ORGANIC FARMING RESEARCH FOUNDATION

Organic Farming Research Foundation
303 Potrero Street, Suite 29-203
Santa Cruz, CA 95060

May 9, 2020

Dr. David Knaebel
National Program Leader - Soil Biology
USDA – Agricultural Research Service
5601 Sunnyside Avenue, Ron 4-2290
Beltsville, MD 20705

Dear Dr. Knaebel:

Thank you for the opportunity to participate in the excellent May 7 listening session, and to provide written input on the 2021-25 five-year action plan for National Program 212 Soil and Air. On behalf of the Organic Farming Research Foundation (OFRF, https://ofrf.org), I would like to offer the following comments and recommendations.

Introduction and Context

OFRF works nationwide to foster the improvement and widespread adoption of organic farming systems through research, education, and federal policies that bring more farmers and acreage into organic production. Since 1992, OFRF has awarded more than 300 small grants to producers, university researchers, and other agricultural professionals to explore and develop new and innovative approaches to crop, livestock, soil, water, nutrient, pest, and weed management within the context of USDA certified organic production systems. Many OFRF-funded projects serve as initial "proof of concept" trials leading to larger research endeavors funded through USDA extramural (NIFA), intramural (ARS), or other sources, and ultimately to valuable practical applications.

Every five years, OFRF assesses current organic farmer research needs to update its National Organic Research Agenda (NORA). The 2016 NORA, based on surveys and listening sessions with nearly 2,000 certified organic farmers, reports that 74% of respondents rated *soil health* as a "high priority" for additional research, while 66% cited soil fertility and nutrient management (Jerkins and Ory, 2016). Soil health ranked highest among respondents from all four major USDA agricultural regions, ranging from 71% in the Western region to 79% in the Southern region. Respondents also cited climate change as a high (34%) or moderate (42%) priority, and extreme weather events since the report's publication have further elevated climate resilience and climate mitigation as urgent research and practical issues for organic producers.

OFRF has conducted an extensive review of the past 18 years of organic agricultural research funded through two NIFA programs, the Organic Research and Extension Initiative (OREI) and

Organic Transitions Program (ORG). Our review of the many valuable OREI and ORG project outcomes provided the basis for OFRF's series of practical farmers' guidebooks on Soil Health and Organic Farming, and additional guides on risk reduction and agricultural resilience (reports available at https://ofrf.org/research/reports/). Topics addressed include *Organic Practices for Climate Mitigation, Adaptation, and Carbon Sequestration* (2018); *Understanding and Optimizing the Community of Soil Life* (2019); and *An Organic Approach to Increasing Resilience* (2020).

OFRF has also appreciated and utilized outcomes of ARS research endeavors, especially the National Program 216 Sustainable Agriculture Systems Research. Examples include long-term farming systems trials of organic and conventional cropping systems (Beltsville, MD); integrated organic management of gastrointestinal parasites in small ruminants through genetic resistance and natural feed supplements (Booneville, AR); cover crops for weed suppression and nutrient management (Salinas, CA); and the use of mustard seed meals to promote disease-suppressive soil microbiomes to aid organic apple production (Wenatchee, WA). In these and other examples, ARS has complemented and enhanced NIFA-funded, OFRF, and other NGO organic research, leading to important advances in sustainable organic production.

Yet, the USDA investment in organic research remains at less than 2% of total USDA research funding, which significantly lags behind the ~5% market share of organic products in the US food system. Organic farming and ranching systems rely to a great degree on healthy soils for successful production, and this emphasis means that organic approaches have a unique potential to protect soil and air quality, build resilience, and help mitigate the net greenhouse gas (GHG) "footprint" of crop and livestock production. Increased emphasis on organic systems across ARS National Program areas can help the organic sector realize this potential.

It is from this perspective that OFRF offers the following comments and recommendations regarding the five year action plan for ARS National Program 212 Soil and Air. Our recommendations apply to all agricultural regions, farm commodities, and production systems nationwide. While our problem statement is addressed to USDA certified organic, transitioning-organic, and exempt organic producers, many of the anticipated research outcomes are relevant to non-organic producers as well.

Statement of the Problem

Organic farmers and ranchers prioritize maintenance of healthy, living, biodiverse soils to provide for plant nutrition, crop protection, yield stability, and agricultural resilience. Organic producers rely on soil health to a greater degree than conventional producers, who can resort to synthetic fertilizers and pesticides to address nutrient limitations; kill pests, weeds, pathogens, and parasites; and sometimes compensate for stresses related to climate change.

Organic production systems offer unique opportunities to enhance soil health, air quality, and climate stewardship. USDA Organic Standards require certified organic producers to utilize biological processes and natural materials for fertility and crop protection; to enhance and maintain biodiversity in the agroecosystem; to protect natural resources including water and air quality; to build soil organic matter with cover crops, rotations, and organic amendments; and to select tillage practices that maintain or improve the physical, chemical, and biological condition of the soil. A growing number of organic producers apply the four NRCS Principles of Soil Health to their operations: *keep soil covered with crops and residues, maximize living roots through the year, maximize biodiversity, and minimize soil disturbance*.

Soil health practices mandated by the USDA Organic Standards and recommended by NRCS enhance resilience to extreme weather and other stresses, sequester carbon (C) in the soil profile, and can reduce GHG emissions, especially nitrous oxide resulting from surplus soluble soil N (Schonbeck et al., 2018). In addition, by largely excluding the use of synthetic chemical inputs, organic systems further protect soil micro- and macrobiota that play essential roles in soil C sequestration, tight nutrient cycling, crop nutrient and water uptake, and protection of crops from soilborne pathogens (Schonbeck et al., 2019).

Plant biodiversity also plays important roles in the health and resilience of grazing lands, as Dennis Thompson of the National Grazing Lands Coalition cogently pointed out during the May 7 listening session for NP212. With some 200 million acres of US grazing lands in monoculture grasses showing declining productivity and resilience, forage biodiversity emerges as a vital component of advanced rotational grazing systems for both organic and non-organic ranchers. While rotational grazing is covered primarily in ARS program area NP215, exploration of the impact of grazing land plant biodiversity versus forage monocultures on the soil ecosystem, climate resilience, carbon sequestration, and nutrient cycling lie within the scope of NP212.

The USDA Organic Standards require certified organic producers to maintain a high level of biodiversity throughout the farming system. Research has shown that cropping system biodiversity in organic cropping systems contributes to soil health and carbon sequestration (Cavigelli et al., 2013; Wander et al., 1994), and that adding just one or two new, unrelated crops to a low-diversity conventional crop rotation can enhance soil microbial activity and carbon sequestration (McDaniel et al., 2014; Tiemann et al., 2015).

Organic producers also face several unique challenges in building and maintaining healthy soils. First, with conventional herbicides excluded, organic production of annual crops relies to a greater degree on tillage and cultivation to manage weeds, and cover crops, and to prepare the soil for planting. Tillage can promote erosion and compaction, and adversely affect earthworms, fungi, and other soil biota, to varying degrees depending on type, depth, timing, and frequency of tillage. Furthermore, this “tillage factor” has led to a belief among some agricultural conservationists that organic systems cannot optimize soil health outcomes – a belief that overlooks a small yet growing body of research evidence that herbicides, fungicides, soluble fertilizers, and other agrochemicals can also harm or suppress earthworms, mycorrhizal fungi, and other key components of the soil biota (Druille et al., 2013; Klein, 2019; Nicolas et al., 2016).

Organic farmers need science-based guidance on how best to minimize the impact of tllage on the soil organisms and good soil structure that are essential to successful organic production. Additional research into the relative impacts of various agro-chemicals and different forms of tillage on soil biota and soil health is needed to help current or aspiring farmers in making decisions regarding whether to adopt organic methods.

Second, utilizing organic inputs such as compost and manure as the primary fertility source often builds up excessive levels of soil phosphorus (P), especially in smaller-scale, intensive vegetable production. Excessive soil P can suppress the activities of mycorrhizal fungi and some other beneficial soil biota, tie up zinc and some other micronutrients, and run off to nearby streams. While legume cover crops and low-P organic N fertilizers such as feather meal can help balance the nutrient budget, organic producers utilize compost for other benefits as well, including stable soil organic carbon, plant disease suppression, micronutrients, and plant growth promoting factors, which complement the soil health benefits of cover and sod crops. Additional research is needed to help organic producers optimize soil ecosystem health and nutrient balance through best site-specific combinations of organic amendments, cover crops, and rotations.

Third, nutrient dynamics in biologically active soils amended with slow-release organic and natural-mineral nutrient sources differ qualitatively from nutrient dynamics in soils amended with soluble fertilizers. Thus, standard soil test recommendations and nutrient management guidelines developed for conventionally managed soils and crops may not apply to organic systems. For example, a South Carolina coastal plains soil (Orangeberg loamy sand, Ultisol soil order) in an organically managed corn-soy-wheat rotation with cover crops maintained full yields and stable soil test nutrient levels at half the recommended N and no applied P or K (Kloot, 2018). On-farm trials in North Carolina, Ohio, Illinois, and North Dakota have given similar results. Therefore, we strongly concur the comments of Dr. Wayne Honeycutt of Soil Health Institute, Dr Matt Schultz of the Sustainable Phosphorus Institute of Arizona State University, and Gabrielle Ludwig of the Almond Board of California during the May 7 listening session citing the need and opportunity to update Land Grant University fertilizer recommendations to take full account of the capacity of a healthy soil microbiome to enhance N and P cycling and uptake efficiency.

Yet, simply adopting organic production methods as defined by USDA organic standards does not guarantee this level of nutrient efficiency, and organic producers often face challenges with insufficient N at critical times of crop development. Unlike soluble N fertilizer, which can be applied in a "precision" manner to meet crop needs and limit wasteful and polluting N losses, organic sources of N must undergo biological transformation in order to become plant-available, a process whose rate and synchrony with crop demand depends on multiple factors (temperature, rainfall, composition and function of soil and plant root microbiomes, etc.) and is thus difficult to predict. While some studies in organic crops have demonstrated "tightly coupled N cycling" in which crops obtain sufficient N from soils low in nitrate-N (Bowles et al., 2015; Jackson and Bowles, 2013), other organic systems studies have documented both N-limited crops and substantial N leaching and N_2O emissions – sometime at different phases of the same crop rotation (Han et al., 2017; Li et al., 2009; Muramoto et al., 2015).

Soil health, including the capacity of soil biota to support tight nutrient cycling and crop nutrient efficiency may decline in the presence of surplus plant-available N and P from either conventional or organic sources (Hamel, 2004; Schonbeck et al., 2019). In addition, substantial genetic differences in capacity to partner effectively with mycorrhizal fungi, N fixing bacteria, and other beneficial soil biota have been documented in carrot, pepper, corn, sorghum, and other crops (Cobb et al., 2016; Douds, 2009; Goldstein, 2016; Hamel, 2004; Silva, 2016; Weil and Brady, 2017). Additional research into soil microbiome, soil ecology, and nutrient cycling in organically managed soils is urgently needed to help both organic and minimum-input non-organic producers optimize nutrient management for crop production, soil health, water and air quality, carbon sequestration, and greenhouse gas mitigation.

Finally, climate change threatens all agricultural operations, and organic producers are generally well informed and highly concerned about this threat (Jerkins and Ory, 2016). The OFRF research review revealed that sustainable organic systems that include integrated soil health management strategies can enhance climate adaptation (resilience), sequester carbon, and reduce other GHG emissions (Schonbeck et al., 2018). However, more research is needed to provide organic farmers with practical tools to monitor progress toward soil health and carbon sequestration, and to develop the best site-specific strategies for soil health, climate resilience, and net GHG mitigation for their particular locale, soil type, climate, and production system. A nation-de need for farmer-ready, in-field tools and methods to monitor soil carbon, soluble N, microbial activity, and other soil parameters related to climate mitigation was highlighted by several stakeholders who spoke at the May 7 listening session.

Based on these considerations, we recommend that ARS fund research into the following Soil and Air topics for organic systems within the National Program 212:

- Understand and optimize plant-microbiome partnerships, soil biotic communities, and ecosystem functions (crop nutrient cycling and delivery, plant disease suppression, water retention, maintaining soil physical condition) in organic production systems.
- Understand the effects of crop genetics and variety selection on efficacy of plant-microbiome partnerships in enhancing crop nutrition, disease suppression, and resilience to drought, flood, and other stresses in organic systems.
- Explore and document the impact of plant species diversity and functional biodiversity on soil microbial communities, soil health, yield stability, agricultural resilience, carbon sequestration, and greenhouse gas mitigation in organic cropping and grazing systems.
- Document the impacts of various tillage tools and practices, and of agricultural inputs (organic and synthetic fertilizers and crop protection materials) on soil biota and soil ecosystem function.
- Develop practical approaches to conservation tillage in organic systems. Identify tillage implements and methods that minimize harm to soil ecosystem (biotic and physical condition) while adequately managing weeds, cover crops, and residues.
- Optimize integrated organic systems (cover crops, crop rotation, amendments, judicious tillage, livestock-crop integration) for soil ecosystem health, agricultural resilience, yield stability, and farm economic viability. Enhance understanding of site-specific considerations in development of best organic systems for soil ecosystem health.
- Enhance nutrient cycling and nutrient use efficiency in organic systems through soil health practices, crop variety selection, and nutrient input management.
- Document and optimize the capacity of best organic management to enhance agricultural resilience to the effects of climate change.

- Document and optimize the potential of organic systems to sequester carbon and reduce greenhouse gas emissions including nitrous oxide from fertilized soils, and methane and nitrous oxide from livestock operations and manure storage.
- Develop practical, reliable, and accurate methods to monitor soil C sequestration, nutrient cycling, greenhouse gas emissions, and soil health in organic systems.

Time scale and Relevance to the NP212 Candidate Focal Areas

The critical time frame for our research problem is long term, yet also immediate, given the urgency of the climate crisis and the potential of organic systems to support both climate resilience and mitigation especially when enhanced and fine-tuned through targeted research to address knowledge gaps and farmer priorities. Our recommendations address all four NP212 proposed focal areas, as follows.

1. **Soil ecosystem-focused approaches that lead to greater agricultural productivity, sustainability, resilience, and profitability**

Organic producers in particular depend on a healthy, biodiverse, living soil ecosystem for crop nutrition, crop protection and successful production. Non-use of synthetic agrochemicals protects soil life, while greater dependence on tillage can present a soil health challenge. Further research into the soil ecosystem in organically managed cropland, pasture, and range is needed to provide organic producers with the tools to optimize the soil ecosystem for production, conservation, and climate stewardship.

2. **Improving nutrient management to increase agricultural productivity, improve economics and lower environmental impacts**

Reliance on biological processes and organic / natural mineral nutrient amendments improves nutrient cycling efficiency and reduces nutrient losses (protects water and air quality). However, organic amendments can cost more, release N too slowly for optimum crop production, or accrue excess P in the soil. Additional research is needed to realize the opportunities and meet the challenges of nutrient management in organic systems, and to optimize the efficacy of plant-microbiome relationships to enhance nutrient efficiency and minimize N losses via nitrate leaching and nitrous oxide emissions.

3. **Enhancing productivity, sustainability, resilience, and profitability in light of short term and long term climatic impacts on agriculture**

Best soil health management practices can enhance climate resilience in both organic and non-organic production systems. Science-based and site-specific implementation of organic production principles and practices, combined with locale-appropriate functional biodiversity and enterprise diversity contribute to resilience. Additional research is needed to address remaining knowledge gaps to help organic producers realize this potential.

4. **Improving agricultural ecosystem services - and minimizing negative agricultural biological and chemical emissions - to soil, water, and atmosphere**

Best organic management systems can effect a net sequestration of carbon in soil organic matter, and reduce other agricultural GHG emissions, with potential to achieve net mitigation in GHG "footprint" in organic farming and ranching ecosystems. Additional research is needed to develop better practical monitoring tools and to realize the full potential of organic systems to sequester carbon, mitigate GHG emissions, protect air and water quality, and provide other ecosystem services.

Additional Comments

In addition to the above comments specific to the soil and climate challenges and opportunities faced by organic producers, OFRF endorses the written comments on NP212 submitted by the National Sustainable Agriculture Coalition (NSAC). In particular, we appreciate the broadening of perspective reflected in the four focal areas listed for the NP212 Soil and Air action plan for 2021-25, compared to the 2016-2020 action plan. The latter appeared to give greater emphasis on efforts to mitigate the water and air quality, climatic, and other environmental costs of confined animal feeding operations (CAFOs). The outline of focal areas for 2021-25 appears to give more latitude for funding cutting edge research into sustainable approaches such as organic, conservation agriculture, advanced grazing management, silvopasture, and crop-livestock integration. We urge ARS to give priority to these systems to improve soil health, air quality, and climate resilience and mitigation over the next five years.

Thank you for the opportunity to provide comment on the ARS Soil and Air National Program (212), which is highly relevant to the goals and needs of the producers we serve.

Sincerely,

Mark Schonbeck, Research Associate
Organic Farming Research Foundation

Brise Tencer, Executive Director
Organic Farming Research Foundation

References

Bowles, T. M., A. D. Hollander, K. Steenwerth, and L. E. Jackson. 2015. *Tightly-Coupled Plant-Soil Nitrogen Cycling:Comparison of Organic Farms across an Agricultural Landscape*. PLOS ONE. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0131888.

Cavigelli, M. A., J. R. Teasdale, and J. T. Spargo. 2013. *Increasing Crop Rotation Diversity Improves Agronomic, Economic, and Environmental Performance of Organic Grain Cropping*

Systems at the USDA-ARS Beltsville Farming Systems Project. Crop Management 12(1) Symposium Proceedings: USDA Organic Farming Systems Research Conference. https://dl.sciencesocieties.org/publications/cm/tocs/12/1.

Cobb, A. B., G. W. T. Wilson, C. L. Goad, S. R. Bean, R. C.Kaufman, T. J.Herald, and J. D. Wilson. 2016. *The role of arbuscular mycorrhizal fungi in grain production and nutrition of sorghum genotypes: Enhancing sustainability through plant-microbial partnership*. Agriculture, Ecosystems, and Environment. 233 (3): 432-440.

Douds, D. D. 2009. *Utilization of inoculum produced on-farm for production of AM fungus colonized pepper and tomato seedlings under conventional management*. Biological Agriculture and Horticulture 26: 353-364.

Druille M, Cabello MN, Omacini M, Golluscio RA. 2013. *Glyphosate reduces spore viability and root colonization of arbuscular mycorrhizal fungi*. Applied Soil Ecology, 64:99–103; https://doi.org/10.1016/j.apsoil.2012.10.007.

Goldstein, W. 2016. Partnerships between Maize and Bacteria for Nitrogen Efficiency and Nitrogen Fixation. Bulletin 1. Mandaamin Institute, Elkhorn, Wisconsin, 49 pp. http://www.mandaamin.org/about-nitrogenfixing-corn.

Hamel, C. 2004. *Impact of arbuscular mycorrhizal fungi on N and P cycling in the root zone*. Can J Soil Sci. 84(4):383-395.

Han, Z., M. T. Walter, and L. E. Drinkwater. 2017. *Impact of cover cropping and landscape positions on nitrous oxide emissions in northeastern U.S. agroecosystems*. Agriculture, Ecosystems and Environment 245: 124-134.

Jackson, L. and T. Bowles. 2013. *Researcher and Farmer Innovation to Increase Nitrogen Cycling on Organic Farms* (Webinar). http://articles.extension.org/pages/67391/researcher-and-farmer-innovation-to-increase-nitrogen-cycling-on-organic-farms-webinar.

Jerkins, D, and J. Ory. 2016. *National Organic Research Agenda: Outcomes and Recommendations from the 2015 National Organic Farmer Survey and Listening Sessions*. Organic Farming Research Foundation, https://ofrf.org. 126 pp.

Klein, K. 2019. *Pesticides and Soil Health.* Friends of the Earth, 9 pp. Includes a review of refereed journal articles.

Kloot, Robin. 2018. *Using adaptive nutrient management to answer "how much fertilizer do you actually need?*" NRCS webinar May 8, 2018. Science and Technology Training Library, http://www.conservationwebinars.net/listArchivedWebinars.

Li, C., Salas, W. and Muramoto, J. 2009. *Process Based Models for Optimizing N Management in California Cropping Systems: Application of DNDC Model for nutrient management for* *organic broccoli production*. Conference Proceedings, 2009 California Soil and Plant Conference, 92-98. Feb. 2009. http://ucanr.edu/sites/calasa/files/319.pdf.

McDaniel MD, L. K., Tiemann, and S. Grandy. 2014. *Does agricultural crop diversity enhance soil microbial biomass and organic matter dynamics? A meta-analysis*. Ecol Appl. 24(3):560-70.

Muramoto, J., C. Shennan, and J., M. Gaskell. 2015. *Nitrogen management in organic strawberries: challenges and approaches*. (Webinar) http://articles.extension.org/pages/73279/nitrogen-management-in-organic-strawberries:-challenges-and-approaches.

Nicolas V, Oestreicher N, Vélot C. 2016. *Multiple effects of a commercial Roundup® formulation on the soil filamentous fungus Aspergillus nidulans at low doses: evidence of an unexpected impact on energetic metabolism*. Environmental Science and Pollution Research 23, 14393–14404; doi: https://doi.org/10.1007/s11356-016-6596-2.

Schonbeck, M., D. Jerkins, and V. Lowell. 2019. *Soil Health and Organic Farming: Understanding and Optimizing the Community of Soil Life.* Organic Farming Research Foundation, http://ofrf.org. 89 pp. Includes literature review.

Schonbeck, M., D. Jerkins, and L. Snyder. 2018. *Soil Health and Organic Farming: Organic Practices for Climate Mitigation, Adaptation, and Carbon Sequestration*. Organic Farming Research Foundation, http://ofrf.org. 78 pp. Includes literature review.

Silva, E. 2016. OFRF project summary. https://ofrf.org/research/grants/creating-climate-resilient-organicsystems-enhancing-arbuscular-mycorrhizal-fungi.

Tiemann, L.K., A.S. Grandy, E.E. Atkinson, E. Marin-Spiotta, and M.D. McDaniel. 2015. *Crop rotational diversity enhances belowground communities and functions in an agroecosystem*. Ecol. Lett. 18(8): 761–771.

Wander, M. M., S. J. Traina, B. R. Stinner, and S. E. Peters. 1994. *Organic and Conventional Management Effects on Biologically Active Soil Organic Matter Pools*. Soil Sci. Soc. Am. J. 58:1130-1139.

Weil, R. R., and N. C. Brady 2017. The Nature and Properties of Soils, 15th Edition.