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The Cover Crop Seed Industry: An Indiana Case Study

John C. Tyndall (Iowa State University), Adriana Valcu-Lisman (Iowa State University), Melanie Bogert (Iowa State University), and Abigail Zobrodsky (Iowa State University)

ABSTRACT

Winter cover crops are plants used to protect soils during the period between the harvest and establishment of cash crops such as corn and soybeans, effectively providing farm fields with perennial cover. The total cost of cover crops varies considerably from site to site and year to year, yet the single costliest aspect of using cover crops is the cost of seed. Seed cost also tends to be the most volatile component of the cost of cover crop use, subject to complex supply dynamics associated with producing viable seed, storage capacity, and unpredictable regional demand. We conducted a survey of seed dealers who sell cover crop seeds using the state of Indiana as a case study. The majority of the respondents believe that sales for cover crop seeds over the next five years in Indiana will increase. In response to this expected increased demand, seed dealers noted they intend to (in no particular order): increase contracted cover crop seed production and invest in seed handling and storage capacity; increase direct interaction with farmers; become more active with workshops and demonstration field days; and/or create marketing materials that specifically promote the soil health benefits of cover crops. The top three factors seed dealers believed would improve the Indiana cover crop seed market the most were: (1) financial incentives for cover crop use; (2) improved customer knowledge of cover crop management; and tied for (3) reduced seed production costs, and broader support of cover crop usage from commodity groups. The top three topics of publicly funded research most useful to the cover crop industry were: (1) understanding factors that influence farmer cover crop adoption; (2) cover crop impact on field profitability; and (3) understanding long-term soil benefits of cover crops. Seed dealers play a unique role in conservation practices such as cover crops, not just because they are often trusted facilitators of information and guidance, but also because their business actions strongly influence available conservation opportunities, management options, and direct cost to farmers. The respondents to the survey offered their opinions regarding a number of issues that would help their business viability in a sustainable way while promoting farmer adoption of cover crops and their long-term commitment to the practice.

KEYWORDS

cover crops, seed industry, survey research, conservation, U.S. Midwest

INTRODUCTION

Winter cover crops are plants used to protect soils during the period between the harvest and establishment of cash crops such as corn and soybeans, effectively providing farm fields with perennial cover. Cover crops enhance many aspects of soil health and nutrient management that return field-level benefits to farmers and landowners (Clark, 2008). Soil health-related outcomes include prevention of wind and water erosion, increased soil organic matter and tilth, soil fertility, improved soil structure and hydraulic conditions, recycled nutrients, and enhanced beneficial microbial habitat (Chatterjee & Clay, 2016; Daryanto et al., 2018).

Used broadly at watershed scales, cover crops are considered a water quality Best Management Practice (Hanrahan et al., 2018; Lawrence & Benning, 2019). Water quality benefits associated with cover crops are largely due to reductions in field-level runoff, erosion, sedimentation, and concomitant nutrient transport. Research has noted that cover crops can decrease field-level runoff by 80% or more, sediment loss by upward of 96%, and nitrate leaching between 18% and 96% (Blanco-Canqui et al., 2013; Blanco-Canqui, 2018).

Due to their versatility and multi-outcome nature, the USDA Natural Resource Conservation Service has long promoted winter cover crops broadly. For example, USDA cost share funding

for cover crops as part of the Environmental Quality Incentive Program (EQIP) increased (nominally) from about \$5 million in 2005 to more than \$90 million in 2016 (Bowman & Lynch, 2019). Cover crops are also broadly promoted by state-level nutrient reduction strategies whose goals are to guide nutrient loss reduction (nitrate and phosphorus) from field to whole state scales (Christianson et al., 2018).

Despite evident field and watershed scale benefits, widespread farmer adoption of cover crops has been limited. Based on the 2017 USDA Census of Agriculture land cover data, less than 2% of the nation's total row crop land was planted to cover crops¹ (Runck et al., 2020). Cover crop usage, however, appears to be slowly increasing throughout the U.S. Midwest region (Meyers et al., 2019). This is particularly true in the state of Indiana, where farmers planted over 1,000,000 acres of cover crops in 2018, representing a 450% increase since 2011 (ISDA, 2018). Cover crops are now the third-most planted crop in Indiana next to corn and soybeans with at least 10% of all corn and soybean acres in Indiana being planted to cover crops (ISDA, 2018).

The choice of a farmer to adopt and maintain a conservation practice such as a cover crop over time involves a complex of individual, social-psychological, institutional, land tenure, and agronomic factors that vary tremendously across farmers, geography, and time (e.g., Liu et al., 2018; Prokopy et al., 2019). The decision process also involves weighing a number of pragmatic issues. The choice of cover crop species is a function of geographical suitability (e.g., hardiness), land use goals (e.g., nitrogen scavenging, erosion control, weed management, building soil fertility and tilth, etc.), ease of establishment and termination, local or regional seed supply, availability of custom planting and management services, and overall cost (Bergtold et al., 2019; Clark, 2008). The direct cost of cover crop adoption and continuing use tends to be particularly concerning to farmers and landowners (Lira & Tyner, 2018; Roesch-McNally et al., 2018).

The total cost of cover crops can vary considerably from site to site and year to year, and it is largely contingent on cover crop species and concomitant seed cost, planting and termination methods, field conditions during planting and termination, site hydrology, soils, cash crop, and

experienced yield impacts relative to the cash crop (which can be highly variable across time) (Roley et al., 2016). The single most costly aspect of using cover crops is the cost of seed, accounting for anywhere between 29 and 50% of total direct cost (Bravard 2021; Roley et al., 2016).

The high cost of cover crop seed is a fact not lost on farmers. A third of respondents to a 2012–2013 Corn Belt region farmer survey indicated seed cost alone as one of the most significant barriers in using cover crops (Bergtold et al., 2019). Seed cost also tends to be the most volatile component of the cost of cover crop use, subject to complex supply dynamics associated with producing viable seed, storage capacity, as well as variable and unpredictable regional demand (Brooks, 2019; White, 2014). In the long run, assuming demand for cover crops continues to expand in accordance with recommendations from various state-level nutrient reduction strategies (e.g., Iowa's strategy calls for ~12.5 million acres of cover cropped farmland), a broadly robust cover crop seed industry will be critical to maintaining high-quality and affordable seed throughout the region (Runck et al., 2020).

Because of the significant importance of cover crop seed cost, we conducted a survey of seed dealers who sell cover crop seeds using the state of Indiana as a case study. The objectives of this study are to better understand the status of the cover crop seed industry, explore current sales trends, and elucidate seed dealer needs, interests, and views on the future of the industry and factors that would help facilitate sustained growth and adoption of cover crops. The stakeholders of this survey data include the cover crop seed industry, state and federal agencies tasked with facilitating the adoption of cover crops as well as funding research, and farmers who currently use cover crops or are exploring the option.

COVER CROP SEED MARKET ANALYSIS

Brief Overview of the Cover Crop Seed Industry in the U.S. Midwest

The majority of cover crop seed that farmers utilize is purchased from regional seed dealers or seed retailers (CTIC, 2017). In the U.S. Midwest, farmer trade in saved cover crop seed or purchase and use

of unlabeled seed is potentially illegal under federal and state laws (Groff, 2015). To meet farmer demand, seed dealers largely obtain seed by contracting with custom growers, though it is not uncommon for seed dealers to purchase seed from other dealers when inventories are unbalanced (Midwest region seed dealer 1, confidential personal communication, 2019). Individual cover crop seed dealers typically maintain seed procurement contracts with regional farmers. These farmers in turn harvest cover crop seeds from anywhere between 400 to 5,000 acres per contract (Ogawa, 2014; Midwest region seed dealer 1, confidential personal communication, 2019). Because of relatively high transportation costs, seed production tends to occur where the end use markets exist, though cool season seed utilized in the U.S. Midwest region can be produced as far away as the Willamette Valley in western Oregon (Larsen, 2019).

Seeds typically go through a series of tests for purity, germination, weed seeds, other types of contamination, weight, and moisture content (Ogawa, 2014). Though not all states regulate the small-scale seed industry in the same way, cover crop seed in Indiana is tested and/or labeled for identification, purity, and viability as per seed labeling requirements of Indiana Seed Law (Office of Indiana State Chemist, 1987).

Structure of Cover Crop Seed Market Survey

In an effort to comprehensively explore the current nature of the cover crop industry relative to sources of seed for Indiana farmers, we developed a survey that covers a number of different aspects of the industry and cover crop sales during the 2017 growing season. One section of the survey involves questions regarding the scale of cover crop seed sales, who the primary buyers are of cover crop seed in Indiana (e.g., wholesale or retail seed dealers, direct sales to farmers, etc.), and the most common cover crop species sold now and 5 years ago in Indiana. Other questions were to determine industry expectations for cover crop seed sales in the next 5 years in Indiana. Another survey section explored factors that seed companies believe would improve the Indiana cover crop seed market the most (factors range from seed production-side issues to consumer-side issues). Seed company managers were asked about what

publicly available research topics they believe would be most useful to the industry. And finally, the survey asked what are the primary reasons that the seed industry believes that farmers (a) utilize cover crops and (b) are the primary barriers to cover crop adoption in Indiana.

METHODS AND DATA

During summer 2018, we utilized the Dillman Tailor Design Method (Dillman et al., 2009) and conducted a mail-out survey with a Qualtrics online survey option (survey questions were the same in both modes). Iowa State University's Institutional Review Board approved the research protocol and methods. An introductory letter was mailed, followed by a booklet-type questionnaire, and a return stamped envelope for the completed survey. The initial survey mailing included a Qualtrics link for those who preferred this option. Follow-up reminder postcards were sent out two weeks after initial mailing; again an online link was provided. We sought data from an initial list of 226 national seed dealers located throughout the U.S. Midwest who were licensed to sell seed in the state of Indiana (as per the Office of Indiana State Chemist). A total of 36 dealers returned a survey. Only 19 of those who responded, however, sold cover crop seed in 2017. Based on follow-up phone calls to verify if a seed company sold cover crop seed in Indiana, we have an adjusted list of 151 known or potential Indiana cover crop seed dealers; the adjusted response rate is estimated to be at least 13% (Wiseman, 2003). Despite the relatively low response rate, we believe that our findings are still broadly informative regarding the cover crop seed industry. The results are presented as response frequencies and other descriptive statistics.

RESULTS

Respondent Characteristics, Seed Sales, and Demand Expectations

Most of the respondents (~40%; $n = 8$) are cooperative seed companies, 35% ($n = 6$) describe themselves as independent seed dealers, and the remaining respondents ($n = 5$) are wholesale seed distributors or retail seed dealers. The respondents have on average sold cover crops in Indiana for

about 13 years; as such they have a significant amount of experience within the industry. These seed dealers procure cover crop seed from a number of different sources in any given year (depending on the species and the volume sold). In 2017, about 35% of the seed sold in Indiana by the respondents was purchased on contract from individual farmers within the state of Indiana, 31% from farmers in adjacent states, about 22% of the seed was purchased online from national seed distributors, and 12% of the seed was grown and harvested from company-owned farmland.

In all, at least 18 different species of cover crops were sold in Indiana in 2017. The top five cover crops sold in Indiana in 2017 by these seed dealers were: cereal rye (*Secale cereal*; 25% of total sales), spring oats (*Avena sativa*; 19%), winter wheat (*Triticum aestivum*; 14%), annual ryegrass (*Lolium multiflorum*; 11%), and hairy vetch (*Vicia villosa*; about 6%). Survey respondents sold an estimated 6.34 million pounds of seed. Assuming just the top five most sold species, based on weighted sales per species plus average seeding rate per species in Indiana (as per the Midwest Cover Crops Council cover crop decision tool, <http://mccc.msu.edu/2011>), and assuming uniform planting conditions, this accounts for roughly 164,000 acres of cover crops. Based on reported total seed sales, we estimate that the dealers who responded to our survey supplied the seed for somewhere between 15 to 20% of the 936,000 acres of cover crops planted in 2017 (ISDA, 2018). Historically (prior 3 years, 2014–2016), our respondents indicated that cereal rye had been the primary cover crop sold, followed by winter wheat and a tie between spring oats and annual ryegrass.

The majority of seed dealers surveyed (63%; $n = 12$) sold their 2017 cover crop seeds directly to farmers/landowners, with another 19% ($n = 4$) selling their seed directly to retail outlets. Another 12% ($n = 2$) of the respondents split their seed sales to cooperatives and to farm management agencies. One dealer sold seed primarily to an NGO outlet.

Sixty-three percent of the respondents ($n = 12$) believe that sales for cover crop seeds over the next 5 years in Indiana will increase. Seventeen percent ($n = 3$) believe sales will increase significantly. One respondent believed demand would remain the same, and two respondents “don’t know” what

seed sales will do over the next 5 years. In response to this expected increase in seed demand, seed dealers variously noted in an open-ended question the following individual actions they intend to take (in no particular order):

- Increase contracted cover crop seed production and invest in seed handling and storage capacity to ensure their seed supplies of key species are adequate to the increase in demand (this was in essence the most common seed dealer response);
- Increase direct interaction with farmer clients (direct sales);
- Become more active with local/regional awareness events like workshops and seminars and participate in cover crop demonstration field days so as to have more face-to-face contact with farmers and their advisors;
- Provide in-house incentives for customers who purchase cover crop seed;
- Create marketing materials that specifically promote the soil health and compaction management benefits of cover crops.

Cover Crop Seed Industry Needs

Seed dealers were asked to choose from a list the top three factors they believed would improve the Indiana cover crop seed market the most. The top three most selected responses were: (1) continued financial incentives for cover crop use (e.g., USDA EQIP) (28% selection rate); (2) improved customer knowledge of cover crop management (20%); and tied for (3) reduced seed production costs (15%), and broader support of cover crop usage from commodity groups (15%). Other topics receiving interest are policy and infrastructure-related factors including crop insurance flexibility (13%) and availability of technical support and custom labor. [Table 1](#) summarizes the findings and the other factors considered.

Seed dealers were then asked to select from a list what they believed to be the top three topics of publicly funded/available research that would be most useful to the cover crop industry in Indiana. The top three selected research topics were: (1) better understanding of the factors that influence farmer cover crop adoption (31% selection rate); (2) cover crop impacts on field profitability

Table 1. Factors that seed dealers believe would improve the Indiana cover crop seed market the most. $N = 16$; 40 choices made.

Factors that would improve the Indiana cover crop seed market	Percent selected ¹
Financial incentives for farmers to use cover crop (e.g., government conservation program money)	28%
Customer knowledge of cover crop management	20%
Reduced seed production costs	15%
Support of cover crop usage from commodity groups	15%
Crop insurance flexibility	13%
Technical support for farmers (for cover crop establishment and management)	8%
Availability of custom labor	3%
Seed availability for desired species	0%
Managing regional seed demand-supply imbalance	0%

¹ Does not sum to 100%; respondents could select up to three responses.

(26%); and (3) understanding the long-term soil benefits of cover crops (25%). **Table 2** summarizes the findings and the other factors considered. Other topics that received some interest were largely seed or seed mix related and included increased seed production (7%), seed germination (5%), seed purity (5%), and weed seed content (2%).

Seed Dealer Views on Farmer Benefits and Barriers

Seed companies were asked for their opinions regarding various field and farm benefits of cover crop adoption, and challenges that they see as the primary barriers to farmer adoption of cover crops. Regarding the benefits of cover crops, the respondents were asked to choose from a list the main three primary reasons why farmers use cover crops. Dealers selected as the most common reasons that farmers use cover crops: (1) improved overall soil health (23% selection rate); (2) erosion control (21%); and (3) for long-term economic benefits (16%). Other noted factors included increased organic matter (9%),

Table 2. Publicly funded/available research topics that seed dealers believe would be most useful to the Indiana cover crop seed industry. $N = 16$; 41 choices made.

Research topics	Percent selected ¹
Farmer cover crop adoption	31%
Cover crop impact on field profitability	26%
Long-term soil benefits of cover crops	25%
Increasing seed production	7%
Seed germination	5%
Seed purity	5%
Noxious weed content	2%
Breaking seed dormancy	0%
Seed conditioning techniques	0%
Seed storage innovations	0%

¹ Does not sum to 100%; respondents could select up to three responses.

Table 3. Primary reasons why farmers use cover crops according to cover crop seed dealers. $N = 16$; 43 choices selected.

Reasons why farmers use cover crops	Percent selected ¹
Improved overall soil health	23%
Erosion control	21%
Long-term economic benefits	16%
Increased organic matter	9%
Reduced compaction	9%
Grazing opportunity	7%
Weed control	7%
Improved off farm water quality	5%
Better farm management	2%
Increased yields	0%

¹ Does not sum to 100%; respondents could select up to three responses.

reduced soil compaction (9%), grazing opportunity, and weed control. The one listed factor that involves a specifically off-farm benefit, off farm water quality improvement, had a selection rate of 5%. **Table 3** summarizes the findings and the other factors considered.

Likewise, the respondents were asked to choose from a list what they believed to be the three primary barriers that farmers face relative to cover crop adoption. The top three selected factors were: (1) the cost of seed (25% selection rate); (2) time and labor required for planting and increased management (20%); and tied for (3) determining the right cover crop species for their operation (12%) and the potential time-delayed planting of the following cash crop (12%). Other noted potential barriers to cover crop adoption included: no measurable economic returns when using cover crops (10%), cover crop may become a weed in the following season (10%), and the costs of planting and terminations are too high (7%). [Table 4](#) summarizes the overall findings.

Table 4. Barriers that seed dealers believe that farmers face relative to cover crop adoption. $N = 16$; 41 choices made.

Barriers that farmers face relative to cover crop adoption	Percent selected ¹
The cost of seeds	25%
Time/labor required for planting and increased management	20%
Figuring out the right cover crop species for my operation	12%
Potential for delayed planting of the following cash crop	12%
No measurable economic returns when using cover crops	10%
Cover crop might become a weed in the following year	10%
Cost of planting and managing cover crops is too high	7%
Insufficient farmer knowledge of cover crop establishment/ termination	5%
Cover crop seed availability	2%
Cover crops sometimes use too much soil moisture	0%
Yield reduction in the cash crop following cover crop	0%
Cover crops increase overall crop production risk	0%

¹ Does not sum to 100%; respondents could select up to three responses.

DISCUSSION

Cover crops are a heavily featured Best Management Practice in midwestern state-level nutrient reduction strategies (Christianson et al., 2018). Yet current levels of cover crop adoption in midwestern states lag well behind the scale of use that is recommended by these strategies (e.g., IDALS et al., 2017). If cover crop adoption is to increase to scales relevant to broad regional goals, coordinated investment in the social and market infrastructure that supports an expanding cover crop industry will be required (Runck et al., 2020). As such, the primary goal of this survey is to provide insights from the cover crop seed dealers who participated as to how the industry has responded to current seed markets and what they believe the future holds regarding cover crop seed demand. The majority of seed dealers who responded to this survey (63%; $n = 12$) anticipate an increase in cover crop seed demand in Indiana over the next 5 years, and consequently about a third of the respondents listed various individual business decisions they intend to explore to better position themselves in the market.

One of the responses to this expected increase in seed demand that was noted by our survey respondents was to work directly with their seed growers and other suppliers to plan for an increased production of seed across desired species of cover crop. It is the opinion of the authors that a distinct challenge for seed dealers who wish to do this is the lack of key information to guide their demand projections. As noted in Longbuco and Porter (2019), farmers do not typically plan cover crop seed purchase via prepaid ordering the same way they plan for cash crop seed purchase. Likewise, there often is very limited information exchange with agencies such as the USDA Natural Resource Conservation Service regarding the county-level availability or scale of next season's cost-share program funding or new outreach initiatives that may influence conservation interest (Regional Seed Dealer 1, confidential personal communication, 2019). Seed companies tend to plan supply stocks simply based on sales from previous years, which does not allow for adjusting supplies relative to a potential increase in volume. Seed dealers are likewise at a supply disadvantage when there is interest in a new species of cover crop, when

the previous year's weather impacts seed yields, or when there is a change in cost-share payment and availability (Regional Seed Dealer 2, confidential personal communication, 2019). These confounding factors possibly help explain why short supply of cover crop seed has been a chronic issue in U.S. midwestern states (Brooks, 2019; Queck-Matzie, 2019; White, 2014). These factors are a challenge relative to farmers simply procuring appropriately sourced seed of the desired species, but also relative to the absolute cost of available seeds. Bergtold et al. (2019) observed that because purchasing cover crop seed is an annual event, if the cost is too high or volatile, farmers may seek more stable alternatives or reject conservation altogether.

Respondents to the survey stated that to better handle an increased volume of sales and seed, they would look to invest in expanding or improving the seed handling and storage capacity of their facilities. Expanded or updated onsite infrastructure can help seed companies manage variable and often uncertain demand conditions as most cover crop seeds can remain viable for 3–5 years with appropriate storage facilities and controlled conditions (McLeod, 1982; Roos, 1986). Uncertainty in seed demand, however, adds risk to this type of investment. If cover crop seeds need to be stored for sale in subsequent years because of mismatched supply and demand, there can be opportunity costs associated with available storage space if the cover crop seed has a lower value than other seeds sold (Larson, 2019). Enhancing facility capacity and increasing seed procurement arrangements are related issues and are, as noted prior, impeded by lack of key information to guide demand projections. This suggests that stakeholders such as government agencies (e.g., USDA NRCS), industry groups, NGOs, and seed dealers and allied industry partners should actively seek out ways to foster more communication.

Another idea that seed dealers mentioned in the survey is that they can become involved in direct marketing events such as field days and on-farm demonstration events. Demonstration via field days as outreach has long been recognized as a way for extension and technical advisors to network with partners, stakeholders, and potential clients/customers while “selling” ideas, techniques, and products (Dromgoole et al., 2018; Maddy et al., 2015). Demonstration of cover crops on working

farms can be useful for displaying or observing longer-term emergent qualities of continued cover crop use such as improved soil tilth, or reduced erosion, as well as pragmatic decisions such as requirements for use, timing of seeding, and cover species options (Singh et al., 2018). Likewise, seed dealers and other sales-oriented entities play important roles in extending advice and guidance directly to farmers (e.g., Houser et al., 2019; Prokopy et al., 2014). As such, seed dealers may well create their own outreach and educational materials promoting certain benefits of the cover crops they wish to sell, thus perhaps having some influence and perhaps a modicum of predictability on the seeds that will be demanded in the future.

In this survey cover crop seed dealers were asked to identify various factors they believe would benefit the cover crop seed industry the most, research topics that would be most beneficial to the industry, reasons they believe farmers adopt cover crops, and what they believe to be the primary barriers to adoption. Perhaps not surprisingly, there appear to be a number of overlapping and complementary opinions, all of which provide insight into how the cover crop seed industry might manage uncertainty in navigating increased seed demand.

The primary factor that would benefit the seed industry noted by respondents to this survey is the availability of financial incentives to farmers to facilitate cover crop adoption. The added direct and labor cost of establishing and terminating cover crops is routinely noted in supporting literature as a primary barrier to adoption (Bergtold et al., 2019; Myers & Watts, 2015; Roesch-McNally et al., 2017). Offsetting or reducing this cost constraint to farmers and landowners is one of the primary goals of conservation cost-share programs (Reimer et al., 2018). Some studies have noted that incentive payments can be very influential in the initial decision to use conservation practices in general (e.g., Reimer et al., 2012) and cover crops specifically (Roesch-McNally et al., 2017). These payments can also be important relative to long-term continued use or maintenance of conservation practices including cover crops, because private benefits of adoption tend to emerge slowly over time, and the practice may therefore have (or appear to have) high upfront costs relative to benefits (Bowman & Lynch, 2019).

A number of sources provide farmers with financial incentives for cover crop use in the United States. Cover crop incentive payments are often available through state agencies typically in partnership with local soil and water conservation districts (ISDA, 2021). From federal sources, the two primary cost-share programs available to farmers based on total expenditures are the USDA Natural Resource Conservation Service's Environmental Quality Incentive Program or EQIP (Sawadgo et al., 2019) and to a lesser degree, the Conservation Stewardship Program (CSP). Relative to cover crops, a challenge of these incentive programs is consistency. The scale of payments and program parameters of these two programs vary from state to state and year to year (Meyers et al., 2019). In most cases neither EQIP nor CSP payments cover the full private costs of establishing and terminating cover crops (Meyers et al., 2019; Roley et al., 2016). EQIP cover crop payments per acre in Indiana have changed every year since 2015. Beyond offsetting direct cover crop costs, conservation programs help provide the technical advice that seed dealers in our survey believe is needed to increase farmer knowledge relative to cover crop establishment and management, thus reducing the perceived risk of managing farm fields with cover crops, and in some cases lowering overall cover crop costs or preventing additional mismanagement costs (Dunn et al., 2016; Roesch-McNally et al., 2017).

Seed dealers also noted in the survey that keeping the costs of seed production low is an important factor. Cover crop seed production is done on a very small scale relative to cash crop seed production and tends to be a side business for farmers who grow seed (Gross, 2011; Runck et al., 2020). As such, managing costs of production via capital investment can be particularly risky. There are a number of uncertain cover crop seed production factors that can increase the costs of production. The timing of cover crop seed production is often complicated by weather and the needs of the primary cash crop system. Additionally, as with any crop grown for salable volume, production inputs such as fertilization and pest management are utilized, and opportunity costs associated with alternative land use opportunities exist; all of these costs can vary annually. Harvest equipment is also required and equipment needs

are often complicated when the seed of multiple cover crop species is being harvested. Small crop industries tend to have less information, production support, services, and infrastructure that can be utilized to manage production and financial risk (Bower, 2019; Longbucco & Porter, 2019). When production costs increase, these increases are more readily passed on to the end users, and in this case will increase the price of cover crop seed to dealers and then to farmers.

Dealers also indicated in the survey they would like to see more support or encouragement from commodity groups for cover crop adoption. This aspect may become more important over time because as Carlisle et al. (2019) discuss, significant private investment in infrastructure for seed production support and services will be required and commodity or industry groups are often well positioned to provide this, particularly in partnership with NGOs and governmental entities. Furthermore, direct industry participation ties into new policy models that view agricultural extension as a process that necessarily involves all relevant end users including supply chain representatives (Rose et al., 2019). In practice, commodity group involvement in public-private partnerships that are centered on watershed-scale conservation efforts is evident in large-scale cover crop demonstration and research projects in northeastern Indiana (e.g., Hallett et al., 2017).

In the survey, seed dealers weighed in on desired research topics that they believe would benefit the cover crop seed industry and farmers alike. The primary research topic noted by survey respondents was related to farmer adoption of cover crops. Other key research topics that seed dealers noted in the survey are centered on better understanding field-level financial benefits and the underlying beneficial soil dynamics that dealers believe are the primary motivating factors for farmer adoption and long-term use of cover crops.

Like the seed dealers who responded to the survey, most researchers who conduct conservation adoption research conclude that more research is required so as to better understand the decision process and informational needs of farmers and other stakeholders (Prokopy et al., 2019). Based on conservation meta-analyses, the factors that influence farmer adoption of cover crops (and other conservation practices) are

decidedly complex and involve more than just financial concerns, though cost as well as time/labor constraints appear universal (e.g., Liu et al., 2018; Prokopy et al., 2019). The utility of research regarding farmer decision making and conservation adoption is myriad. Extension and outreach professionals often point out that understanding specific farmer motivations and concerns (for example about cost, profitability, risk, stewardship) and the more nuanced factors such as beliefs and attitudes about conservation is critical information for framing extension programming and targeting outreach to best address specific as well as general issues alike (Arbuckle et al., 2017; Daloglu et al., 2014; Jennings et al., 2012).

Research studies that reveal key financial implications of cover crop usage are in demand not just by the seed dealers who participated in this research, but also by farmers broadly speaking and can be critical to the initial adoption of cover crops and their prolonged use (Roesch-McNally et al., 2017). Yet translating field-level benefits associated with the use of cover crops into financial outcomes is a complex analysis. This is because field-level benefits associated with soil health or field management are complex in space and time and often difficult to define, isolate, measure, track, and monetize (Bergtold et al., 2019). Part of the challenge is that benefits are a function of emergent biophysical and microbial interactions within the soil that may take years to manifest or may be most noticeable in extreme situations such as drought or on highly erodible land. Additionally, the level of benefit changes based on field conditions or commodity market trends (Snapp et al., 2005). Nevertheless, there are research techniques that provide insight into the potential whole field benefits that farmers and landowners may variously experience while using cover crops (Bergtold et al., 2019; Plastina et al., 2018; Thompson et al., 2020).

As noted, important to exploring the financial effects of cover crops is understanding the underlying biophysical soil-process dynamics. The seed dealers in this study appear to recognize this research topic as being equally important as financial assessment. Additionally, because many of the field-level benefits that may accrue to a cover cropped farm field are due to emergent soil physico-chemical processes and dynamics

associated with long-term use of cover, this type of research can help guide financial incentive-based policy mechanisms that foster a longer-term perspective on cover crop usage (Bowman & Lynch, 2019; Roesch-McNally et al., 2017).

Finally, the seed dealers in this study weighed in on what they believe are the primary reasons farmers adopt cover crops and the primary barriers to adoption. Primary reasons for farmer adoption are field-level soil health and reduced erosion outcomes that farmers directly and/or indirectly benefit from in both the short- and long-term. This finding parallels how the USDA NRCS changed their policy and programming in 2012 to promote a Soil Health Initiative that is centered on farmer education regarding practices (such as cover crops) that promote key aspects of soil health so as to sustain productive soils, maintain crop yield, and minimize cash crop management costs (Roesch-McNally et al., 2018). Interestingly, these seed dealers did not overwhelmingly believe that the off-farm benefit of water quality improvement was particularly important to farmers. This finding that private benefits outweigh public benefits as a motivating factor parallels findings from farmer-oriented studies of conservation actions (e.g., Zimmerman et al., 2019). Regarding perceived barriers to cover crop usage, seed dealers identified in the survey two primary issues that are related to the various factors they believe would improve the cover crop seed market and are pragmatic in nature: the cost of seed and the amount of time and labor required for planting and increased management.

CONCLUSIONS

Seed dealers play a unique role in vegetation-based conservation practices such as cover crops, not just because they are often trusted facilitators and arbiters of information and guidance (e.g., Prokopy et al., 2014), but also because their business actions can strongly influence available conservation opportunities, management options, and direct cost to farmers. The respondents to this survey offered their opinions regarding a number of issues that would help their business viability in a sustainable way while promoting farmer adoption of cover crops and their long-term commitment to the practice.

This research points to ways that a number of interconnecting facets can come together so as to benefit all partners in conservation broadly speaking, and with regard to cover crops specifically. The better communication and connection that seed dealers have with entities that can help forecast seed demand and informational needs regarding species and management options (e.g., NRCS) will better position seed dealers to work with seed-producing farmers and other modes of seed supply, plan capital investment for infrastructural enhancement and outreach programming, and broadly endeavor to keep the cost of cover crops seed as low as the market will allow. Furthermore, the more informed and connected seed dealers are with industry partners (e.g., conservation agencies, seed producers, farmers, professional outreach entities), the better they in turn can help facilitate conservation interest and use of existing incentive funding, but also guide future funding needs, opportunities, and support the consistency of cover crop usage.

Regarding beneficial research, as noted in Groff (2015) it is difficult for cover crop seed companies to balance the business and capital needs of their retail or wholesale enterprise while at the same time investing in research that broadly promotes the use of cover crops. Rather, the insights of seed dealers such as those presented in this research can help support evolving research agendas and guide investment needs and partner opportunities. Because there is remedial immediacy in conservation needs in the U.S. Midwest, and there are expectations that seed demand will increase in the short run, it is important that investment and research integrate synergistic relationships as articulated above, for example understanding farmer conservation motivations, quantifying field-level financial benefits and the emergent soil dynamics that underlie them, and creating market and industry infrastructure that broadly supports expanded use of cover crops.

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NOTE

1. The 2017 USDA Census of Agriculture questionnaire defined cover crops by asking respondents, "During 2017, considering the cropland acres on this operation, how many acres were planted to a cover crop? (Cover crops are planted primarily for managing soil fertility, soil quality, and controlling weeds, pests, and diseases.) Exclude CRP" (Appendix B, p. B-30).

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