



Research Paper

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Emerging specialty crop farmer perspectives and educational needs related to soil health and nutrient management in the Upper Midwest

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Abstract

Emerging farmers, including immigrant farmers, play an increasingly important role in the food system of the Upper Midwestern United States but face significant barriers to success. One important barrier is the lack of culturally relevant and system-specific training and technical assistance, particularly related to soil health and nutrient management. A team of researchers and farm support professionals was convened to conduct a farmer engagement process consisting of a survey and focus groups to better understand the experiences and wisdom that emerging farmers already have, and their educational needs related to soils. The broader goal was to inform the development of culturally relevant tools and training. Here we identify key takeaways related to content needs and learning style preferences. While emerging farmers are already skilled in assessing physical and biological aspects of soil health, they often need support in understanding chemical properties of soil, how to do soil testing, and how to translate soil test results into actionable practices. Additionally, many emerging farmers have experience in other countries and in agricultural systems based on practices such as shifting cultivation. Supporting farmers as they adapt these practices to a Midwest context requires educators to learn about these systems and value the expertise of farmers from diverse farming backgrounds. There is a particular need for more nuanced and farm scale-specific training about inputs in highly diversified, mostly organic systems, especially related to compost and manure management. In terms of learning styles, farmers preferred hands-on training opportunities with as much mentorship and peer learning as possible. Many Midwestern emerging farmers participate in incubator farm programs for beginning growers. While such programs provide valuable access to land and infrastructure, they often lack the capacity to provide tailored participant mentorship. This leaves program graduates unsure about how to utilize soil health and nutrient management practices when they start their own farms. To improve soil health and nutrient management outcomes for emerging farmers, we propose investing in train-the-trainer type programs for farmer leaders and staff with beginning farmer organizations. These programs should include tailored one-to-one mentorship and peer learning with an emphasis on organic inputs, chemical aspects of soil health, and diversified production systems.

Introduction

Since the early 2000s, a growing movement has been underway to support beginning and emerging farmers who have been historically marginalized within US food system. This has included federal grant programs such as the Beginning Farmer and Rancher Development Program, university outreach programs, and grassroots community organizations developing farmer training programs (Niewlony and Lillard, 2010). The New Entry Sustainable Farming Project maintains a list of existing incubator and apprenticeship programs for beginning farmers, which as of 2024 lists 55 incubator programs, 11 dual incubator and apprenticeship programs, and 76 apprenticeship programs nationwide across the US and along the Canadian border (New Entry Sustainable Farming Project, 2024). The organization's 2018 survey of incubator farm programs estimated that approximately 4520 people participated in these programs; most participants grow vegetables and about 50% are estimated to be refugees or immigrants (New Entry Sustainable Farming Project, 2018). As of 2023, there are at least seven incubator farms in Minnesota, collectively serving hundreds of emerging farmers, and providing varying levels of education and technical assistance. In 2019, the Minnesota Department of Agriculture convened six Emerging Farmers Listening Sessions, and subsequently formed an Emerging Farmers Office. They defined emerging farmers as 'those who

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traditionally face barriers to the education and resources necessary to build profitable agricultural businesses, including immigrant farmers and farmers of color'. Emerging farmers in Minnesota tend to be young, more likely to identify as Queer or LGBTQ+, lack inherited land and capital, and are more often urban/suburban based. They often grow vegetables or other specialty crops due to lower barriers to entry than other farming enterprises (Bailey and Kagan, 2020). While the term 'emerging farmer' encompasses many groups, our focus for this project was on farmers who are new to farming in the United States (but who may have farming experience in another country), lack formal training in agriculture, grow specialty crops, and who may be likely to seek educational opportunities through beginning farmer programs and events.

One key barrier to address in support of emerging farmers in the Upper Midwest is the lack of culturally appropriate and accessible technical assistance programs and resources. This need was demonstrated by a survey of Hmong and Hispanic farmers in Minnesota, which indicated only 5% would turn to a traditional Extension or university entity for advice about farming practices (McCamant, 2014). This is in stark contrast to a 2019 needs assessment of predominantly white fruit and vegetable growers in Minnesota, in which 22% of growers sought information from Extension or a university entity about farming practices (Klodd and Hoidal, 2019). The lack of training resources specific to emerging farmers was also cited as a key barrier to success in the 2020 Emerging Farmers report to the Minnesota State Legislature (Bailey and Kagan, 2020). Common challenges that limit the utility and accessibility of traditional technical assistance programs include limited English proficiency, small farm scale, highly diverse cropping systems that include non-traditional crops and agronomic practices, unstable land tenure, and limited access to transportation and credit (Bailey and Kagan, 2020). To effectively support emerging farmers, technical service providers must develop alternative, community-specific outreach approaches.

Soil health is one of many areas where culturally appropriate support is lacking. The University of Minnesota has established nutrient management guidelines for common specialty crops grown in the Midwest (Rosen and Eliason, 2005). Recommendations provided in pounds of nutrient per acre are valuable when using fertility sources with labeled nutrient concentrations (e.g. urea, potassium sulfate, etc.), but they do not easily translate to growers using fertility systems that rely on compost, manure, and other organic inputs. While these inputs can be tested, doing so is costly and may require additional math and know-how to convert results into a usable form. Nutrient management recommendations from most Midwestern universities are also specific to crops grown and consumed by European descendants, and with limited resources existing for crops culturally relevant to immigrant and BIPOC growers.

Emerging farmers also tend to be highly diversified, growing several crops in a small area. Nutrient recommendations developed for single crops grown on multiple acres can be difficult to translate to more diverse systems. Over-applying nutrients is costly and has potential environmental risks (Small et al., 2019), while under-applying nutrients can result in crop stress and reduced yield. Without accurate and relevant soil health and nutrient management recommendations, diversified growers face outsized risk. Furthermore, small-scale fruit and vegetable production is complex, with multiple windows for planting, weed management, and harvest and termination of a diverse crop portfolio. These systems often depend on frequent and intensive tillage, with limited fallow periods to implement soil health

practices like cover crops (Lowry and Brainard, 2019; Osterholz et al., 2021). Recommendations for soil health practices should be tailored to these complex systems.

Study context

In 2022, staff at a regional farmer advocacy organization, Big River Farms (BRF), approached University of Minnesota soil scientists and Extension educators to request training materials that addressed the concerns outlined above. BRF is both an incubator farm and an education farm, providing land access, infrastructure, and an educational program where growers can access classes and mentorship. After gaining experience with BRF, participants graduate from the program to start their own farms. As one of the oldest and most established beginning farmer programs in Minnesota, BRF has been a model for newer incubator farms. In the last two years alone, they have provided mentorship and curriculum support to 24 beginning farmer programs in seven states.

In response to this request, we formed a team of farmers, researchers, and Extension educators to develop a soil health train-the-trainer curriculum that would incorporate emerging farmer expertise and worldviews. Our team included a soil science professor, a soil science researcher, an Extension specialty crops educator, the director of BRF, and a specialty crop consultant (both the farm director and consultant were also organic vegetable farmers). Our ultimate goal was to develop relevant resources for emerging farmers, so it was critical to first understand how end users of this curriculum conceptualize and implement soil health practices.

In the spirit of reflexivity (Finlay, 2002), we recognized that the majority of us did not reflect the communities we intended to support; we therefore needed to implement a robust engagement process to better understand the needs of emerging farmers related to soil management. The terms 'beginning farmer' and 'emerging farmer' have been defined differently across programs that cater to new grower audiences, but some defining factors include level of farming awareness, experience, and demographics (e.g. immigrant, refugee, new urban farmers, women in farming, people making mid-career pivots, people interested in small-scale farming, age-based categories). Many programs for beginning farmers and sustainable agriculture cater to a wide audience of beginning farmers without specificity (Newolny and Lillard, 2010). The heterogeneity of this group as well as the fact that emerging farmers may be less likely to be part of databases or registries of farmers due to language and other barriers pose challenges for robust research methodologies that adequately sample the full population of emerging farmers. In this paper, we focus on a subset of emerging farmers: those who participate in educational programs designed primarily for immigrant, BIPOC, and other farmers historically marginalized within the food system.

Agroecologists have long recognized that knowledge sharing and co-creation are pillars of food system transformation (Anderson, Maughan and Pimbert, 2019; Asprooth, Norton and Galt, 2023), and that recognizing farmer expertise is critical to developing sustainable agroecosystems (Pretty, 1995; Van de Fliert and Braun, 2002; Lacombe, Couix and Hazard, 2018). Immigrant farmers in Minnesota often have experience in farming in diverse climates and soil types, with experience in production systems that incorporate a range of soil protection and renewal practices. Some of these practices include shifting cultivation (sometimes called 'slash and burn' or swidden cultivation), deep

compost mulch, terraced agriculture, and crop–livestock integration. These practices do not easily align with current research-based nutrient and soil health recommendations. Further, farmers' background knowledge and experience is not always visible to, or recognized by, agricultural professionals who seek to advise these farmers. By determining farmer perceptions and experiences, we hoped to develop a soil health and nutrient management curriculum and train-the-trainer program that honors the backgrounds and diverse experiences of emerging farmers.

This paper presents survey and focus group findings from a diversity of farmers who participated in a regional farming conference for emerging farmers, farmer incubator program participants, and those selling to a food hub with a focus on supporting BIPOC and emerging farmers. Our results have implications for anyone working with beginning and emerging farmers across the US in small-scale specialty crop production systems. In particular, we believe these results will be useful for educators working with immigrant farmers who may have experience in other farming contexts and who are seeking educational opportunities to farm in a US context.

Materials and methods

Survey development and implementation

The first step in the needs assessment was a survey administered at the 2022 Emerging Farmers Conference (Shoreview, MN, USA). This conference is hosted by The Food Group, the parent organization of BRF, and caters to farmers who traditionally face barriers to the education and resources necessary to build a profitable agricultural business, with a particular emphasis on immigrant farmers and farmers of color. All conference content is interpreted in up to 12 languages each year and attended by farmers from across the Upper Midwest region. As such, sampling at this conference allowed for an opportunity to survey a range of farmers self-identifying as 'emerging', and actively seeking education about farming topics. The intention of this study was not to collect data reflective of all emerging farmers across the US, but instead to target a population of emerging farmers opting to participate in educational events to inform development of future such events. Conference attendees were recruited to participate in the survey, and prospective participants were offered a \$50 gift card as compensation. Participants completed the survey online via Qualtrics using tablets provided at the table or using identical paper copies of the online form. Interpreters were available to support growers in survey completion.

Participation was open to any conference attendee self-identifying as a farmer or aspiring farmer. The conference attracted 300 attendees, 175 of whom identified as farmers and producers. Our survey was completed by 60 individuals, representing a 34% response rate among farmer attendees. While we did not ask for location information on the survey, grower participants at the conference came from 28 of the 87 counties in Minnesota as well as eight other states: Wisconsin, Illinois, Missouri, Kansas, North Dakota, Kentucky, Ohio, and Iowa.

The survey included 22 questions grouped into four sections: demographic information, soil amendments and fertility practices, resources and support, and soil health educational needs. The survey was granted a human research exemption by the University of Minnesota Institutional Review Board (study #00017327).

Survey data were analyzed using R. Descriptive statistics were calculated for demographic data, and ggplot2 was used to create figures (Supplementary material)

Focus groups

We conducted six focus groups with emerging farmers in the spring of 2023. Discussion questions for these focus groups were developed after reviewing survey results to provide deeper context to the survey findings. Four of the focus groups were conducted in person and two via Zoom, with a total of 50 farmer participants. We worked with partner organizations including four incubator farms and a Twin Cities based food hub to recruit growers to participate, and all participants were given a stipend of \$100 for their time. One of the incubator farm programs works with East African immigrants; the three others work broadly with growers self-identifying as immigrant, BIPOC, LGBTQ+, and emerging farmers. Three of the incubator programs were based within an hour of the Twin Cities, and the fourth was based in Kansas City. The food hub specifically works with small-scale growers who fall into the Minnesota Department of Agriculture's definition of 'emerging farmer' (defined above), buying produce from 120 emerging farmers and providing mentorship and education to their network. Most of the farmers in this network farm within approximately one hour of the Twin Cities metro area. Each incubator farm hosted a focus group with 6–11 farmer participants from their programs; the food hub hosted two focus groups with farmers who sell to them.

Focus groups followed the format outlined in Krueger and Casey (2014). After a round of introductions, interview questions were structured around three primary themes: grower perceptions of soil health, soil testing experience, and educational needs and preferences. Each focus group was attended by a facilitator and a note taker. The facilitator had extensive experience as a farmer and farmer trainer. Note-takers were experienced in vegetable production and familiar with the soil health concepts discussed in the focus groups. The focus groups were recorded, and the note-takers documented nonverbal communication such as head nodding and short verbal responses. In two groups, interpreters were also present, and some or all participants communicated with interpretation. Each focus group lasted approximately one hour.

The focus group audio recordings were transcribed using Rev.com; note-takers reviewed the transcripts and added context from their written notes. Transcripts were analyzed using a quasi-deductive approach with descriptive coding. Broad categorical codes were created based on the interview questions. We then used an inductive approach when coding the text, adding codes to match the content of the focus group discussions. Each focus group was given a letter and each participant a number, allowing us to anonymously track trends across focus groups and individuals. To prevent individual bias, four team members participated in this process: an Extension specialty crops educator, a soil science researcher, and two soil science interns. The Extension educator and one intern coded the interviews then arranged them into sections. Each evaluator analyzed each section individually, summarizing the content and highlighting quotes to illustrate the summaries. Our team then collaboratively summarized each section and reviewed the summary document to develop key conclusions using a consensus process.

Results

Participant demographics

Survey respondents and focus group participant demographics are reported in [Table 1](#) alongside 2022 USDA Agriculture Census statistics for Minnesota for comparison. In general, the people participating in both parts of this study were farming on a much smaller scale, had less farming experience, were less likely to own their land, were far more likely to be immigrants and people

of color, and more likely to be certified organic than the average Minnesota farmer.

Part 1: farmer knowledge and experience

Perceptions of healthy soil

Focus group participants identified short- and long-term benefits to investing in healthy soil. They noted that healthy soils are easier to work with and produce healthy plants, while poor soils require

Table 1. Survey respondent and focus group participant demographics compared to all Minnesota farmers according to the 2022 USDA Agricultural Census

	Survey respondents	Focus group participants	2022 US Ag Census—Minnesota
Land ownership			
Own (full or partial ownership)	27%	12%	93%
Long-term lease	3%	6%	7%
Year to year lease	23%	51%	
Shared farm—incubator or Tribal land	37%	31%	
Other	7%	0%	
Farm size			
<1 acre	N/A	44%	7%
1–5 acres	N/A	35%	
6–10 acres	N/A	15%	
10 + acres	N/A	6%	93%
Experience			
<1 year	12%	0%	N/A
1–5 years	62%	55%	12%
6–10 years	18%	20.5%	14%
10 + years	8%	24.5%	74%
Demographics			
Immigrant	N/A	74%	N/A
Person of color or Latino heritage	N/A	72%	1.5%
Woman or nonbinary person	N/A	44%	31%
Urban resident	N/A	29%	N/A
Veteran	N/A		8%
Organic status			
Certified organic	22%	19%	0.89%
Using organic practices, but not certified	N/A	8%	N/A
Using conventional practices	76% (2% 'unsure')	73%	N/A
Language preferences for educational content			
Comfortable in English			N/A
Equally comfortable in English and another language	17%	12%	N/A
More comfortable in another language	32%	27%	N/A
Preferred languages (in descending order)	Burmese, Kirundi, Hmong, Swahili, Korean, Somali, Nepali, Ojibwemowin, Lisu	Hmong, Burmese, Falam Chin, Karen, Swahili, Kisii, Kachin, Somali, Arabic	N/A

more inputs and money. Investment in soil health was perceived as something that can reduce labor and produce food for their community. One focus group participant stated:

I think just like we say, water is life. I think soil is life. Without it, nothing else. But the health of the soil matters in the sense of it sustains life. It helps us grow the food ... if you have the right pH, if you have the right nutrients, if you have the right components of the soil, then I would say you have a good soil health. And that is vital for farmers and for growing food and for the things that we do.

We asked survey respondents and focus group participants about soil health indicators, and the responses provided by each group mirrored the other. One open-ended survey question asked respondents to define healthy soil. The most common words and phrases provided by respondents were: good, nutrients, rich, production, healthy, alive, dark, organic matter, worms, and crops. Similarly, focus group participants said they assessed soil health based on indicators such as: soil texture and color, organic matter content, nutrient availability, water retention, erosion control, and the presence of beneficial microorganisms. Texture and color were the most frequently cited soil health indicators in all of the focus groups. Positive textures and colors included soft, loose, clumpy, and black. Less healthy soils were characterized by terms such as: compaction, hard pans, texture (specifically 'powderness' or 'falling apart'), and dry. Several participants said they assess soil health by the health of their plants, relying on visual cues like size and nutrient deficiency symptoms.

Another characteristic of healthy soil mentioned across focus groups was water retention. Many participants had experience in farming in countries where erosion was a significant problem. These participants were particularly attuned to the soil's ability to hold moisture and withstand rainfall events.

Two less common soil health indicators discussed by survey respondents and focus group participants were biology and nutrients. Three farmers across three different focus groups discussed indicators such as 'life within the soil'. Other comments included soil as a healthy habitat for microorganisms, whether or not certain weeds or plants grow in specific soils, and the presence of earthworms. Nutrients were discussed extensively in some but not all focus groups.

One trend that emerged was a tendency to label soil as 'good', 'bad', or 'good for growing certain crops'. Although focus group participants and survey respondents were able to name a number of soil health indicators, survey respondents selected 'How to tell whether my soil is healthy' as their top educational priority (Table 2). This suggests there is still a desire for further education on this topic.

Soil health practices

Survey respondents were asked to rank the health of their soil on a scale of 1 (terrible) to 5 (excellent), and their motivation to improve the health of their current soil on a scale of 1 (not at all motivated) to 5 (extremely motivated). On average, respondents ranked their current soil health at 3.7/5 and their motivation to improve their current soil at 4.7/5.

Focus group participants discussed a wide range of soil health practices they currently use or used on previous farms before coming to the United States. These soil health practices included cover crops, fallows, rotation, erosion control, compost applications, reduced tillage, and crop–livestock integration. Table 3 lists the soil health practices that focus group participants use,

Table 2. Educational topics ranked by order of interest

Of the following topics, what are you most interested in learning about (select top 3)?	Response count
How to tell whether my soil is healthy	39
How much and which types of fertilizers will make my crops more productive	38
How to understand soil test results	37
How to do a soil test	35
What nutrients crops need to grow well	31
How to improve long-term soil health and fertility	29

Respondents were asked to select their top three educational priorities, but some ranked more than three on the paper survey. $n = 60$, with multiple responses per participant.

the number of focus groups in which farmers discussed each practice, and relevant phrases or comments that illustrate nuances or ways that farmers discussed each topic. Our survey was focused on farmers' knowledge and outlooks rather than practices; therefore, we did not ask survey respondents about specific practices.

While many of the soil health practices discussed in the focus groups are well known and commonly practiced in US agriculture, discussions of fallow periods, compost, and cover crops exposed unique challenges.

Fallow periods: 'Letting the land rest' was presented in all focus groups. Farmers from Thailand, Burma, and Kenya described the use of burning and shifting cultivation as a tool for fertility:

We learnt to clear all the trees and bushes. And then let it sit there until it turn yellow, and then we'll burn it. And then those ashes becomes compost, nutrients to the soil. And then again, maybe farm there for a few years, and then rotate to somewhere else for a few years and then come back to the old one and let the land rest. At least, that's what his experience watching his parents and grandparents doing how they do back in Thailand.

Growers who are accustomed to farming in a shifting cultivation system may have distinct educational needs related to adapting to system that does not involve burning for nutrient management. Alternatively, directly addressing how growers can continue or adapt this practice in a new context may be helpful.

Compost: Growers commonly reported using compost as a primary soil health strategy. Most participants were familiar with using compost and plant residues to conserve soil moisture, reduce erosion, and 'feed the soil'. However, multiple focus group participants differentiated between composts and other fertility sources, as highlighted in the following quote:

So I don't think we should be measuring compost, we should be measuring the fertilizer, but not the compost. The compost, it doesn't matter how much you put [on]. I think as time goes on, you should add more and you see the roots getting thicker and bigger.

Focus group participants commonly applied large volumes of compost every year, despite noted challenges with how variable and expensive it can be and the labor required to apply it. This motivated farmers to better understand the role compost plays in soil health and nutrient management. The discussions exposed discrepancies in the way farmers and educators used the term 'compost'. For instance, commercial fertilizer products derived from composted manure and animal materials were described

Table 3. Soil health practices identified by participants of five focus groups, with the number of focus groups in which each practice was discussed with farmers, and phrases or comments that illustrate nuances in each practice

Soil health practice	Number of focus groups mentioned	Relevant phrases or comments
Fallow periods	5	'Letting the land rest' was a theme identified in every group.
Cover crops	5	'Keep roots in the soil', connecting cover crops to erosion prevention
Rotation	5	Intercropping often discussed in the same context as crop rotation
Compost and plant residues	5	Often tied to soil moisture. Comments about how compost feeds the soil but not plants, and how it is separate from fertility.
Reducing tillage	4	Many growers knew about this practice and its benefits, but struggled to implement it.
Crop-livestock integration	3	Rotational grazing was the most frequently mentioned in US practice. Few people were currently integrating livestock into vegetable production, but several described livestock practices in other countries. Many use manure, but in the US this is generally purchased from off-farm.
Erosion control	2	Terraces, channels, and cover crops
Inoculants	1	One farmer discussed experimenting with various soil inoculants to increase beneficial microbes in the soil.

as 'compost' in some cases and 'commercial fertilizer' in others. Composted manure and vegetative compost were both simply referred to as compost by many participants. Such discrepancies in definitions highlight the importance of clarity and specificity when data on farmer practices are collected, and when training educators and farmers.

Cover crops: Across focus groups, farmers understood that cover crops can increase or maintain soil fertility. Most had either used cover crops themselves or were familiar with the concept. Some participants from incubator farms shared that farm staff planted the cover crops each year, so while farmers were familiar with cover crops, they lacked experience and confidence with planting, management, and termination.

These data imply some important lessons for educators developing resources for emerging farmers. Farmer perceptions of soil health were primarily based on physical and biological properties of soil and crop performance. This is consistent with other studies showing farmers are generally very good at assessing biological and physical properties of soil based on observations, but do not often utilize soil chemical properties or soil tests as indicators (O'Neill, Sprunger and Robertson, 2021; Obour et al., 2020). Tools focused on soil chemical properties may be beneficial, particularly those tailored to organic management. As illustrated by the cover crops discussion, familiarity with a concept does not necessarily translate to confidence implementing a practice. Creating opportunities for farmers to gain hands-on experience will be critical for the adoption of soil health practices. Additionally, using language that farmers are already familiar with, including phrases like 'letting the land rest', may be helpful.

Fertilizers and soil amendments

Fertilizers and soil amendments were discussed extensively across all five focus groups. Although a few participants mentioned using conventional fertilizers, the majority used organic practices whenever possible, even those who were not certified organic. This is consistent with findings of other small-scale vegetable growers in the Midwest that show growers using primarily organic practices, even when not certified organic (Klodd and Hoidal, 2019). Additionally, immigrant farmers face structural barriers to organic certification including land tenure, distrust of government,

cost of certification, and language barriers (Minkoff-Zern, Welsh and Ludden, 2020)

Common amendments mentioned by focus group participants were compost, fish emulsion, and commercially available composted poultry manure products. Some participants used water-soluble conventional fertilizers like urea or blended synthetic products. Fresh and composted cow and chicken manure were mentioned by farmer participants in four out of the five groups. In some cases, participants described inputs they had used without knowing what they were. For example, one participant described using 'white pellets'. Upon discussion, other farmers in the group concluded that the pellets were urea.

The most common amendments mentioned by survey respondents were (in descending order) compost and mulch, manure, and commercial organic fertilizer products. Blood meal and microbial products were less commonly used, and synthetic fertilizers were the least commonly used (Fig. 1). Other inputs included feather meal, bone meal, blood meal, crop residue, and leaves. When asked to rank their primary driver(s) for choosing inputs, respondents most often selected 'last year's crop performance' and 'soil test results' (Table 4).

When focus group participants were asked how they apply fertilizer, most said they added it directly to plants by hand, while a few applied products through drip irrigation systems or backpack sprayers. A few focus group farmers reported using plastic mulch. When this was the case, farmers relied on fertigation systems and backpack sprayers with liquified fertility products to make adjustments after the plastic had been applied.

Several focus group participants reported negative experiences sourcing or applying inputs. Two recent instances included suppliers providing 'bad' batches of potting soil or compost that were subsequently used by many farmers. Based on group discussions, it appeared these incidents damaged participants' confidence in their ability to source quality inputs.

Four farmers also shared stories about damaging or killing plants with incorrect fertilizer applications, as illustrated in the following quote:

Yeah. And I make a big mistake. I put a fertilizer on the soil to make the plant to seeding. After the plants look good, when the planted field to go on the trays, the root go bad and die, maybe 800 plant[s].

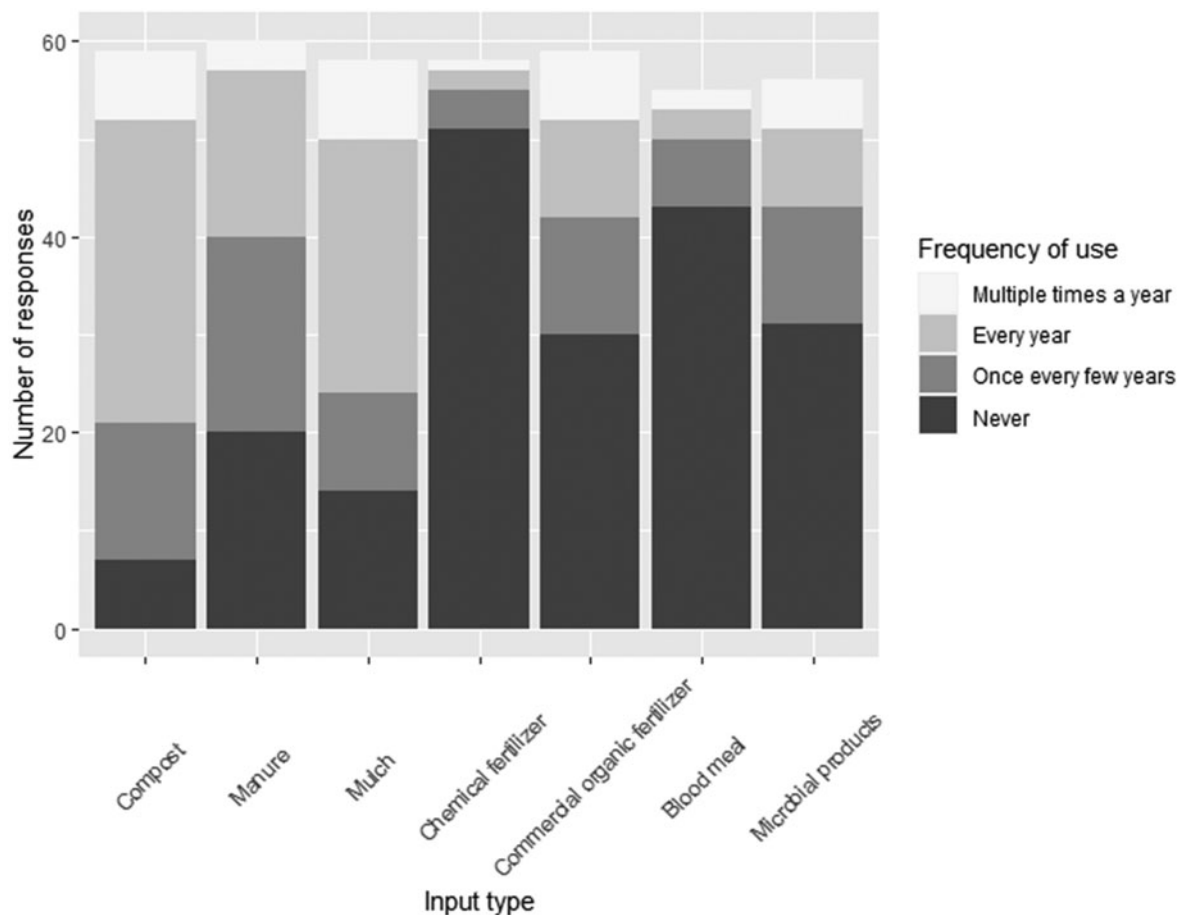


Fig. 1. Participant responses to a multiple choice question about the frequency with which they used various inputs including compost, manure (fresh or pelleted), mulch, chemical fertilizers, commercially available organic fertilizer products (e.g. Sustane), blood meal, and microbial products or compost teas. *n* = 59.

Several participants said they would like to better understand the contents of the products available to them. In particular, they expressed a need for guidance on what inputs and quantities were suitable for specific crops or soil types. Similarly, when survey respondents were asked about their main areas of concern related to nutrient management, they answered (in descending order): providing enough nutrients, building long-term fertility, and providing the correct nutrient balance (Fig. 2).

The following quotes from focus group participants illustrate the confusion of having so many product options:

So on the fertilizers, There was a specific one for tomatoes and a specific one for other vegetables...So I don't know if this one is just going for

everything. But I think that tomatoes had its own, which means that maybe there's more nitrogen that is needed for tomatoes than the other plants. And I don't know if this one has the same thing.

Because when you go read instructions on the label of what they're buying, it's usually going through by thousands of acres only. Which they're only go by like five acres...or if they only use sprays, going by five gallon or four gallons. Which you look at the instructions, it goes by hundreds of gallons.

In addition to the educational needs described above, focus group participants requested more information about personal protective equipment during fertilizer applications, and food safety requirements when using manure or other animal-based products.

Collectively, these results suggest that inputs should be a key focus for farmer outreach and education. Growers discussed knowledge gaps related to understanding nutrient concentrations of fertility sources and assessing the quality of inputs. Additionally, decisions about inputs centered primarily on visual cues, such as previous year plant performance. While visual cues may be helpful for diagnosing deficiencies, they are an insufficient tool for assessing soil chemical properties and developing nutrient management plans (O'Neill, Sprunger and Robertson, 2021; Obour et al., 2020).

Decision-making related to the use of soil health practices

Farmers in our study drew on a variety of sources for decision-making. They specifically mentioned: traditional knowledge

Table 4. Survey responses indicating decision factors regarding inputs

How do you decide what fertilizers to add to your soil? (Select all that apply)	Response count
Performance of last year's crop	28
Soil test results	23
Using the same products and quantities as the year before	16
Whatever is most easily available	12
Other	

n = 60, with multiple response options per respondent.

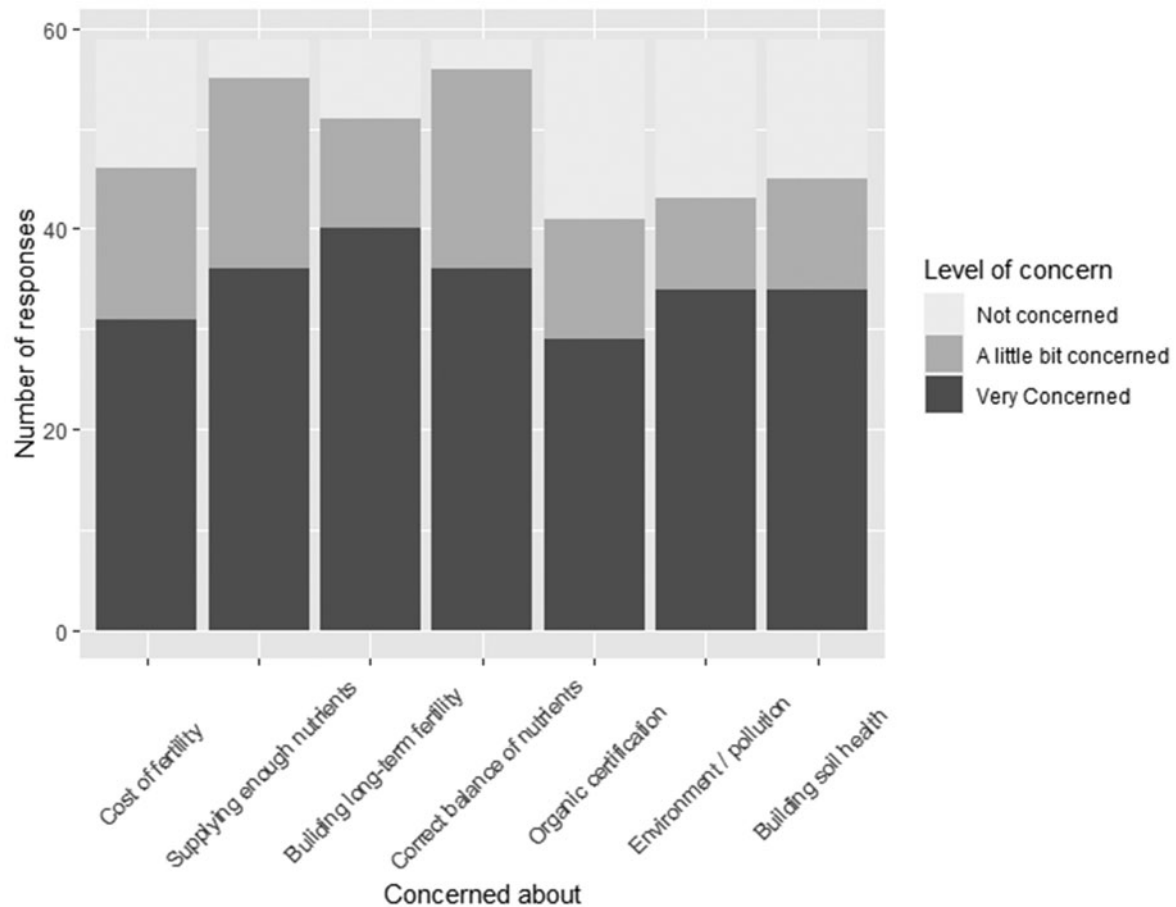


Fig. 2. Participants were asked to rate their level of concern about various aspects of nutrient management on a scale of 1–3. $n = 59$.

learned from parents or grandparents, personal experience, educational or incubator programs, YouTube, the Emerging Farmers Conference, books, and interactions with fellow farmers.

Support networks play a critical role in farmer decision-making. Focus group participants commonly farmed in communal settings where they shared insights, sought advice from one another, and collaborated with fellow farmers. Similarly, survey respondents ranked fellow farmers as the primary source of support, followed closely by farm organizations and internet searches (Table 5).

Focus group participants noted a few important and unique barriers to decision-making about soil health including organic certification, being part of an incubator farm, labor, and land tenure.

Some participants from certified organic farms felt that their options for inputs were limited. They expressed confusion about whether municipal compost could be used in certified organic systems and reported incidents of paying substantial sums of money for compost or having to ship compost from far away. These challenges are illustrated in this quote:

Municipal compost's available for free. You could go in, fill up your truck and it's amazing. And if you're certified organic... you're dependent on two main suppliers, both of whom are in Wisconsin, one of them's in Madison. They take leaves from Milwaukee and compost them and then put them on a truck and we pay \$3,000 to get them to come to our place. So limited access to a very basic, fundamental input for building soil health when you're certified organic here.

Organic certification limited farmers' ability to make their own decisions about inputs, especially in the context of incubator farms where managers often make decisions that impact individual farmers. For example, to ease the burden of recordkeeping, a farm manager at one incubator farm purchased all the fertilizer, and then distributed it to individual farmers. This led farmers in their program to feel they were not receiving training on the full range of available fertility options and took away an opportunity to practice

Table 5. Survey responses indicating where farmers learn about fertility practices and inputs

Where do you learn about what practices or fertilizers to use on your farm (select all that apply)?	Response count
Other farmers	37
Farm organizations	35
Internet searches	32
Books or other printed materials	26
Extension staff or website	26
YouTube videos	26
Farm supply store	16
Other	9

$n = 60$, with multiple response options per respondent.

sourcing and calculating inputs. This was also true in the context of non-certified organic incubator farms, where bulk purchasing was cheaper and made it easier for farm managers to maintain records. While ordering inputs in bulk cuts cost and relieves some decision-making and sourcing burden for beginning farmers, focus group participants discussed the difficulty of transitioning from a mentored situation to independent farming:

Most of my other farmers, they depend on [leader of the program] to make decisions for them. So when you move out from [the educational arm], then you are on your own.

Labor and land tenure were two other challenges that limited decision-making about soil health. Some focus group participants rent small parcels of land from larger farmers who incorporate the rented area into their large-scale tillage or fertilization programs. In one instance, a participant was restricted from using a particular fertilizer by their landlord. Conversations in three focus groups centered around land tenure and the challenge of investing in soil health without long-term land access. Two participants discussed the difficulty of starting with land that was already degraded. Another shared:

On rented land, we want to prioritize building up the soil, whether it's for us or not, but at the end of the day, it's still sometimes challenging to justify some of those costs knowing that we're not going to be there the next year...

In three focus groups, participants discussed the labor intensity and physically demanding nature of soil health practices, and the need for mechanized tools at appropriate scales. Several participants expressed interest in learning more about mechanical weed control options that could save them time and energy. They suggested educators talk openly about labor when promoting practices such as mulching or reduced tillage. One participant said it would be helpful to have grants available for soil improvement. Others expressed that managing soil health felt too complex. They felt it was an afterthought that was separate from other farming practices.

These results suggest that while incubator farms are an important resource for emerging farmers, they may need additional support to provide accessible and relevant training. Limited capacity, recordkeeping and other regulatory processes, and equipment shortages may lead staff to implement soil health practices like planting cover crops without spending the time to adequately train participants. This was less of an issue at incubator farms with dedicated educational programming and staff, but these programs could still benefit from additional staff training and support to ensure that educators are confident with the subject matter and taking time to include farmers in their processes. People in these roles should be key partners to Extension programs and should have regular access to training so they are well equipped to train farmers in their programs.

Farmers claim they learn best from one another; therefore, training managers and other key leaders in farming communities to do outreach may be an effective way to reach larger farmer audiences. This style of education (working in collaboration with farmer leaders in train-the-trainer models) is consistent with agroecological models such as the campesino-a-campesino model used by La Via Campesina, where farmers train one another in agroecological practices (Holt-Giménez, 2006). By empowering community leaders to share information through grassroots social networks, knowledge is shared horizontally,

and farmers are empowered to ask questions and learn together (Mier Terán Giménez Cacho et al., 2018). Additionally, farmers are more likely to adopt new practices introduced by communicators who share a group identity with them (BenYishay and Bobarak, 2019).

Finally, developing resources that address labor challenges and ergonomics (e.g. how to use soil health practices on different scales with scale-relevant equipment) may improve grower uptake of soil health practices. While educational programs cannot easily address land tenure challenges, focusing on low-cost and ergonomic soil health practices can support growers in these short-term programs.

Part 2: soil testing

Approximately half of focus group participants had completed a soil test at least once, often with the help of farm program staff or University personnel. Similarly, half of survey respondents had completed a soil test at least once. In some cases, farmers knew their incubator farm programs or landlords were taking soil samples but had not participated in the process themselves. Some had participated in collecting a sample with someone else but were not confident in being able to replicate it. Focus group participants who had completed soil tests said they were helpful, but only when results were accompanied by clear guidance for interpretation and next steps.

Soil testing motivation

In all focus groups, the majority of participants expressed interest in soil testing. Even those farming on rented land acknowledged the value of this practice. Farmers' motivations for soil testing included determining whether soil was contaminated with pollutants (including pesticides), determining what crops would grow best, determining which inputs to add, understanding why crops did not perform well in past seasons, deciding whether land was suitable to buy or rent, and measuring the impact of soil health practices over time. With 29% of participants based in urban areas, the focus on pollutants is not surprising. Some participants expressed interest in expanding beyond the standard suite of chemical soil tests to include more soil health and microbial measures.

Barriers to soil testing and interpretation

Among survey respondents who had completed a soil test, 62% found it very useful, 34.5% found it somewhat useful, and 3.5% did not find it useful. This suggests many growers could benefit from more education about interpreting reports.

Two barriers to soil testing were mentioned in all focus groups: cost and lack of knowledge about the process. One participant stated that cost was especially prohibitive in urban environments, where it becomes important to test for contaminants. Some were unsure about who should perform soil tests, when they should be completed, and where to send them. Multiple participants shared that in their home countries, government officials visited farms to conduct soil tests; they were therefore unfamiliar with the concept of testing soil themselves.

Educational needs related to soil testing

Focus group participants requested guidance about how to determine the size of a sample plot, what crops to grow, and what actions to take based on soil test results, interpreting results in organic systems, and tracking soil trends over time. Participants also emphasized the importance of practicality, affordability,

and accessibility. Some expressed the need for better recommendations for culturally relevant crops, such as African greens. Many also requested access to one-on-one consultations that would help them understand test results and make a management plan. This is reflected in the following quote:

They told me a lot of number[s], and I was like, 'Is that good? Just tell me. Is that good?'

One open-ended survey question asked respondents what they hoped to learn from soil tests. Responses were coded into the following categories, with the number of responses in each category noted in parenthesis: how to do a soil test (11), which amendments to apply (11), determining which nutrients are already present (8), what to grow (6), quantity of inputs to apply (5), assessing soil health (3), how to improve soil health (3), determining soil structure (3), determining physical properties (3), preventing runoff (2), safely applying manure (2), biological properties (1), and determining whether toxins are present (1). Six respondents wrote 'everything'.

These results suggest that while simple educational outreach about how to conduct a soil test and what to test for would be valuable, it should be paired with in-depth training about how to make meaning from soil test results. The variable nature of farms and the need for tailored advice supports the development of train-the-trainer educational models to build capacity for one-on-one support of emerging farmers growing in complex farming systems (many crops, primarily organic inputs, small plot sizes, etc.).

Part 3: learning styles and goals

Preferred learning styles

Focus group participants expressed a need for resources with examples specific to their farming situation, including the scale and region of their farm, the crops they grow, and their organic certification status. Hands-on learning and on-farm demonstrations were discussed as the best form of learning in all five focus groups. This aligned with survey results where respondents prioritized one-on-one discussions over small, and especially large group discussions. They also preferred hands-on workshops over educational videos and written materials (Table 6). This is consistent with preferences shared by Latino immigrant farmers in Minnesota and Wisconsin (Wauters and Hoidal, 2022), but differed from a 2019 needs assessment of mostly white, English-speaking Minnesota fruit and vegetable farmers who preferred webpages, videos, newsletters, and printed guides (Klodd and Hoidal, 2019).

Focus group participants were especially interested in learning from other farmers who have successfully implemented soil health practices. A few suggested that field days held throughout the growing season helped them learn about soil at various stages. This type of networked learning has been shown to increase the degree to which management options are learned and practiced among farmers (Asprooth, Norton and Galt, 2023), leading to enhanced adoption across communities of interest. A quote from one participant exemplifies this concept:

I would say I learn best when people are hands-on right next to you and you're both doing it together.

Although participants expressed interest in this type of learning, they were concerned about finding time to attend field days and other hands-on learning events during the season.

Table 6. Survey responses indicating grower preferences for different types of learning styles

Learning style	Mean rating	Standard deviation
One-to-one discussions	4.25	1.33
Small group discussions	4.21	1.21
Large group discussions	3.67	1.43
Hands-on workshop	4.27	1.42
Educational videos	4.21	1.20
Written materials with photos and illustrations	4.11	1.35

Each participant ranked each learning style on a 1–5 scale (1 = not helpful at all, 5 = very helpful). Mean rating and standard deviation are reported for each learning style.

Extension has made efforts to work around farmers' busy summer schedule by hosting evening and weekend events; however, many participants said they have competing obligations on the weekends (e.g. attending church) and other work to do in the evening. One quote summarizes this:

I always feel like the catch-22 is that I want hands-on stuff...but typically the way to make that happen is to do it in the summer, and then summer rolls around, and then I'm like 'Oh, I'm too busy. I can't go to that right now.'

Participants in every focus group expressed a desire to engage with a larger community that could learn together. The need for support from peer cohorts and mentorship or coaching relationships was mentioned regularly, and participants continually stressed the value of learning from other farmers. Farmers in two focus groups said they wanted more connection with research, including collaborative on-farm demonstrations with researchers and other farmers. These participants requested that researchers who visit farms for trials or to provide technical assistance take time to explain what they are doing and involve growers. They also requested that research results be made readily available through video or other accessible formats.

These findings provide strong evidence that practitioners and educators may best support farmers by increasing their use of peer-cohorts and networks to encourage sharing of knowledge and experiences. Cohort-style or social-network-based learning environments have been successful in leading growers to adopt agroecological practices in other contexts (BenYishay and Mobarak, 2019; Warner, 2006).

Focus group participants also used learning tools such as video content and printed materials. YouTube was identified as a tool in all focus groups. Many participants also expressed appreciation for printed fact sheets and infographics, especially when paired with a hands-on learning experience. Unfortunately, language presented a significant barrier to accessible video and print resources. Participants reported that these tools, and other important tools such as pesticide labels, are often not available in their native language. Furthermore, several participants did not have computers, and were therefore limited to tools that could be accessed on a small phone screen. Participants shared that educational videos and product instructions are not always targeted to small-scale growers; one farmer noted that this is part of a broader issue of equity for farmers of color.

Another frequently cited barrier was the expense of educational offerings. Participants listed several cost-prohibitive examples such

as: master gardener programs, permaculture training, and ‘master-class’ offerings. Participants stressed the importance of cost accessible learning opportunities for emerging farmers.

Therefore, educational programs for emerging farmers should be cost accessible, available in a variety of formats and languages, tailored to the scale of the growers participating, and framed around peer learning opportunities. As often as possible, they should include one-on-one mentorship opportunities and hands-on learning.

Conclusions

While our findings cannot speak for all beginning or emerging farmers, we believe that the recommendations from this study can inform the development of educational tools and programs for incubator and educational farms as well as outreach programs focused on soil health concepts. In particular, these recommendations are for growers who tend to use organic practices, growers with limited formal training in soil health and nutrient management, and those with farming experiences in other countries adapting their practices to a US farming context. By applying these concepts to the development of educational programs, we hope that growers will be better supported in farming in a way that promotes improved plant health, reduced input costs, reduced externalities such as pollution from the over-application of fertilizer, and more supportive, beneficial relationships between emerging farmers and technical service providers. Focus group participants and survey respondents expressed a high degree of motivation to learn about soil health and nutrient management and sought support to translate these concepts into concrete management actions. Due to the heterogeneity of emerging farmers and their farming systems, farmers may benefit from one-on-one interactions with mentors, educators, and peers, and the opportunity to ask questions and receive guidance specific to their own farm.

Farmers in our study were very familiar with visual and tactile observations of soil including soil texture, color, and structure; however, they were less familiar with the chemical properties of soil and interpreting soil test results. Only half had completed a soil test, and many were confused about who was responsible for testing soil and which tests were most appropriate. There is a particular need for educational materials related to inputs, particularly in organic systems where nutrient sources are not clearly labeled, and for clarifying terminology and regulations related to compost and composted manure. Farmers in our study sought concrete and tailored advice about fertility needs for specific crops, appropriate inputs to meet crop needs, suggestions for where to purchase inputs, and guidance on how much to apply and when.

Many growers in our study were part of incubator farms that supported emerging farmers. While these programs were extremely helpful for land access and mentorship, they also created bottlenecks where specific people in each farmer community were the primary source of information. Furthermore, these incubator programs commonly lacked the capacity, funding, or expertise to fully meet the educational needs of participants, even when some educational opportunities were provided. To address these critical challenges, we recommend training and support for community leaders, educational program staff, and informal peer mentors who support emerging farmers. A train-the-trainer model allows educators to increase their reach, and builds capacity for farm-specific, one-on-one support and relationship building.

Aside from one-on-one mentorship, farmers in our study preferred a variety of learning formats. There was consensus that

in-person, on-farm events were valuable; however, farmers were not always able to access or attend this type of event. Collectively, our data suggest that training for community leaders should be supplemented by programs and tools in a variety of formats, including field days, videos, hands-on activities, and fact sheets. These tools should be available in a variety of languages, and the content should be specific to small-scale diversified production. Additionally, educational outreach should explicitly address labor requirements and costs when promoting or comparing practices like cover crop seeding and termination methods, reduced tillage methods, and new equipment.

Regardless of the format, farmers found value in peer-to-peer learning. Not only can farmers learn from each other, educators have much to learn from farmers. Cohort learning models should be considered in order to foster relationships between growers and community leaders. When cohort or co-learning models are not possible, educators should build opportunities for dialogue and hands-on activities into their outreach.

Our final recommendation is to create soil health resources that use the language farmers use. Many emerging farmers have experience in systems that are very different from the Upper Midwest. While a farmer may not have used cover crops, they may have experience letting the land rest through fallow periods. Using terminology familiar to emerging farmers when creating soil health resources acknowledges farmer expertise, and ensures these resources are relevant to the user.

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