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Biologicals: The New Green Revolution or Snake Oil for Ag? Reflections from Agricultural Stakeholders



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Abstract

Modern agricultural systems are increasingly reliant on inputs and technological developments from private industry. In recent years, there has been a rapid growth in the market for inputs (seed treatments and inoculants, foliar sprays, etc.) derived from biological (especially microbial) origins, so-called "biological" products. Farmer use of these emerging technologies and farmer advisors' views of these products have not been systematically investigated. We report an exploratory effort to understand this emerging market and agricultural stakeholders' perspectives on these new products. This research revealed significant communication and information disconnects between agricultural stakeholders and the farmers with whom they work. Four major themes emerged from our research:

- a. the biologicals market is competitive and growing;
- b. retailer and advisor knowledge of product development and mechanisms is lacking;
- c. definitions of key terms are complex and contested; and
- d. product efficacy is largely evaluated on production impacts (i.e. yield).

Keywords: Agricultural stakeholders, Green Revolution, Biologicals, Microbial Products, Seed Treatment, Soil Health, Field crops

Introduction

Modern agricultural systems, in particular row cropping systems producing grain and oilseed commodities, are increasingly reliant on chemical inputs and technological developments from private industry [1]. Concurrently, the recent focus on soil health from public and private sectors alike has brought biology to the forefront of agriculture. Key to improving the biology of soil is a vibrant microbial community, teeming with beneficial bacteria and fungi that promote plant growth and protect the plant from pests [2]. While basic principles of soil health are well defined [3], researchers understand only a sliver of the diverse, complex microbial community in soils [4].

There are two main ways managing the soil microbial community is being promoted to farmers: manage and improve

the soil environment to enhance the existing microbes or add microbes to the plant-soil system via external inputs. While managing the quality of soil microbial communities has long been identified as a key to building a sustainable agricultural system [3,5], there has recently been a rapid growth in the market for cropping system inputs derived from microbial origins, so-called "biologicals" or "microbial" products¹. These inputs include seed treatments and seed inoculants, foliar sprays, and soil additives intended to boost crop production through a range of mechanisms [6-8].

These biological products are increasingly being touted in popular science and farm press as the new future for agriculture, even being referred to as the next green revolution [10,11]. Are

¹Other products can also be characterized as biologically based, including green manures and biologically derived stimulants, but we are particularly interested in products derived from living microbial inoculum used to benefit cropping systems.

farmers using these products? What do they, and the professionals who advise them, understand and believe about biologicals? To date, farmer use of these emerging technologies and farmer advisors' views of these products have not been systematically investigated. Farmers increasingly rely on private sector advisors for a wide range of recommendations [12,13], so these advising relationships have the potential to increase the pace at which these new technologies are adopted by farmers, with important ramifications for the sustainability of major cropping systems.

To address this knowledge gap, we used an exploratory research effort to identify the current market for biologicals in row-crop systems in the US Midwest and to understand the perspectives of important agricultural stakeholders on these products. In 2018 we held a roundtable discussion bringing together university scientists, university Extension educators, agricultural retailers, and professional crop advisors from Michigan and Indiana to discuss biological products and their current role in Midwestern cropping systems. These discussions and an additional focus group with four Michigan farmers conducted before the roundtable, revealed significant communication and information disconnects between agricultural stakeholders, including differing perspectives on how product efficacy should be evaluated. Identifying these areas of disagreement are critically important to understand the potential role of these technologies for advancing agricultural production and sustainability. The research presented here represents a first effort at understanding these perspectives and whether agricultural stakeholders view these products as a potential "green revolution" or simply as "snake oil".

In this article, we present four major themes that have emerged from our research:

- a. the biologicals market is competitive and growing;
- b. retailer and advisor knowledge of product development and mechanisms is lacking;
- c. definitions of key terms, including biological products, are complex and contested; and
- d. product efficacy is largely evaluated on production impacts (i.e. yield). We close this research note by outlining our agenda for advancing knowledge in this emerging agricultural technology realm.

Major Themes

The biologicals market is competitive and growing

Biologicals are being developed by a wide range of firms, from small start-ups to large multi-national conglomerates. The wide range of product developers leads to high levels of product differentiation, and subsequently, confusion among advisors and farmers. Our participants said that the product market has grown exponentially in the previous 18-24 months; advisors indicated

that they have been overwhelmed by the number of available products and have struggled to understand the range of available products. Retailers indicated that they are often contacted by developers promoting their products, especially smaller start-ups. Large seed and product developers, such as Pioneer-Dow (now Corteva) and Monsanto (now Bayer), have also rapidly expanded their available biological products in the past few years: now, new corn varieties all have a biological treatment on their seeds [14]. While biologically based products are wide ranging, the market seems most mature in the seed treatment area, particularly as seed companies have invested in biologicals. Participants noted that rhizobia inoculants have been used in soybean production systems for years but have generally not been considered as 'biologicals' in the way new products are being developed and marketed. This disconnect in marketing between products with similar origins is striking and reflects the distinct new market for products intended to increase soil microbial activity as a means to enhance crop production.

On-the-ground understanding of biological product development & mechanisms is lacking

Fast developments in the input and seed treatment marketplaces, along with corporate concerns over proprietary science and product information, have resulted in a lack of understanding and awareness of new products, their intended modes of action, and the science behind the reported increases in yield or performance. This was especially clear among university Extension professionals, who were aware that such products existed but mostly did not know the extent of the current market. Biological products were most often framed in terms of their mode of application (i.e. seed treatment or soil inoculant) rather than their intended mechanism or mode of action (e.g. fungicide or early growth stimulation). While largely unaware of the intended modes of action, farm advisors and retailers largely trusted certain product lines. In particular, existing relationships with certain suppliers and product developers informed trust in certain product lines, especially those developed by large seed or product companies with a long track record. Both public and private farmer advisors and farmers were unaware of the extent to which biological treatments, if any, were on corn seed. Indeed, they voiced much skepticism that a biological seed treatment would be on the seed they buy unless they had specifically ordered it. Scientists were aware of the potential modes of actions that could be delivered by biological products, but they were cautious about seed treatments based on single or few species and successful establishment of a few microbes into a complex soil system.

Definitions of key terms, including "biologicals", are complex and contested

While industry rhetoric and company marketing materials regularly tout "biologicals" as an important development in agricultural technology, participants found it difficult to establish a clear definition of the term. It was apparent during the facilitated

discussion that the term “biologicals” was not common parlance among the participating advisors or the farmers they work with. Instead, on-the-ground advising appeared to largely revolve around product categories based on delivery system (e.g. seed treatments, soil amendments, foliar sprays, etc.) rather than the provenance of the product or even the intended mode of action in some cases. Therefore, it was challenging for many participants to differentiate whether a product was biologically-based or “hard chemistry”. Even within these delivery-based product categories, the term “biologicals” did not necessarily add clarity. Retailers and advisors were often still unclear of how products worked and what science underlies the product. This was especially evident in the area of seed treatments. These products are typically bundled with a particular seed product line (along with other non-microbially based treatments), making it difficult to differentiate the mechanisms and efficacy of biological versus “hard chemistry” treatments. Advisors often indicated that they thought there were microbially-derived treatments on various seed product lines but were not entirely sure what they were or how they worked.

Another particularly important area of confusion was the relationship between microbe-based products and genetically modified (GM) products such as BT corn². In our facilitated discussion, there was considerable disagreement over whether GM products that incorporate microbial genetics into crop genetics counted as biological, not only between stakeholder groups but within groups (e.g. not all scientists agreed about what constituted a biological/microbial product). The incorporation of new areas of science, a low level of understanding of soil microbial systems among most stakeholders, and different types of knowledges among stakeholder groups contributed to the difficulty of defining key terms. Importantly, many participants indicated that they had not had conversations about biological products with others in the past. This lack of ongoing dialogue among and between key agricultural stakeholders exacerbates the inherent difficulties of defining, describing, and developing a broad and emerging area of technology.

Product efficacy is largely based on local trials and trust in existing stakeholder relationships

One of our key discussion questions was how various stakeholders evaluate the efficacy of biological products. How do they define whether a product is working or not and how do they determine this? Most product developers are not marketing to farmers directly, but to retailers, Extension educators, and crop advisors. Due to the scale and diversity in products and product developers, most advisors did not feel confident in vouching for the efficacy of most available products. This was especially true with seed treatments, which are most often bundled with the seed product lines, making it difficult to determine the effectiveness of any particular treatment. Among retailers in particular, there was

more confidence in products developed by large companies, such as multinational seed companies than in products from start-ups or small firms. This confidence was largely based on established corporate relationships and trust in robust private sector science, even if the individuals did not have a deep understanding of this science themselves. Retailers and private sector advisors indicated that product developers typically provide information about the scientific basis of the product and data indicating how the product has performed in trials. It was clear during our discussion however that this information is not always well understood by the retailers or advisors and often does not seem to be carefully evaluated. Crop advisors in particular seemed to discount this information, preferring to evaluate product efficacy in local production settings. These advisors acknowledged the difficulty in this form of local trialing and experimentation: most advisors in both the private and public sector had not rigorously evaluated most products themselves, in part due to the vast diversity of available products and limited time and resources to devote to field experiments.

Future Directions

This research shows that agricultural advisors are curious about biologically based agricultural products, but that limited understanding of product terminology and mechanisms, overwhelming marketing agendas, and lack of local efficacy trials makes them skeptical to promote the products to farmers. Therefore, because the science and markets for biologically based agricultural products are rapidly developing [6] but the state of agricultural advisors' knowledge and trust for biologicals has not changed since our interviews in 2017 [11,15, 16], there is a critical need to focus on the human dimensions of these technological advancements. Farmer-advisor relationships (especially between farmers and private sector retailers and crop advisors) play a critical role in on-farm decision making; it is therefore vitally important to also understand the knowledge, perspectives, and attitudes of these advisors on biologicals. Moreover, it is important to understand how agricultural stakeholders of all types view the role of microbial systems in crop production systems, particularly in light of the growing emphasis on soil health [3,9]. Farmer perceptions of these products will play a key role in their adoption and integration into modern cropping systems, but the pace of technology development and opaqueness of the underlying science behind these technologies may place more of the decision-making burden on advisors in both the public and private sector. Continued engagement and dialogue between university scientists and Extension educators, retailers, crop advisors, and industry scientists will be critical in building a shared understanding of these new products and their role in advancing cropping system sustainability.

²Bt corn is genetically engineered to include genes isolated from a bacteria, *Bacillus thuringiensis*. The addition of these bacterial genes makes the crop toxic to many insects (FAO).

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Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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