortable						
a.	**Structural Components:**	**1**	**2**	**3**	**4**	**5**
b.	**Fish and Plants:**	**1**	**2**	**3**	**4**	**5**
c.	**Nutrient Cycling:**	**1**	**2**	**3**	**4**	**5**

Please comment:

8. How comfortable would your employees be describing the following components of an aquaponics system to a customer:

Comfortable: means to have knowledge of the component and find it easy to share this knowledge with others. 1= Not comfortable 5 =Very comfortable

a.	**Structural Components:**	**1**	**2**	**3**	**4**	**5**
b.	**Fish and Plants:**	**1**	**2**	**3**	**4**	**5**
c.	**Nutrient Cycling:**	**1**	**2**	**3**	**4**	**5**

Please comment:

The next sections focuses on the types of training offered by your organization:

9. Does your organization use education and training to support the customers who purchase products from your store? *For example, shade garden design, deck building, or other relevant topics. Circle one response.*

YES **NO**

If no: **Why not?** *Briefly explain.*

If yes: **a. Where and how do people receive this training?** *Check all that apply.*

On-site:	**On-line:**
□ **Informational Posters**	□ **Videos**
□ **Handouts**	□ **Pamphlets**
□ **Workshops**	□ **Related Web Links**
□ **Other** *(Please describe)*	□ **Other** *(Please describe)*

For on-site workshops:

b. Do you conduct these trainings? *Circle one response.*

YES **NO**

c. In general, how long are the sessions?

_____ **# hrs**

_____**# times a year**

d. Does your organization offer aquaponics related training?

Circle one response.

YES **NO**

e. If yes, what types of information do you offer customers at these trainings?

Information pertaining to —*Check all that apply*

□**Physical system components**
□**Biological system components**
□**Economic information**
□**Other (*Please describe*):**

We conclude with two follow up questions.
Please feel free to discuss these questions directly with your surveyor.

10. What would you like to know about aquaponics?

11. What questions do you have for us?

Thank you so much for taking the time to fill out this survey. If you're interested in viewing the results of our study we will notify you when they are available at the University of Minnesota Aquaponics website.

APPENDIX D: COMPLETE DATA FROM SURVEY

Question number	Survey question	Response codes	Response Small Independent	Response Big Box
1	What is your role at this establishment? *Please respond with your title and primary duties.*	Text from survey	-President -Retail Operations Manager -Principal -Manager -Manager	-Garden Sales Associate -Garden Center Specialist
2	How long have you been with the company___# years	Number of years	Average 12.45	Average 6.0
3	Please provide a brief statement describing the organization's general goals.	Text from survey	"Provide excellent product and customer service with a fair price." "Provide high quality plugs and retail ready plants to the wholesale and retail marketplace." "To produce most of our plants locally and sustainably to support local economics and reducing our carbon footprint while leaving our green thumb footprint for now and future generations." "To provide a quality product and service the trade and DIY homeowners." "Sustainable, organic, local, family-owned, independent, co-operatively managed products."	"To facilitate the needs of the average homeowner/'do it yourselfer' with home remodeling, building, garden/landscaping needs."
4	How familiar are you with aquaponics? *Circle one response.*	Scale 1-5 (1=not familiar/5=very familiar)	Average 2.6	Average 4.5
5	Have you been asked by customers about aquaponics? *Circle one response.*	Yes or no	YES NO 1 4	YES NO 2 0
5a	*If yes:* How often do you get inquiries about aquaponics? *Circle one response.*	Weekly, monthly, yearly, seasonally (if seasonally what season)	Week Month Year Season 0 1 0 0	Week Month Year Season 1 1 1 (Sp/Sum)
5b	Have you observed an increase in customer inquires about aquaponics? *Circle on response.*	Yes or no	YES NO 0 5	YES NO 1 1

5c	If a customer asks about aquaponics do you refer them to other sources of information? *Circle one response.*	Yes or no	YES NO 2 1	YES NO 2 0
5d	*If yes,* please list the sources you recommend	Text from survey	-Interior Gardens -Midwest Hydroponics	-EcoGardens -Interior Gardens -HomeDepot.com
6	For the average consumer, how capable are they of creating a home aquaponics system? *Circle one response.*	Scale (1=not capable/5=very capable)	Average 2	Average 2.5
6a	Please Comment	Text from survey	"They would need to be educated on it first." "Average consumers like the ideas behind sustainable systems, but aren't always willing to invest the time and effort. They choose to due so with their pocketbooks with buying/choosing ready to consume/take home products that are local, organic , sustainable, green, etc.	"Customers that inquire have done their homework on what they want but seem like more information would be helpful." "Most people are unwilling to put in the regular maintenance a aquaponic system would take.
7	How comfortable would you be describing the following components of an aquaponics system to a customer?	Scale (1=not comfortable/5 very comfortable)	Average 1.4	Average 3.5
7a	Structural Components	Scale (1=not comfortable/5 very comfortable)	Average 1	Average 3.5
7b	Fish and Plants	Scale (1=not comfortable/5 very comfortable)	Average 1.6	Average 3.5
7c	Nutrient Cycling	Scale (1=not comfortable/5 very comfortable)	Average 1.6	Average 3.5
7d	Please comment	Text from survey	Being familiar with what and how aquaponics works doesn't equate to being an expert or teacher/sharing knowledge w/ conficence.	
8	How comfortable would your employees be describing the following components of an aquaponics system to a customer:	Scale (1=not comfortable/5 very comfortable)	Average 1.2	Average 4.5

8a	Structural Components	Scale (1=not comfortable/5 very comfortable)	Average 1.2	Average 4.5
8b	Fish and Plants	Scale (1=not comfortable/5 very comfortable)	Average 1.2	Average 4.5
8c	Nutrient Cycling	Scale (1=not comfortable/5 very comfortable)	Average 1.2	Average 4.5
8d	Please comment	Text from survey	"One of our landscape formen is familiar with aquaponics, as well as a few of the individuals in our production facility – again doesn't equate to selling a system to a consumer – nor would it be the first thing we would add to our mix of offerings." "They would need a lot of education." "We don't sell anything related to aquaponics so they don't have to know about it." "We have every level of expertise with numerous interest areas so hard to average out."	We offer PK or product knowledge classes for new products coming into our store/department. Mandatory class offerings.
9a	Does your organization use education and training to support the customers who purchase products from your store? *For example, shade garden design, deck building or other relevant topics. Circle one response.*	Yes or no	YES NO 4 1	YES NO 1 1
9b	*If no:* why not? *Briefly explain.*	Text from survey		Monthly merchant updates PK or product knowledge classes
9c	*If Yes:* Where and how do people receive this training	Text from survey	<u>Onsite</u> Informational Posters - 0 Handouts - 3 Workshops - 2 Other -1 <u>Online</u> Videos - 0 Pamphlets - 0 Related Web Links - 1 Other - 2	<u>Onsite</u> Informational Posters - 0 Handouts - 0 Workshops - 1 Other -1 <u>Online</u> Videos - 1 Pamphlets - 0 Related Web Links - 0 Other -0
9c.1	If you selected "Other", please describe.	Text from survey	"'Classroom' training at store. Training on the floor."	"In store class workshops asking seasoned professionals of associates."

			"Through consultations and professional design and coaching on site and at our retail store. (On-Site Description); Social media website content and inspiration (Online Description) "Monthly store e-newsletter with applicable garden information" (Online Description)	
9c.2	Do you conduct these trainings	Yes or no	YES NO 3 2	YES NO 1 1
9c.3	In general, how long are the sessions	Hours and times per year	Average Hour(s) – 2.2 Average Year(s) – 4.5	Average Hour(s) - 4 Average Year(s)- 3
9d	Does your organization offer aquaponics related training?	Yes or no	YES NO 0 5	YES NO 0 2
9d.1	If yes, what types	Text from survey	N/A	N/A
10	What would you like to know about aquaponics	Text from survey	"Nothing right now." "Nothing more at this time." "The principles of aquaponics sounds good but I doubt its practicality in a retail setting. The amount of inventory to stock and lack of turns in the allotted space on the sales floor would deter me from stocking it." "More interested in how aquaponics may serve a roll in our plant production versus retail sold to consumer (systems sold to consumers)."	"As it is becoming more prevalent and readily avaible any and all information would be helpful." "Is there other uses for aquaponic fish other than the local restruant industry? Is the water usable/solerable for other purposes? Is the demand large enough and consistent enough to sustain an aquaponic farm."