Science Societies

Soil microbes for agriculture: Enhancing resources for farmer outreach

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Farmers need practical information about soil microbes and their impacts on agricultural systems, and in-person field days are an important tool for communication. Photo courtesy of Flickr/K-State Research and Extension. Courtesy of this Creative Commons license (https://creativecommons.org/licenses/by/2.0/).

Soil microbes perform important agronomic services such as breaking down crop residues, recycling nutrients, improving soil structure, and supporting plant growth (Kaminsky et al., **2021**; Neher et al., **2022**). As more farmers recognize the importance of these services and aim to incorporate them in farm management strategies, they need practical information about soil microbes and their impacts on agricultural systems. Although farmers are aware that soil microbial activities can improve soil health and crop performance, the invisibility of soil microbes and their functions makes it difficult to convey their impacts (Isbell et al., **2021**). As a result, extension practitioners and other agricultural service providers often struggle to describe how management affects soil microbes and vice versa in farmer-based education programs.

Sales of microbial products in the agricultural industry are expected to nearly double from $US6 billion to $US11.6 billion by 2025 (Markets and Markets, **2020**). While more commercial products that contain microbes are being marketed to farmers, some companies are offering soil microbiome analysis services of uncertain utility in farmer decision-making. Additionally, the goals of improving soil quality and sequestering carbon using regenerative agricultural practices are being heavily promoted in the public sector (Bossio et al., **2020**; LaCanne & Lundgren, **2018**). It is important that farmers have access to valid, meaningful, and cost-effective information to make appropriate management decisions. Extension and other outreach professionals also need suitable resources to inform farmers interested in attaining the emergent soil properties that indicate robust soil biological activity.

To learn whether and how service providers inform farmers about soil microbes, we conducted a survey-based study. Our objectives were to identify common challenges faced by service providers when communicating with farmers about soil microbes and

the kinds of resources they would find useful.

Qualtrics survey software was used to develop an online questionnaire for distribution to known groups of professionals who provide farmer-based educational programs focused on soil health management. Service provider groups included those from University Cooperative Extension, USDA-NRCS, soil and water conservation districts, non-profit organizations, crop consultants, and professionals associated with ASA's Soil Health Community and SSSA's Soil Biology and Biochemistry Division. Email or digital platforms were used to distribute an invitation to known groups inviting them to participate using the questionnaire link. Participation was voluntary.

The questionnaire consisted of 10 questions (Table 1), six of which were multiple choice and four write-in.

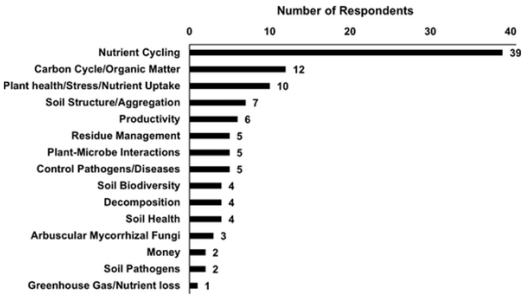
Table 1. Questions from the questionnaire and their format types

Q1	Check the description that best describes you professionally. (Check one)
Q2	How often do you communicate with farmers or service providers about soil microbes? (Check one)
Q3	Do you feel like you have effectively communicated the importance of soil microbes to farmers or service providers? (Check one)
Q4	Explain what soil microbe topic(s) you were communicating and how you knew that the farmer or service providers comprehended the information. (Write-in)
Q5	What do you think are important agricultural functions that soil microbes perform? (Write-in)
Q6	Which agricultural function performed by soil microbes do you think is the most important for farmers or service providers to be aware of? (Write-in)
Q7	What do you find challenging when communicating information about soil microbes to farmers or service providers? (Check all that apply)
Q8	Is there anything else that you would like to share with us regarding your experiences, or lack of, communicating information about soil microbes with farmers or service providers? (Write-in)
Q9	What resources have helped you communicate information about soil microbes with farmers or service providers? (Check all that apply)
Q10	What resources do you wish you had more of that could improve how you communicate information about soil microbes to farmers or service providers? (Check all that apply)

Demographic Profile

In total, there were 91 respondents to the questionnaire. For Question 1, 31 respondents identified as research scientists, 30 as extension faculty/staff, 13 as graduate students, 10 as industry professionals, and seven as other professionals. Those identifying as "other professionals" included five working for the USDA-NRCS or soil and water conservation districts, one crop consultant, and one laboratory staff member.

Questions 2 through 5 addressed the respondents' own experiences with communicating information about soil microbes with farmers and other service providers. Forty-two respondents stated that they communicated with farmers or service providers about soil microbes several times per year, 18 respondents communicated monthly, 15 respondents communicated once per year, 13 respondents communicated weekly, and three respondents stated that they have not discussed soil microbes with farmers or service providers. Thirty-nine respondents stated that they felt "unsure" that they had effectively communicated the importance of soil microbes to farmers or service providers while 33 respondents stated "yes," 16 stated "no," and three stated, "does not apply." The three main topics respondents communicated with farmers or service providers about were nutrient cycling, [farm] management impacts on soil microbes, and microbial diversity/functions. Twenty respondents stated that they knew when information was comprehended because farmers or service providers asked appropriate questions or had quality discussions, and four respondents said they used a survey to assess comprehension.



Most Important Agricultural Function

Nutrient cycling (especially nitrogen and phosphorus) was identified by 39 respondents as the most important function that farmers or service providers should be aware of (Figure 1). The next most important function was carbon cycling and building organic matter with 12 responses. Alleviation of plant stress and aiding in plant nutrient acquisition was the third most important function identified by 10 respondents. Functions related to suppressing or causing plant diseases, soil health, and greenhouse gas emissions/nutrient losses were noted but had fewer responses.

Figure 1, *Questionnaire responses to the write-in question, "Which agricultural function performed by soil microbes do you think is the most important for farmers or service providers to be aware of?" Respondents were not limited to a single response.*

Biggest Communication Challenge

More than half of the respondents indicated that communicating information about soil microbes to farmers or other service providers was challenging due to lack of information relating management practices to soil microbes (52) and use of scientific jargon (49) (Table 2). Thirty-four respondents said that they were unsure what information should be communicated with farmers or service providers. Only 12 respondents said that they faced challenges because they did not have formal training or education in soil microbiology. Several respondents (11) noted that farmers or other service providers did not show an interest in soil microbes, and seven indicated that they had not had an opportunity to discuss soil microbes with farmers or other service providers.

Table 2. Questionnaire responses to the "check all that apply" question "What do you find challenging when communicating information about soil microbes to farmers or service providers?"

Challenges respondents have faced	Number of respondents
Difficult to relate soil microbes to management practices	52
Scientific jargon makes communication difficult	49
Unsure what information should be communicated	34
Other (please explain)	29
I have no formal training in soil microbiology	12
Farmers/service providers not interested in soil microbes	11
Have not had an opportunity	7

Of the 29 write-in responses under "Other" in Table 2, nine highlighted soil and microbial variability. Another eight respondents answered that farmers had incorrect information or lacked a basic understanding of soil microbes. Difficulty relating soil microbes with short-term management or soil health was mentioned by six respondents, and another six mentioned the lack of applicable examples of use in demonstrations or at field days.

To further explore difficulties faced by respondents when communicating information about the benefits of soil microbes, an option was provided to share anything else about their experiences. Approximately 36 of the 91 respondents wrote in answers to this question. Thirteen respondents indicated a lack of resources aimed at non-academic audiences, and another three indicated that on-farm visuals and demonstrations are needed. Insufficient knowledge of how management impacts soil

microbiomes was mentioned by 11 respondents. Nine respondents said that farmers have expressed interest in understanding soil microbes and their communities, and seven respondents suggested that research should focus on areas that are of interest to farmers. Other responses indicated concerns about efficacy and economics of commercial products, a lack of basic understanding by farmers about soil biology, and limited opportunities for farmer engagement.

Helpful Resources for Service Providers

Respondents were asked about resources that they have found helpful in the past and what resources they wish they had more of when communicating information about soil microbes (Figure 2). The top three resources that respondents had used and considered helpful were in-person events, images/photos/infographics, and extension articles or factsheets.

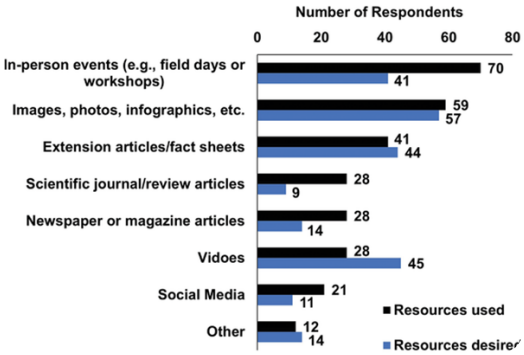


Figure 2, *Questionnaire responses to the check-all-that-apply questions, "What resources have you found helpful when communicating information about soil microbes to farmers or service providers?" (black colored bars) and "What resources do you wish you had more of that could improve how you communicate information about soil microbes to farmers or service providers?" (blue colored bars).*

Accordingly, the top three resources that respondents wanted more of were:

1. Images, photos, infographics, etc.
2. Videos.
3. Extension articles and factsheets.

Other responses to the question about what resources respondents wanted more of essentially fell into two main categories that included the need for more compelling and clearly communicated data as well as demonstrations that help farmers and service providers visualize soil microbes, especially in a farm setting.

Recommendations for specific products included prepared PowerPoint presentations for use at crop days and farmer meetings, decision support tools, and curriculum-based activities that support experiential learning in farmer-focused programs, especially as they related to the role of soil microbes in nutrient cycling. A research-focused area of need identified by one respondent was the provision of information to farmers about specific soil health tests.

Conclusions

The two most common themes identified from questionnaire responses were (1) lack of understanding of how soil management impacts soil microbes and (2) need for resources aimed at educating non-scientific audiences that include farmers as well as other agricultural service providers. Creating content that features management effects on soil microbes and their functions should be a priority. This content would be best focused on nutrient cycling and building soil organic matter, which were the functions identified by respondents as most important, and should include products like images, photos and infographics, videos, and extension factsheets. Because in-person field days, workshops, and direct communication with farmers have been identified as important methods for communication, products or information that can be used to enhance field demonstrations, hands-on activities, or to support presentations would be most useful. To this end, an open-source database about soil microbes accessible to agricultural service providers would satisfy an important demand in the agricultural community.

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Acknowledgments

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Dig deeper

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