Agricultural Science and Organic Farming: Time to Change Our Trajectory

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Abstract: Organic farming bans all rates and uses of nearly every synthetic fertilizer and pesticide. This comprehensive ban ignores the range of differences in these materials, from dangerous to benign, and ignores research showing that specific uses and rates of synthetic fertilizers and pesticides can be the best solution to specific agricultural problems. Although organic farming emphasizes beneficial practices like crop rotation and application of manure and compost, it is this ideological ban that defines a farm as “organic.” Despite this rigid rejection of some parts of modern farm technology, organic farming has been incrementally embraced by agricultural science, influencing research, education, and outreach. Mingling ideology and science compromises science, misleads the public, and hinders efforts to sustain agriculture. It is time to review our relationship as agricultural scientists to organic farming and change the current trajectory.

Scientists have debated many aspects of organic farming: environmental effects, food quality and safety, crop yields, and economics. While those debates discuss scientific evidence, here I want to address organic farming’s prohibition of synthetic fertilizers and pesticides, and how it affects agricultural science and society. Although this prohibition is often taken for granted, discussion of it should precede other debates.

The Prohibition and Science of Synthetic Fertilizers and Pesticides

When the term organic farming was first used (ca. 1941; Paull, 2014), it was as a response to the introduction of synthetic fertilizers and pesticides to farming (Watson et al., 2008). Its founders believed that these materials were not compatible with the “natural” ways of farming and so should not be used (this assumes that agriculture is natural; see Denison and McGuire, 2015). In their place, organic farming stresses the maintenance of the soil fertility and quality by application of organic amendments and the use of diverse crop rotations. However, because these practices are also used on nonorganic farms, the prohibition of the use of synthetic fertilizers and pesticides is what defines organic farming (MacKerron et al., 1999). Thus, this prohibition became central to the development of formal organic standards (IFOAM, 2014; USDA, 2015).

Science Builds on Science

In 1941, development of pesticides was just beginning. We knew little about how these chemicals worked, where they went after they were applied, and their effects on nontarget organisms, including us. It is no surprise that we encountered problems. Yet over the years, the agricultural science community, together with new regulatory agencies, has improved the safety and management of these materials.
There are no perfect solutions in agriculture. We make decisions based on the trade-offs between the benefits of using any specific tool and its detrimental effects. In making decisions about synthetic fertilizers and pesticides, specifics matter: rate, location, timing, crop or noncrop use, toxicity, longevity, hazard, risk, and so on. Only with these details can we view the trade-offs between the risks and benefits of specific materials, used at specific rates, and for specific uses. We may find a specific use and rate of a synthetic fertilizer or pesticide to be beneficial, whereas a different rate and use of the same material may be harmful.

Indeed, this is what we see. Each synthetic pesticide is evaluated, as required by law, based on its unique characteristics. Over the past 75 years, research has found many uses and rates of many of these materials beneficial, and so their use is allowed. Some chemicals were banned completely, while others had restrictions placed on their uses, rates, and timing, implemented through pesticide labels. We also developed new synthetic chemicals that were effective at lower rates, that were more pest-specific, and that stayed active in the environment for much shorter times. Similarly with fertilizers, improved materials and methods of application, new formulations, reduced rates, improved soil tests, and precision application methods have been developed. Although the process is not perfect, with both fertilizers and pesticides, science built on science, leading to improvement over time (Fernandez-Cornejo et al., 2014).

Organic Farming’s Ban Unaffected by Advances in Science

While the science of fertilizers and pesticides advances, organic farming’s judgment of these materials remains rigid. The range of differences in these materials, from dangerous to benign does not matter, nor do rates or specific uses. Neither are the trade-offs weighed for the most common synthetic fertilizers and pesticides. The arbitrary nature of the prohibition is such that “synthetic substances are prohibited . . . unless specifically allowed and non-synthetic substances are allowed . . . unless specifically prohibited.” (USDA Agricultural Marketing Service, 2017) So, although there are exceptions (e.g., Section 205.601 of the USDA Organic Program Regulations; USDA, 2015), these only tend to prove the rule; the primary factor is whether a material is synthetic or not. Because of this, organic farming does not give us the best solutions, but only those that fall within this arbitrary rule. Below are two examples.

The first concerns the use of a banned material at a low rate for a specific purpose. In a meta-analysis of organically grown crops, Barański et al. (2014) found that the protein of organic cereals was significantly lower than conventionally grown cereals. A solution would be a timely application of a small amount of synthetic nitrogen fertilizer, perhaps controlled-release urea, to a wheat crop (Ottman et al., 2000). However, organic farming disallows the use of any urea at any time; 100, 10, or 1 kg per hectare—even the ecologically insignificant rate of 0.1 kg per hectare—are all prohibited (Kirchmann and Ryan, 2004). Orders of magnitude do not matter in organic farming because it is not a matter of degree but of kind; all the most common synthetic fertilizers are banned outright.

The second example is of a specific use of a banned product: applying an herbicide to kill a pasture in transition to a direct-seeded row crop. Using an herbicide preserves soil structure and the protective plant cover (Hobbs et al., 2008; Rose et al., 2016). Furthermore, the sprayed nonfood vegetation will never be harvested. In contrast, the organic solution for killing a perennial pasture is tillage, which degrades soil structure and leaves the soil bare and prone to erosion. Trade-offs between using tillage or using an herbicide are not evaluated in organic farming, only whether a material is synthetic (by definition), soap-based herbicides being the only exception (but only for noncrop areas and ornamental crops; USDA, 2015).

It could be argued that in 1941, farming without synthetic fertilizers and pesticides was a reasonable approach. However, after more than 75 years of scientific advancement, it is no longer reasonable. The rule-forming bodies for organic farming have not conducted any rational, compound by compound, evaluation of the risks and benefits of all synthetic fertilizers and pesticides, nor have they considered the existing evidence for lifting the ban on specific rates or uses of prohibited materials. Only for a few exceptions to the general prohibition (mostly insignificant in terms of the materials most used in agriculture) has a review of the evidence been conducted (USDA, 2015). What is clear now is that the scientific evidence derived from broadly accepted protocols supports the beneficial use of many materials banned in organic farming.

The urea and herbicide cases above are just two examples of how inflexible organic restrictions do not allow the best solutions to be used. Tasked with producing food for a growing population, we need to have all the available tools at our disposal—none should be prohibited arbitrarily. If there are solutions that we cannot use, then we should have a well-supported, rational argument of why we cannot use them. Organic farming provides only ideology for maintaining its comprehensive ban for over 75 years. Prohibiting beneficial practices hinders our efforts to improve agriculture, but the implications go further.

The Incremental Embrace of Organic Farming by Agricultural Science

Over the past two decades, agricultural science has incrementally accepted organic farming (OFRF, 2012; CERES Trust, 2015). From research to extension, in university courses and majors, to professional organizations and top-tier agricultural journals, organic farming has been legitimized as just another agricultural system. Acceptance starts with money. Targeted funding is offered for researchers to do organic farming research. Researchers carry out projects. Scientific organizations then host organic sessions at their meetings to allow researchers to present their findings and publish their results in peer-reviewed journals. In pursuit of funding and relevancy; universities establish certified
organic farms, offer organic farming courses, and even offer organic farming majors (Francis, 2009).

One problem with this acceptance is that it brings with it a de facto acceptance of the a priori prohibition of synthetic inputs, which is rarely challenged. Although it is acknowledged in papers, it is also glossed over as the focus moves to the evaluation of performance. In their otherwise thorough review, Seufert and Ramankutty (2017) fail to mention the ideology, toning it down to “avoidance” of banned materials. Although Reganold and Wachter (2016) mention the ideology of organic farming, they say nothing more about it. Their observation of the profits that come from organic premiums takes precedent. This is the case repeatedly: the research may be robust, the education rigorous, but the fact that it all takes place within the boundaries of unscientific prohibitions is glossed over. Thus, an unsupportable belief ends up guiding agricultural science.

Worse, with more dire consequences, this rigid system is taught to students who will be the future scientists. Regardless of whether professors teach strict adherence to organic prohibitions, students in organic farming classes and majors must be prepared to adhere to the prohibitions that exist if they want to claim they are producing certified organic food. In thus preparing them, we send a mixed message about the ideals of science that will be a hindrance for years to come. Instead, if the goal is to find the best solutions, students should be taught the scientific method, which would require testing of the assumptions of organic farming, not adherence to them.

Furthermore, when researchers and educators accept organic farming without challenging the comprehensive ban, it is given undeserved scientific legitimacy. The government funding it, scientists studying it, and professors teaching it can reasonably be viewed as tacit approval of the ideology by our trusted scientific institutions. This misleads the public, most of whom are generations away from the farm, and most of whom live in cities, into believing that synthetic fertilizers and pesticides are so dangerous, or detrimental, that they should be banned, or at least viewed with suspicion. As Younberg and DeMuth (2013) found, “the American consumer has enthusiastically embraced organic products and much of its ideology.”

All this, in turn, weakens the legitimacy of the USEPA and similar organizations that regulate the materials that are banned in organic farming. It undermines agricultural chemical science, risk analysis, and pesticide labels and adds authority to fear-based organic food marketing campaigns. Finally, it feeds into a more general increase in “chemophobia” (Francl, 2013) that stigmatizes synthetic chemicals in all industries.

Support for Organic Farming from Scientists

Not all scientists think alike on organic farming. Some claim that organic agriculture’s rules are based on science. They point to the problems resulting from the use of synthetic fertilizers and pesticides. This, however, dismisses 75 years of improvements in synthetic fertilizers and pesticides and their management. We must continue to improve our use of synthetic fertilizers and pesticides, but this is best done not through a comprehensive ban but through an assessment of the trade-offs associated with their use or prohibition and then a careful deliberation of how science can improve the materials and their use.

Others argue that organic farming will change, allowing some uses and some rates of banned materials in response to the evidence. I disagree. Whatever organic agriculture started as, it is now a growing and well-developed market based on the claim that organic food is produced without the use of chemical fertilizers and pesticides. This is the cornerstone of organic food marketing campaigns and the key to maintaining premium prices for organic food. By insisting on this ban for so long and basing its marketing on it, organic farming cannot afford to change now. Doing so would undermine its clear message and weaken its market. It would lose its distinctive advantage in the marketplace and would enter the more nuanced, and therefore less competitive, realm of sustainability labels.

Where science has compared systems that combine organic amendments, crop rotations, and judicious use of fertilizers and pesticides (low-input systems as compared to conventional practices), it has found the organic system lacking. A meta-analysis of comparisons of organic, low-input, and conventional systems for wheat and corn (Hossard et al., 2016) found that low-input systems had better yields than organic systems and used 70% less pesticide for wheat (50% less for corn) and 28% less nitrogen fertilizer (36% less for corn) than the conventional systems. This is a beneficial compromise between intensive, high-input, high-yield agriculture and organic agriculture, but it has little marketing power in the general population. Only the most sophisticated consumer would be able to discern the value of a “low-input” marketing campaign. Nevertheless, marketing should not trump science.

A better argument for agricultural science continuing a relationship with organic farming is that it spurs innovation. I concede this. Organic farming is one of the forces that shifted the dominant paradigm to include biological solutions, even as the preferred option over synthetic pesticides. A similar shift has increased awareness of the inefficiencies in our use of synthetic fertilizers (Cassman et al., 2003). However, as sustainability has become a common standard for agricultural research, this benefit now no longer balances the adverse effects of organic ideology to science.

There is also evidence that organic farming’s comprehensive ban has allowed us to observe mechanisms that would not occur otherwise. Especially with pesticides, not using them can sometimes give beneficial insights [Lestourneau et al., 2009]. Here again, the answer is not a ban of these materials but judicious use, as in the low-input example above.

Another argument for organic farming is that it is an integrated system and that use of banned materials will prevent the system from performing as designed. Again, the comprehensive nature of the ban is its downfall. The evidence does not show that every use and rate of all banned materials would destroy the integrity of an organic farming system.
The decision to ban synthetic materials just because they are synthetic is arbitrary, not based on system design.

Finally, there is an argument for supporting organic agriculture that can be summed up as: “No one farming system alone will safely feed the planet” (Reganold and Wachter, 2016; Foley et al., 2011). While I agree that distinct locations and situations can require different solutions, I also believe that synthetic fertilizers and pesticides should not be arbitrarily banned from any of them. Science must reject the postmodern philosophical notion of considering all points of view as equally valid (Kuntz, 2013).

Time to Change Our Trajectory

My critique here is not aimed at changing organic farming or its ban on these chemicals. Organic farmers can remain true to their ideals as they have for over 75 years and market to consumers who share those ideals. Rather, it is aimed at this embrace of organic farming by the agricultural science community. What is acceptable in the personal realm, and in the marketplace, is not acceptable in science. Science has a different ideal, the pursuit of facts about measurable reality. We often struggle to reach this ideal, but it has long served us well. With the number of large, complex problems we face today, the last thing the public needs is a waverer of commitment to high standards for science.

It is time for the agricultural science community to review its current trajectory regarding organic farming. While our current direction is troublesome for agricultural scientists, for students, and for the public, continuing it would be perilous. In research, education, and extension, we must ask ourselves what agricultural science accepts. Why should we fund and conduct organic farming research if it blocks certain solutions arbitrarily? Why should we teach this rigid rule-based system to college students in organic farming courses and programs? Should organic farming’s rules and certification standards be included in extension programs? And if there is no scientific support for organic farming’s comprehensive ban, shouldn’t the agricultural science community make this clear to the public? This will cause conflict between organic farming and the science community but is necessary to preserve the legitimacy of agricultural science. Those of us in the agricultural science community must make a choice: either continue on this current trajectory or remain true to the ideals of science. I believe it is time to change course.

Acknowledgments

Some of the ideas in this article were first presented in a video at the 2016 ASA, CSSA, SSSA Annual Meetings in Phoenix, AZ (https://scisoc.confex.com/scisoc/2016am/webprogram/Paper100414.html). It can be viewed at https://www.youtube.com/watch?v=lx3MUN_a9j4.

References


