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A Soil Health Needs Assessment Survey in Arizona

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Abstract

A needs assessment survey is an important tool for designing an efficient research-based extension and outreach plan. The Soil Health Research and Extension (SHRE) team at the University of Arizona designed and conducted a statewide soil health needs assessment survey to document stakeholder perceptions, interests, and expectations on soil health research and educational needs. The survey successfully documented essential information from a diverse group of producers, pest control advisors, and other industry members (total respondents 107) that represented the commercial agricultural industry in Arizona. The data confirmed stakeholder interest in soil health research and educational programs and provided the necessary information on their soil health needs to build an effective research-based soil health extension program. The survey outcomes revealed that the respondents are majorly interested in on-farm soil health assessments and learning about soil biology. The respondents also indicated that research demonstrations, workshops, and training events are important to them in adopting new technologies for soil health improvements.

Introduction

The United States Desert Southwest is an agriculturally diverse area known to produce many different agricultural commodities and specialty crops, and Arizona is the primary contributor to the agricultural gross domestic product (AZDA 2018; Hait 2021). In Yuma County alone, there are approximately 180,000 acres dedicated to agriculture, with most growers producing multiple crops a year on the same land. In doing so, they are effectively raising annual production levels to over 230,000 acres a year, generating $1.14 billion of annual revenue on the agricultural census taken five years ago (NASS, 2017). Maricopa County, on the other hand, generates a ~$1.2 billion revenue from farming, with more than 1,800 active farms (AgCensus NASS 2017). However, the prolonged drought coupled with increasing water scarcity in this region has necessitated growers to improve soil health for water conservation and higher crop productivity (Nabhan et al. 2023).

The University of Arizona Cooperative Extension team(UACE) is tasked with providing educational offerings to the agricultural stakeholders in the state of Arizona, so growers and industry can make well-informed decisions that lead to the best management practices (BMPs). A 'needs assessment survey' (NAS) is a crucial tool to identify stakeholder needs, concerns, and interests. Two previous NASs circulated by the UACE indicated a high level of desire for more Soil Health research and extension (Masson, 2020; Community Research, Evaluation & Development (CRED) Team, January 2023). Therefore, to construct an effective soil health research and extension (SHRE) plan, a NAS was crafted and circulated to agricultural stakeholders and the survey outcomes are summarized in this article. The objective of this NAS is to gather information on specific soil health needs and priorities of agricultural stakeholders in Arizona, guiding the soil health research and extension program to craft and conduct effective research and extension activities. Soil health is distinct from soil quality and is majorly defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans, though it can be defined in many different ways (Acton et al. 1995; Kibblewhite et al. 2008; Lal 2016; Lehmann et al. 2020). The approaches to improve soil health in any commercial agricultural operation, therefore, can be very specific to the stakeholder goals and resources available. Hence, it was necessary for the SHRE team to understand stakeholder perceptions and expectations in Arizona in order to design better research and educational programs. This article summarizes stakeholders' needs and interests in a research-based soil health extension program in Arizona.

Materials and Methods

Survey description

A fourteen-question survey was developed in the spring of 2022 and disseminated to agricultural stakeholders in Arizona. The survey included initial questions regarding background information about the stakeholders' operations, such as operational locations, length of agricultural experience, operation size (acreage), production methods, and crops grown. The survey then asked for critical information related to the stakeholders' perceptions and existing knowledge of soil health as they describe the barriers to soil health management, the importance of soil health, the most important soil health features, and current soil health approaches in their operations. To conclude the survey, the survey-takers were asked about their soil health extension and/or research needs and their willingness to collaborate with the SHRE team at the University of Arizona to pursue future soil health projects.

Survey distribution and target group

The survey was circulated to the stakeholders via email newsletters moderated by UACE representatives with more than 5,000 recipients, and was additionally provided at eight in-person educational workshops in Arizona, two meetings in Imperial Valley, California, and during many one-on-one stakeholder meetings across the state of Arizona. The NAS was distributed using an online format (Qualtrics, March 2022) and printed copies. The survey was initiated on March 7, 2022, and stakeholder responses were recorded until June 30, 2022. All agricultural stakeholders were requested to take this survey to understand the diverse soil health needs in the state of Arizona; a total of 107 responses were collected during this survey, with all responses coming from commercial growers.

Data collection and analyses

Survey respondents were allowed to enter multiple responses to several of the questions in order to account for the possibility of multiple responses. Statistical analysis was adjusted to reflect the proportion of respondents who selected each option. For example, in question 1, *What are the locations of your farming operations?*, if 100 people took the survey, it would be possible to receive the answer Yuma 100 times and Maricopa 100 times, because 100 people could have operations both in Yuma and Maricopa counties; in this case, both locations would be reported at 100%. This is calculated by summing the responses for each option and dividing by the number of participants (100), instead of the total number of responses (200). It is important to note that for questions with multiple answers, individual percentage values cannot be summed across responses, as they will produce values higher than 100%; each category must be interpreted as a comparison of the individual category to the whole. In preparation for the diagrammatic representation of data, we used tools on Qualtrics and/or MS Excel. The figure showing the farm locations of the survey-takers (Figure 1) was created using tools available in Google Maps (www.google.com/mymaps).

Figure 1. Geospatial distribution of farm operational areas of all survey respondents; each star depicts a single location

Demographics of Survey Respondents

The majority of respondents were clustered into three regions: (1) within 70 miles of the Colorado River, in Yuma County, AZ, and Imperial County, CA, (2) within a 100-mile radius of Phoenix, AZ in the center of the state, and (3) a smaller group within 60 miles of Tucson, AZ in South-Central AZ; 18% of people reported working in multiple regions (Figure 1). Most respondents (53%) had been farming for over 20 years, while 14% of respondents were beginner farmers with less than five years of experience. Majority of the respondents (57%) operated on large farms that operate on over 1,000 acres, while almost one-fifth (19%) of the respondents operated on farms with less than 10 acres. This data on respondent demographics strengthens the survey outcomes by concentrating information from growers with a diverse range of experience and operation sizes, indicating representation from diverse agricultural stakeholders around the state.

Production systems and crop types

Arizona growers historically practiced conventional agriculture, but in recent years, organic agriculture has gained increasing attention due to higher commodity values and increasing demand for organically grown commodities (Bonin 2022). Many growers also practice organic farming for soil health improvement (Reeves et al. 2016). Our survey revealed that conventional agriculture was practiced by a majority of the respondents (75%). However, almost one-third of the respondents (35%) were also practicing or transitioning to organic farming (Figure

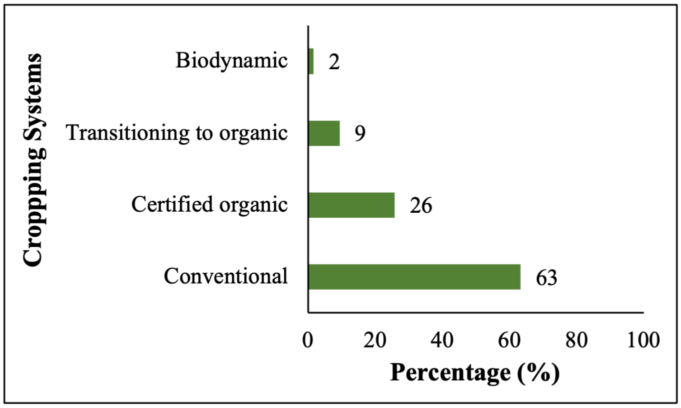

Figure 2. Bar diagrams representing the number of respondents that operate on different production systems (total responses 107)

2); only growers operating on fewer than 10 acres of land have biodynamic systems (data not shown). This survey was successful in including producers growing major crops in the state of Arizona. The majority of the respondents grew wheat, alfalfa, and vegetables (56%), followed closely by leafy greens, cotton, and hay (~ 40-45%). The survey also included respondents growing fruit crops (24%), tree nuts (10%), indigenous crops (7%), and managing pasture (19%).

Barriers to agricultural production

In order to design successful soil health improvement plans, one must first identify the factors that can prevent the adoption of new technologies or approaches. According to our survey, the largest barrier in commercial agricultural production was water (67% of the responses), followed by skilled labor shortages (48% of the responses). Additionally, pests, arid soil chemistry (salts and pH), market forces, and land availability (41%, 39%, 29%, and 28% of the responses, respectively) were identified as major barriers to adoption. A comparatively smaller group of growers (9%) thought that more research and extension could help them boost crop productivity (Figure 3). The SHRE team acknowledges that it is necessary to consider these barriers while designing soil health research demonstrations and extension programs. The challenges with the shortage of labor might change as the adverse impacts of the COVID pandemic fade away, but soils in Arizona may still have high pH, high sodium concentration, and an abundance of calcium carbonate deposits (also known as 'caliche') (Stuart et al. 1973).

Results and Discussion

Need for a Soil Health Research and Extension Program

Primarily, it was necessary to know how much the growers prioritize soil health in their operations. The survey takers were asked to provide ranks between 0 and 10, with 0 being the lowest priority in their operations and 10 being the highest priority in their operations. 38% of the respondents ranked soil health 10 out of 10, 67% of the respondents ranked soil health above 8, and 98% of respondents ranked soil health above 5, indicating soil health as one of their top priorities in agricultural operations. Interestingly, most respondents operating on smaller acreages ranked soil health as their top priority (10/10), while the majority of respondents operating on larger acreages (>1000 acres) have ranked soil health below 10 (data not presented). This outcome matched with findings reported by Mpanga et al. (2021) that detailed information on the adoption of regenerative practices by small-scale growers. Most respondents valued increased soil fertility (72%) as the most important soil health goal, followed by water conservation (59%) and improved crop productivity (55%) (Figure 4). Surprisingly, less than half of the respondents (45%) think of financial gain as one of the major soil health goals, which indicates a progressive mindset and the industries' motivation towards soil improvements. Environmental stewardship, pest management, and reduced chemical usage are also included in the list of soil health goals but ranked much lower. This outcome emphasizes that growers expect healthy soils to provide optimum plant nutrition that can be translated into increased crop productivity (Sainju et al. 2022). Especially, when the fertilizer prices skyrocketed in 2022, growers were looking for ways to improve soil

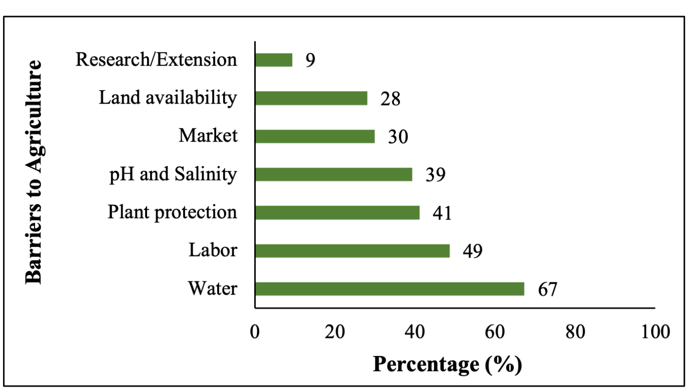

Figure 3. A bar diagram showing the major barriers to commercial agricultural production in Arizona (total responses 107)

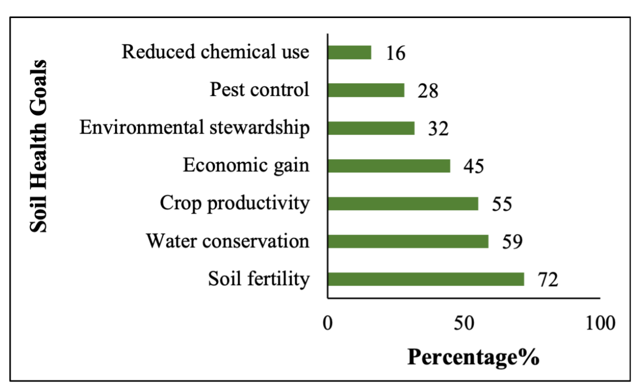

Figure 4. Data indicating the most important soil health goals in their operations as voted by the respondents (total responses 107)

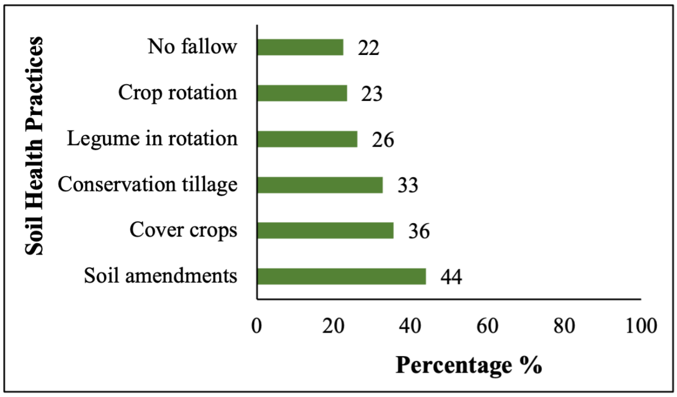

Figure 5. Current soil health practices in Arizona agriculture

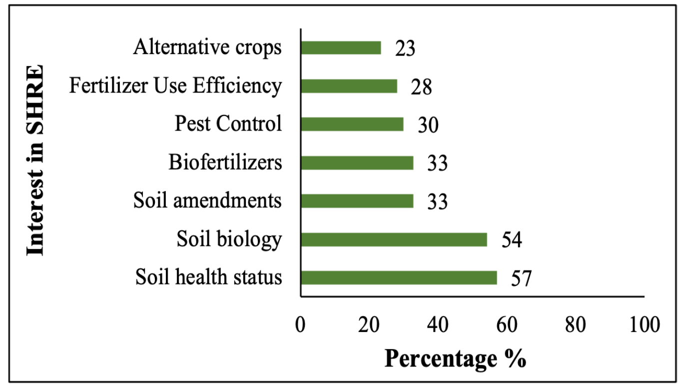

Figure 6. Soil health applied research interests as identified by stakeholders

fertility without investing much in synthetic fertilizers (Hederbrand and Debucquet 2023). Improving soil biology is another major basis for improving soil health and crop productivity, and with many growers have acknowledged this. Little knowledge exists in this scientific domain, as measuring soil biological processes is complex, and we lack information on suitable technologies to improve soil biological functions, especially in arid regions like Arizona (Naorem et al. 2023). These findings should guide future SHRE programs in the state of Arizona as identified by the agricultural industry representatives.

Existing soil health practices on commercial farms

Many growers already adopted several soil health management approaches in their operations. Most respondents use organic soil amendments like compost or manure (44%) followed by cover crops (36%), and conservation tillage (33%). Growers also include legume crops in rotation (26%) with grassy cash crops and practice a diverse crop rotation (23%) by including more than three crops in a single rotation. Almost one-fifth (22%) of the respondents do not practice land fallowing, which means majority of the respondents still use fallowing strategy to economize water use. (Figure 5). These outcomes are interesting, as more than 20% of the respondents are using at least one tool to improve soil health in their operations. This indicates that there has been more interest in and adoption of soil health practices in the last decade (Bowman et al. 2016). Therefore, it is essential for the SHRE team to work collaboratively with the growers to remove barriers, thus allowing for an increased rate of adoption of soil health tools in commercial agriculture. It might also be crucial to modify some of these tools for irrigated desert environments. For example, how might one implement using cover crops in Arizona where water is limited? Can we practice green manuring using cover crops while still being profitable? Or do we need alternative purposes for the cover crops (Sanyal et al. 2023)? These discussions should happen between the stakeholders and the SHRE team.

Interests in Specific Soil Health Research and Extension

Soil health has been identified as a priority for a sustainable commercial agricultural system (Tahat et al. 2020). From the survey it is evident that growers in Arizona are very interested in soil health approaches, as they grow high-value food crops like vegetables, leafy greens, and fruits (Frisvold et al., 2018; Palumbo et al., 2010), requiring healthy soils to produce uniform, high-quality crops. However, there is a paucity of information on how stakeholders' opinions on SHRE activities can be integrated into designing a region-wide soil health program. One of the feasible options is to survey stakeholders and gauge their interests in soil health related topics. Our survey revealed that the majority of respondents were interested in on-farm soil health assessments (57%) and learning more about soil biology (54%). There was also a great deal of interest in research evaluating soil health products (33%), (Figure 6). This is evident from existing reports that in desert agro-environments, field-scale soil health assessments are lacking, and there's no such protocol that is applicable globally (Hughes et al. 2023). Growers in Arizona are interested in understanding soil health status in their operations, which necessitates SHRE conducting on-farm soil health assessments that might guide future management decisions in commercial agriculture.

Extension and outreach activities should be conducted to educate the growers on soil health indicators. Most respondents were interested in research demonstrations, workshops, and training events (53%). The respondents also expressed the desire for a one-on-one consultations with extension specialists and education through webinars, farm tours, and conferences (30-33%) (data not presented). It should be noted that existing information on soil health indicators and assessment protocols may not be applicable to the agroecosystems of Arizona due to climatic conditions, diverse cash crops, and water scarcity and quality that is predominant in this region. Therefore, the demonstration of soil health research and associated extension and outreach activities should be prioritized by the SHRE team.

The University of Arizona SHRE team designed this survey to gauge stakeholders' needs and expectations toward a statewide soil health research-based extension program. It is crucial to integrate stakeholder perceptions and interests into a statewide extension program that would fit stakeholder needs. All survey participants were involved in agriculture, and the ballot culling ensured survey results represented the thoughts of those who would benefit the most from regional education. Our survey showed several essential pieces of information for the SHRE team to work on in the future. As discussed earlier, soil health was found to be highly desired by the agricultural industries, but solutions on how to bring it about weren't entirely clear. The majority of existing reports on successful soil health approaches in regions receiving higher precipitation with a cooler climate may not fit well into the agricultural production systems of Arizona, a state currently facing a 23-year-long mega-drought (Mitchell et al. 2017; Nunes et al. 2018; Farmaha et al. 2022; Migoya 2023). For example, cover crops have been recommended as an essential tool to improve soil health, even in irrigated cropping systems (Ghimire et al., 2019; Idowu et al., 2019); however, the recent water-budget situation is posing a challenge to practicing green manuring cover crops, as producers struggle to have enough irrigation water for their cash crops (Nabhan et al., 2023). Therefore, it is necessary to modify the purposes of soil health tools such as cover crops to harvest cover cropping benefits in commercial agricultural systems (Sanyal et al. 2023). Another traditional solution that would need to be modified involves livestock integration, composted manure, and other Biological Soil Amendments of Animal Origins (BSAAO). Though these strategies are historically successful in boosting soil health, they are highly regulated by the desert leafy green and vegetable industry food safety groups as a source of potential biological contamination (Rayne et al. 2020; Urra et al. 2019). The Yuma production region in particular follows strict guidelines enforced by the Food and Drug Administration (FDA) Food Safety Modernization Act (FSMA), and privately organized Leafy Greens Marketing Agreement (LGMA) to maintain good compost manufacturing, handling, and application practices designed to limit biological food-borne contamination (FDA, 2023; LGMA, 2023). Additionally, there are concerns over recently introduced LGMA regulations requiring potable irrigation water to be used near leafy green harvest operations, commonly requiring the use of harsh sanitizers like chlorine or peracetic acid (PAA) (Dery et al. 2020, 2021). However, our survey indicated a strong interest in using organic soil amendments (Figure 5,6), therefore, the SHRE team should innovate a solution (Medyńska-Juraszek et al. 2020) and conduct on-farm research trials to reap benefits from organic amendments.

Conclusion

The needs assessment survey (NAS) outcomes were essential in chalking out the applied soil health research and extension needs in the state of Arizona. We identified that soil health is indeed a major priority among the stakeholders, especially those who are operating on smaller acreages, probably because it is easier to adopt new technologies on a smaller scale. Additionally, the survey takers have provided their opinions on several topics of applied soil health research such as measuring existing soil health status or knowing soil biological processes. The respondents also indicated that they would prefer research demonstrations, workshops, and training events to learn more about the effective adoption of best management practices to improve soil health. Overall, outcomes from this NAS provided us with essential information to carve a path for future research-based extension programs for soil health improvement in the agroecosystems of Arizona.

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