Use of Biological Soil Amendments in Organic Agriculture and Food Safety Risks

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Organic Agriculture and Increase of Demand

Organic farming in the U.S. has been growing rapidly, with over 20,000 certified organic operations in the U.S. (United States Department of Agriculture (USDA)/Agricultural Marketing Service (AMS), 2016): a 300 percent increase in domestic certified organic operations since 2002. Organic food sales have increased by 8.4 percent over the last year, blowing past the stagnant 0.6 percent growth rate in the overall food market to reach annual sales in excess of $7.6 billion in 2016 (USDA-AMS, 2017). Organic food now accounts for more than five percent of total food sales in the U.S., and demand for organic products continues to outpace production (Finley et al., 2018).

Currently, 83 percent of families in the United States have bought organic products one or more times in the past two years, and 90 percent of parents report that they choose organic food for their children at least sometimes (OTA, 2017). This growing demand for organic products is based on consumer trust in the organic label, and the perceived guarantee of quality, safety, and sustainably of organically produced food (Finley et al., 2018).

Use of BSAOAOs and Food Safety Risks

Organic agriculture is one of the most strictly regulated agricultural systems, with a rigorously-enforced list of practices by which organic producers adhere. USDA's National Organic Program (NOP) prohibits organic farmers from using synthetic fertilizer (USDA-AMS, 2000). Instead, they often use biological soil amendments of animal origin (BSAAOs) to replenish soil nutrients, enhance water retention and infiltration, increase soil permeability, increase drainage and areration, and improve soil structure (Rosen and Bierman, 2005; Rosen and Allan, 2007).

Raw manure (uncomposted and untreated animal manure) is a type of BSAAO that is used in many crop-based systems, but is particularly important to certified organic farmers because of the ban on synthetic fertilizer (USDA-AMS, 2000). Unfortunately, crops that are grown in soils amended with raw livestock manure can become contaminated by microbial pathogens carried by raw manure

such as *E. coli* O157:H7, *Salmonella* spp., *Campylobacter* spp., *Listeria monocytogenes* and *Cryptosporidium parvum*. Fresh produce presents a unique food safety challenge due to the absence of a kill step between harvest and consumption. The prevention of microbial contamination of crops has been based on time-interval criteria between the application and crop harvesting (Olaimat and Holley, 2012). It is crucial that raw manure application, compost processing and application practices be adequate to reduce the risk of potential crop contamination.

All photos courtesy of Alda Pires.

Mitigations Strategies to Reduce Food Safety Risks in Soils Amended with BSAAOs

The Food Safety Modernization Act (FSMA), Produce Safety Rule, Subpart F, defines a BSAAO as "untreated" if it has not been processed to adequately reduce microorganisms of public health significance (Food and Drug Administration (FDA), 2015). Untreated BSAAOs consists of animal manure (e.g., raw manure, aged, staked, slurries, animal bedding, agricultural tea made from raw manure) or non-fecal animal byproducts (e.g., bones, offal or feathers), which were not submitted to a valid controlled physical (e.g., heat) or chemical process (e.g., high alkaline pH), biological process (e.g., composting) or combination of processes (FDA, 2015). The rule requires that untreated BSAAOs must be handled, conveyed, and stored in a manner that does not contact covered produce during application and minimizes the potential for contact with covered produce after application (FDA, 2015). However, FSMA does not currently specify safe time-intervals between the application of untreated manure and crop harvesting.

Current USDA's National Organic Program (NOP) standards, on the other hand, do specify wait-times, and require that untreated animal manure be applied at least 120 days or 90 days prior to crop harvest, depending on whether the edible portions come into direct (e.g., carrots, radishes, lettuce) or indirect contact (e.g., peppers, tomatoes) with the manure-amended soil (USDA-NOP, 2011; FDA, 2015). The Leafy Green Marketing Agreement (LGMA) requires a 12-month waiting period between raw manure or grazing animals in a field to produce fresh produce, that is not compatible with most organic cropping cycles (LGMA, 2016).

While the FDA did not specify time-intervals in the current FSMA rule, they have previously proposed a 9-month minimum interval requirement, and are reserving a final decision on the wait time between application of raw manure and produce harvest until more data is collected and a risk assessment is completed (FDA, 2015).

The nutrient and microbiological characteristics of animal-based soil amendments (i.e., untreated livestock manure) depend on several factors such as livestock species (e.g., cattle,

Continued on Page 14

Continued from Page 13

poultry, small ruminants and swine), production system, animal diet, bedding material (amount and type), manure management (e.g., storage, application rate), pathogen itself, and type of manure (e.g., solid slurry or liquid) (Harris et al., 2013). In addition, once the soil amendment is applied other factors may play a role on survival, such as soil properties (e.g., type of soil, composition, temperature, moisture), culture management (e.g., irrigation type, crop type, cover crop, previous use of the land) and environmental conditions (e.g., season, ambient temperature, rainfall, humidity, sunlight) (Hutchison et al., 2005; Harris et al., 2013). These factors may be directly related to the type of livestock production and agricultural practices, which vary between regions and states.

A recent multi-regional study conducted by University of California (UC) Davis and collaborators on current practices of organic farmers regarding BSAAOs reported that while some organic farmers use raw manure, in particular small-scale farms, the majority of fresh organic produce farmers primarily use compost as their major soil amendment (Pires et al., 2018). Manure management practices (e.g., sources, storage, type of treatment, application method, application time, etc.) may affect the survival and persistence of pathogens in amended soils. Therefore, mitigation practices to decrease the risk of potential microbial contamination to fresh produce crops resulting from application of untreated manure must take into account the multiple farming factors (e.g., agricultural and livestock practices) and specific characteristics of the region such as environmental factors, geological factors, growing seasons (year-round versus seasonal) that may be involved (Pires et al., 2018).

Controlled and managed composting processes have been shown to suitably reduce the populations of foodborne pathogens to minimal levels (Bernal et al., 2009; Moral et al., 2009). The United States Department of Agriculture/ National Organic Program requires that compost is produced through a process in which the initial C:N ratio is between 25:1 and 40:1 and maintained at temperature between 131°F and 170°F for 3 days using an in-vessel or static aerated pile systems, or for 15 days using a windrow with a minimum of five times turning (USDA-NOP, 2011).

The same composting parameters are required in Produce Safety Rule (PSR) of the Food Safety Modernization Act (FDA, 2015). FSMA PSR provides these two examples of scientifically valid, controlled biological treatment (composting) but other treatment processes validated that have been proven to meet the microbicidal standards are acceptable (FDA, 2015).

Conclusion

Prevention of pre-harvest contamination of fresh produce is critical for the safety of consumers, and a top concern of farmers regardless of farming system. Best practices can be employed to reduce microbial concentration in manure and preventive control of cross-contamination during farming and harvesting of fresh produce, but more research is necessary to expand our knowledge on the efficacy of current practices and more extension is needed to transfer this information to farmers.

Research must identify the multitude of factors influencing pathogen survival in pre-harvest produce production environments on soil amended with BSAAOs. We must also develop risk mitigation strategies for reducing fresh produce microbial contamination in systems using BSAAOs. The FDA is conducting a risk assessment and, in

Continued on Page 16

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Continued from Page 14

collaboration with the U.S. Department of Agriculture and other stakeholders, is undertaking critical research to provide scientific support for appropriate time interval(s) between application of raw manure and harvest of fresh produce.

Research on organic systems examining the intersection of BSAAO use and pathogen presence and survival is especially critical, because organic farmers are frequent users of BSAAOs. Additionally, pathogen ability to colonize and persist on organic soils may differ from their conventionally managed counterparts, because on average organic soils have higher soil organic matter, more nutrient availability, improved structure, and increased biodiversity (Mader et al., 2002; Marriott and Wander, 2006). To ensure the high-quality of organic products are maintained, we must conduct science-based assessments of current organic practices related to raw manure use and to identify potential food safety risks, which will benefit organic growers and their consumers. Meanwhile, until more data is collected, the Produce Safety Rule of the Food Safety Modernization Act does not interfere with the National Organic Program standards.

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