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The trouble with cover crops: Farmers' experiences with overcoming barriers to adoption

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Abstract

Cover crops are known to promote many aspects of soil and water quality, yet estimates find that in 2012 only 2.3% of the total agricultural lands in the Midwestern USA were using cover crops. Focus groups were conducted across the Corn Belt state of Iowa to better understand how farmers confront barriers to cover crop adoption in highly intensive agricultural production systems. Although much prior research has focused on analyzing factors that help predict cover crop use on farms, there is limited research on how farmers navigate and overcome field-level (e.g. proper planting of a cover crop) and structural barriers (e.g. market forces) associated with the use of cover crops. The results from the analysis of these conversations suggest that there is a complex dialectical relationship between farmers' individual management decisions and the broader agricultural context in the region that constrains their decisions. Farmers in these focus groups shared how they navigate complex management decisions within a generally homogenized agricultural and economic landscape that makes cover crop integration challenging. Many who joined the focus groups have found ways to overcome barriers and successfully integrate cover crops into their cropping systems. This is illustrated through farmers' descriptions of their 'whole system' approach to cover crops management, where they described how they prioritize the success of their cover crops by focusing on multiple aspects of management, including changes they have made to nutrient application and modifications to equipment. These producers also engage with farmer networks to gain strategies for overcoming management challenges associated with cover crops. Although many participants had successfully planted cover crops, they tended to believe that greater economic incentives and/or more diverse crop and livestock markets would be needed to spur more widespread adoption of the practice. Our results further illustrate how structural and field-level barriers constrain individual actions, as it is not simply the basic agronomic considerations (such as seeding and terminating cover crops) that pose a challenge to their use, but also the broader economic and market drivers that exist in agriculturally intensive systems. Our study provides evidence that reducing structural barriers to adoption may be necessary to increase the use of this conservation practice to reduce environmental impacts associated with intensive agricultural production.

Key words: cover crops, agency and structure, U.S. Corn Belt, conservation decision making

Introduction

Cover crops have the potential to improve environmental outcomes and enhance crop diversity in agricultural systems, particularly in the context of intensive commodity production in states such as Iowa, where more than 90% of the harvested cropland is annually planted to monoculture fields of corn (*Zea mays* L.) or soybean [*Glycine max* (L.) Merr.] (NASS, 2014). Crop production in the region typically follows a corn–soybean rotation over the course of

Table 1. Overview of main field activity timing during a corn–soybean crop rotation with an annual winter cover crop.

	Spring			Summer			Fall		
	March	April	May	June	July	August	September	October	November
Year 1		Plant cash crop (corn or soybean)					Harvest cash crop (corn or soybean)[1]		
							Plant cover crop: aerial or broadcast method	Plant cover crop: drill after harvest	
Year 2 corn		Plant corn[1]					Harvest corn		
	Terminate cover crop[2]						Plant cover crop: aerial or broadcast method	Plant cover crop: drill after harvest	
Year 3 soybean			Plant soybean Terminate cover crop[2]				Harvest soybean		

[1] Other field activities during this time period may include tillage or fertilizer and manure applications.
[2] It is generally recommended that to avoid yield impacts, corn should be planted 10–14 days following cover crop termination, while soybean can be planted much closer to termination (Singer et al., 2005).

2 years, but there are farmers who have fields that are in continuous corn production. Cover crops are currently being promoted heavily across the U.S. Corn Belt to address soil and water quality issues (NWF, 2012; IDALS, 2014; ISUEO, 2014; MCCC, 2014) and are recommended to meet the Environmental Protection Agency's efforts to reduce hypoxia in the Gulf of Mexico (NTF, 2013).

Winter-planted cover crops are considered an in-field best management practice, which does not typically require taking land out of cash crop production. They are usually planted after the harvesting of cash crops, with planting generally occurring in the fall and followed by mechanical or chemical termination before the planting of a summer cash crop (Schnepf and Cox, 2006). In the Upper Midwest, the timing of cover crop planting and termination quite often coincides within a small management 'window' that includes other critical field activities such as cash crop harvest and planting (Table 1).

The use of an overwinter plant in a corn–soybean cropping system provides in-field benefits such as erosion prevention, improvements in soil quality and nutrient retention (Schnepf and Cox, 2006; Kaspar and Singer, 2011) while contributing to landscape scale environmental benefits such as decreasing sediment and nutrient transport and reducing water pollution (Kladivko et al., 2014). In Iowa, it is estimated that cover crops were only used on 1.6% of cropland hectares during 2012 (NASS, 2014), which is a notably low level of use across the landscape given evident agronomic and environmental benefits.

To better understand the adoption and sustained use of cover crops, there have been increasing numbers of social science research papers (Singer et al., 2007; Bergtold et al., 2012; Reimer et al., 2012; O'Connell et al., 2014; Arbuckle and Roesch-McNally, 2015; Dunn et al., 2016) focusing on predicting the use and adoption of cover crops by examining the dynamics and characteristics of farmers and their operations. There is, however, a broader need to understand the specific ways that cover crop adoption occurs in agriculturally intensive regions such as Iowa (Carlson and Stockwell, 2013). In particular, there is limited qualitative research on how farmers navigate and overcome field-level management issues (e.g. proper planting of a cover crop) as well as more structural (e.g. market forces) barriers associated with the use of conservation practices such as cover crops. Although prior cover crop research has improved understanding of the factors that lead producers to adopt the practice, there is limited research describing the strategies that allow farmers to successfully overcome barriers and learn to manage cover crops effectively (Carlson and Stockwell, 2013). Such research is needed to understand what policy and outreach interventions might help encourage wider use of this conservation practice to take advantage of the landscape and field-scale benefits that they offer.

Our research questions include:

- What field-level and structural barriers exist that prohibit wider on-farm adoption of cover crops?
- What management approaches do cover crop users employ that enable them to overcome barriers to cover crop adoption?

Identification of barriers to cover crop use, at the field and structural levels, will provide a more complete understanding of the obstacles that may be preventing greater use of cover crops across Iowa. Additionally, examination of innovative strategies that farmers use to overcome these barriers may help illuminate approaches that can inform more effective outreach and policy efforts to facilitate greater use of cover crops.

Literature Review

The use of cover crops is not considered to be a radical or transformative technology nor does the practice require farmers to dramatically change their choice of annual cash crop because cover crops are typically grown during fallow periods. The use of a cover crop does, however, require a farmer to work against dominant practices for the region and can carry an economic cost for farmers who adopt them (Bergtold et al., 2012). First, a farmer must alter their management practices in the fall and in the spring in order to successfully integrate the cover crop with their cash crop system (see Table 1); this can discourage farmers from continuing to utilize cover crops over multiple seasons (Dunn et al., 2016). Next, seeding and terminating cover crops represent additional direct management costs without predictable yield benefits (unlike, e.g, the direct benefits to yield associated with nitrogen fertilizer application) (Bergtold et al., 2012). Therefore, the use of a cover crop in this context can be in conflict with the current system of production that seeks to minimize production costs associated with a single crop in a particular growing year (Roley et al., 2016).

In the context of conservation practice adoption, including the use of cover crops, farmer decision making is shaped by tensions between agency and the broader structural influences that dominate the conventional agricultural system in the Corn Belt (Duram, 2000). According to Duram, 'agency refers to individuals or groups of individuals whose actions are based on their perceptions and past experiences' (see p. 36). Farmers exercise their agency within the agricultural system through a 'creative improvisation and real-time management of variability and stochastic events in social, technical or ecological realms' (Crane et al., 2011, p. 180). These farm-by-farm decisions, in turn, aggregate into land use patterns that have implications at watershed scales. Nevertheless, these decisions are constrained by more structural influences, such as availability of alternative markets, land tenure security, facilitating infrastructure related to farm equipment and other capital investments, which limits famers' ability to make decisions as well as the extent that changes are, or perceived to be, possible at field and farm scales. Structural drivers can be understood as the 'enduring economic, political and social factors that limit human actions' (Duram, 2000, p. 36). In this way, farmer decision making could be considered a form of 'embedded agency' whereby farmers are 'constrained, but also enabled by institutional structures, which in return, are socially [re]constructed by them' (Fuenfschilling and Truffer, 2014, p. 776).

Decision making, in the context of natural resource management, can also be marked by tensions between formal rationality, which is the quantitative calculation of benefits and costs, and substantive rationality, which incorporates other 'ultimate values' such as ethical, political, cultural and normative factors (Weber, 1978). While farmers make economically motivated decisions based on benefits and costs, these are not always the most important factors that farmers take into account when assessing their use of conservation practices (Chouinard et al., 2008; Thompson et al., 2015). Farmers' ability, however, to shift production practices is shaped by many factors at the farmer and farm levels and a complex milieu of broader structural drivers such as markets and policy conditions (Duram, 2000; Stuart and Gillon, 2013; Blesh and Wolf, 2014). Further, when farmers are engaging in decision making around conservation behavior, they must attempt to reconcile profit maximization with stewardship goals (McGuire et al., 2013; Thompson et al., 2015).

At the individual farmer level, a farmer's decision to integrate conservation practices such as cover crops are driven by individual and farm-level characteristics. Reimer et al. (2012) noted that key drivers in the adoption of practices such as cover crops can be farmer interest in improving soil health and fertility, compatibility of cover crops with current systems of production, and relative advantage of cover crops over alternative practices. Farmers who have utilized cover crops have reported minor increases in corn and soybean yields and further cited improvements to soil health, soil organic matter and reduced erosion as major benefits of the practice (CTIC, 2015, 2016). Farmers that integrate diversified crop rotations into their systems (e.g. including third and fourth crops in addition to corn and soybeans) are also more likely to utilize cover crops (Singer et al., 2007; O'Connell et al., 2014; Arbuckle and Roesch-McNally, 2015). Integration of livestock is also an important factor in driving cover crop use as cover crops enhance forage opportunities for many livestock operations (Singer et al., 2007; Arbuckle and Roesch-McNally, 2015).

At a structural level, a major factor that may influence adoption of cover crops is the historic and normative trend toward industrial, commodity-oriented monoculture systems (Blesh and Wolf, 2014) across the Midwest. The homogeneity of the agricultural land use and the resulting land cover in Iowa is part of a historic trend of economic specialization and subsequent narrowing of land use diversity. This trend has manifested in an increase in row crop hectares (Lark et al., 2015) and farm size with less land devoted to small grains (Hatfield et al., 2009; Brown and Schulte, 2011), decreasing pasture (Stuart and Gillon, 2013), associated with increases in concentrated animal feeding operations and declines in grazing operations over the last several decades (Sulc and Tracy, 2007). These cropping trends are, in turn, mirrored by an increase in confinement-based animal feeding operations that are no longer dependent on forage or pasture-based systems (Welsh et al., 2003; Honeyman and Duffy, 2006). Taken together, these factors have led to an overall reduction of crop

diversity and mixed crop–livestock systems in Iowa, which makes the integration of cover crops more challenging. The context of this dominant production system, characterized by the trend of further homogeneity at the field and landscape scale, also influences and is influenced by regional cultural norms (e.g. production practices common in the region). These norms tend to be self-reinforcing, ultimately framing what farmers may consider to be potential opportunities or reasonable changes to their current production systems (Nerbonne and Lentz, 2003; Carolan, 2006), which may also disproportionately affect farmers who rent from landlords who are not as supportive of cover crop integration (Dunn et al., 2016).

Methods

In order to examine the research questions of interest, four focus groups were conducted across the state of Iowa. Focus groups are a qualitative research method that can be more cost effective than individual interviews and also provide researchers with insight into cultural and social norms as well as interactions between participants (Warr, 2005). Focus group research allows for in-depth exploration of social phenomena through semi-structured discussions conducted in a group setting. The focus group approach was implemented for this study because the research team believed that guided discussions about cover crops with groups of farmers would lead to a detailed understanding of factors that influence farmers' use and adoption of cover crops. Farmer participants were recruited during the spring of 2014 using a snowball sampling method for recruiting within existing farmer networks. Existing networks included the Practical Farmers of Iowa (http://www.practicalfarmers.org), Iowa Learning Farms (part of Iowa State University Cooperative Extension and Outreach) and USDA-Natural Resources Conservation Service regional offices. In order to facilitate a conversation that would clarify varying perspectives on the barriers and facilitators of adoption, our aim was to recruit a mix of row-crop farmers in Iowa, including farmers who have experimented with cover crops on their farms. We hosted one focus group in each of four geographic regions in Iowa (Northwest, Southwest, Northeast and Southeast) to conveniently engage farmers from across Iowa.

Four focus groups were held in July of 2014, each lasting approximately 2 h. The focus group discussions were semi-structured, with the research team presenting for approximately 30 min of the 2 h and the other 90 min dedicated to a semi-structured discussion following an interview protocol. The focus group presentations provided information on the long-term benefits and challenges of managing a winter rye (*Secale cereale* L.) cover crop in a corn–soybean rotation, using agronomic data from a multi-year experiment (Kaspar et al., 2012; Basche et al., 2016a, b) as well as on-farm research across the state of Iowa (PFI and ILF, 2014, 2015). The goal of these presentations was to bring all participants to the same understanding of long-term cover crop impacts as studied by researchers in Iowa and to receive feedback from farmers about whether these data might inform their assessment and use of cover crops in their operation. It is common for researchers in focus groups to include stimulus material that participants are then asked for a response (Onwuegbuzie et al., 2009). The focus groups were moderated by a member of the research team and another member of the research team presented cover crop information in order to set out clearly defined roles during the focus group. The moderator asked the farmers to respond to the information provided as well as additional questions related to their perspectives on the barriers and benefits associated with the use of cover crops. Through these semi-structured focus group discussions, broader themes emerged that contributed to the analysis and research questions that we present in this analysis.

Focus group discussions were digitally recorded with participant consent (with Human Subjects approval) then transcribed verbatim. Analysis was performed using NVivo 10 software. We employed a hierarchical axial coding procedure following an inductive approach used to examine emergent concepts that came out of the focus group discussions (Corbin and Strauss, 1990). Our conversation with farmer participants brought forth concepts that enabled a deeper understanding of the primary barriers to cover crop adoption and strategies for overcoming these barriers. The main categories coded for in the analysis include field-level and structural barriers to cover crop adoption and creative approaches to management, which are fully examined in the results section. Intercoder reliability was assessed during initial rounds of coding by three members of the research team with high levels of agreement [a Cronbach's Alpha of 0.6 or greater was assessed for each major category (see Santos, 1999)]. Another three rounds of coding were completed using an iterative and reflexive coding system based on research team discussions and coding memos (Hruschka et al., 2004). As suggested in Prokopy (2011), we further illustrate themes and assure transparency in the analysis via the use of direct quotations from farmer participants.

Results

The four focus group discussions, held during the summer of 2014, included 29 total participants, 28 male and 1 female, with an age range of 40–60 years old, within the range of average age of farmers in Iowa, which is 57 years old (NASS, 2014). Sixty-nine percent of farmers solely utilized a corn–soybean rotation; 31% had a third/fourth crop and/or pasture in addition to

their corn–soybean rotation; and 50% also had livestock in their operations. Although corn and soybeans represent the majority of harvested acres in Iowa, it is estimated that some 38% of farms (NASS, 2014) in the state have some amount of pasture for livestock; however, grasslands, including perennial pasture is declining across much of the Corn Belt (Lark et al., 2015). Therefore, the focus group participants were generally similar to other corn and soybean producers in the state; however, given the small sample size and limitations associated with focus group data collection (e.g. self-selection bias among participating farmers), it is not appropriate to generalize the findings from this study to a larger population of Iowa farmers. Most participants (all but two) had experimented with cover crops previously, with degree of experience ranging from 1 year to 10 or more years, and all but three intended to use cover crops in the fall of 2014. Farmers reported that they were experimenting with cereal rye cover crops, in addition to different mixes of cover crops, typically including brassicas (e.g. tillage radish), legumes, or other grass species. Participants' farm size ranged from 16 to 600 hectares (ha), with a median of 120 ha, slightly smaller than the average size of farms in Iowa, which is 140 ha (NASS, 2014); however, when compared with the midpoint size of farms (estimated as 445 ha) in Iowa, these farmers were operating comparatively smaller systems (MacDonald et al., 2013).

We coded for two major categories in the qualitative data. The first category, barriers, includes both field-level agronomic challenges as well as broader structural barriers that are associated with the corn and soybean commodity-oriented system. Our second major category, approaches to management, represents efforts that farmers have taken to successfully integrate cover crops into their operations. Through the examination of the coding for these separate categories, it became clear that ideas discussed in the barriers and creative approaches to management sections were markedly similar. In other words, while barriers were frequently discussed, farmers were also able to indicate actions they had taken to overcome these barriers in their operation. This dynamic interplay between categories illustrates the dialectic between farmers' agency, as expressed in their creative approach to management, and the barriers that constrain their agency at both the field and structural levels. As such, we present results in this context. That is, farmer discussions that center on challenges to cover crop use and various creative approaches to management.

Challenges with cover crop management

Focus group participants discussed specific challenges they have had with integrating cover crops, some of which were more clearly related to the basic agronomic practices required for cover crop use (field-level), while others were associated with the broader infrastructure of the dominant corn–soybean cropping system in the state (structural drivers). One of the most frequently coded barriers in our analysis was that of difficulty in timing of management, particularly the challenge of establishing a crop in the fall and terminating it in the spring. Due to the average timing of corn and soybean harvest in Iowa, which can occur as late as the end of October or early November, focus group participants expressed concerns about not having enough time to get a cover crop planted in the fall in addition to worrying about not being able to terminate the cover crop in the spring, which might delay spring planting of their cash crop. Several farmers articulated these challenges,

- We've all identified that, when you need to put cover crop on, if it's after harvest, it's … not everybody has that time.
- It's not the perfect solution but it works [inter-seeding in standing corn] if the weather's right and, quite frankly, the weather hasn't been right the last 3 years, so I get a great stand in the spring but I don't get much established in the fall.

Management challenges associated with cover crop adoption, such as timing of establishment and termination, are driven, in a large way, by more structural forces that have to do with the dominant production system that is largely tied into continuous corn and corn–soybean rotations, which limit the planting of a fall-planted cover crop, such as winter rye. Most agricultural infrastructure in Iowa is geared toward production of corn and soybeans, so farmers perceived a lack of facilitating infrastructure for cover crops, which include markets for alternative crops and availability of equipment suitable for cover crop management. These structural barriers around infrastructure were commonly discussed during the focus group discussions, with specific focus on cover crop seed availability, markets for alternative crops (e.g. inclusion of wheat in the rotation to increase timing flexibility with establishment of cover crop) and availability of equipment. One farmer lamented that they wanted to integrate wheat in their crop rotation but were struggling with markets, 'I'm looking at bringing wheat into the rotation and you know, the sad part is our nearest market is Minneapolis…'

Specifically, some farmers discussed the need for greater diversification, including more diverse rotations or the re-integration of grazing livestock, as a necessary structural change that might help influence greater use of cover crops. According to one farmer who summarized this idea, 'making a cover crop work in a corn and soybean rotation is the trick for us. That's hard.' Other farmers express the need for more diversity all within the context of trying to better integrate cover crops in their operation,

- But you need livestock to make that work. I mean, they're using a Kura clover [cover crop] and, when you get clover established…And then third year,

you've got to let it recoup so you don't kill the clover out and they're doing it but you need livestock and that and that's kind of a hard sell around here.

- And if we could raise wheat anywhere like they do in Europe or some of these places, all of a sudden, you might have another viable cash crop there that would give you a lot of these cropping … these options that you can't do with oats, they don't get consistent yield enough but if you had something that would … that you could raise it with [your other cash crops], would get real good income the first time and then give you the rest of the summer to do other things. There's guys talking about maybe putting things into pasture.
- We need more species here. We're getting, you know, all corn and beans type. We could use something else. But somewhere I got to believe though when the demand gets there's going to be a lot of people talking about this.

Although focus group participants frequently addressed the field-level and structural challenges associated with implementation of cover crops, many farmer participants expressed ways that they had overcome these challenges in order to effectively integrate cover crops into their operations. It became clear that their approaches to management led to what they believed to be successful use of the practice. A major component of that success was revealed as these participants tended to view various challenges as management opportunities and as such, learned how to better integrate cover crops through a kind of trial and error approach. A key concept that these particular farmers discussed was a 'whole systems' approach to managing their entire operation, including cover crops. This was articulated by a farmer, who said,

- I look at it as a system. You got to do the whole system. You can't nitpick. You got to manage your nitrogen. You got to get good soil/seed contact cause you're planting into a mass of roots sometimes and you need to do everything. Just to do one piece? One piece…it doesn't work, they get discouraged and say that's no good and they're not going to do it anymore. You need to do everything.

Many of the farmer participants discussed how they had altered their management practices because they had seen the benefits of cover crops (e.g. erosion prevention, improvements to soil health and yield boosts), which had caused them to modify many other aspects of their management, including tillage practices and fertilizer application. Farmers also discussed changes they had made to their timing of management, including their seeding and tillage operations that worked better with the cover crops. A number of farmers also suggested that cover crops were not simply a new practice that could seamlessly slide into a corn–soybean system, but rather they required a more intentional management regime almost as if they were another cash crop.

Throughout the discussions, it was apparent that opinion leaders and conservation organizations informed these creative approaches to management. This appeared to be a very important strategy for how farmers were able to take a 'whole system' approach to their cover crop management. There were often long periods during the discussions when the research team did not need to ask follow-up questions because information on technical details, such as equipment settings and fertilizer application, were being exchanged between participants. The farmer comment below illustrates the point that without the support of a larger network, they would not have felt as comfortable experimenting with a different cover crop seeding method.

- Luckily, I've got a nice watershed [group] to work with. They come out. You want to try this experiment? Sure, we'll try it, you know. And so we did it [planted cover crop] in standing corn and standing soybeans.

Weighing the costs and benefits

During focus group discussions, farmers discussed the challenges associated with direct and opportunity costs associated with integrating cover crops. One frequently mentioned that the farm-level barrier was the direct costs of establishing and terminating cover crops (direct costs for cover crops in Iowa have been estimated to range from US$119 to 198 ha^{-1}, based on the 2015 rates, depending on seeding and termination methods according to Roley et al., 2016), as well as perceived opportunity costs due to uncertain cash crop yield effects. A farmer who articulated this challenge suggested that society needs to more fully bear the costs and potential benefits to adopting cover crops in order to facilitate adoption,

- Now it's getting cheaper now but what does it cost to establish that [cover crop]? Well I got a deal here. We can fly it on for US$45 an acre. Well then and what does it cost me to kill it? They've done the math before and without the incentives, the CSP program, last year's EQIP, last year's state of Iowa incentive programs, it's hard to put the math to cover crop unless you can put a number, a dollar value on that nitrate saved.

Historically high costs of production associated with the current production system tied up in corn and soybean rotations also came up frequently in the discussions as a structural constraint on adopting cover crops. Some participants recognized that at present, economic returns on production are low given high costs of inputs, including seeds, fertilizer and chemicals as well as historically high rental rates; therefore the additional costs of cover crops may be too costly for many producers. These structural challenges were well articulated by a number of farmers,

- … You know, that most of Iowa, or a great percentage, is rented. And it's really tough to put something on rented ground and spend another US$45.
- What's going to get you to use cover crops on a real tight margins [costs/income] year?… I'm looking at it as what most farmers are probably thinking and [asking] why didn't they do it when we had US$7 corn and now they're going to do it at US$3 corn?

Farmers also articulated that commonly held beliefs, or regional norms that emphasize maximizing output of key commodity crops (measured in yields per production area), can also negatively impact farmers' acceptance and adoption of conservation practices such as cover crops. Farmers noted that this influences landlords and custom operators and might serve to discourage, or at times, inspire, the use of cover crops, and that there are distinctly different incentives for landowners and lessees.

- So it's going to be really hard to be getting guys to be stepping up to the plate [to plant cover crops] after they've got a landlord holding them to a lease plus the drop in prices.
- We, as farmers don't even understand all that good stuff [associated with cover crops] so how do you expect the farm manager, who's just doing a commodity, buying and selling a commodity or processing it? … We need landowners out there that are demanding cover crops and willing to help fund it. And also why would you want, as a tenant, do you really want to go out and improve the soil so that the next time the cash rent auction comes around, the neighbors are going [say that] 'he's kind of improved that, I think we can bid that [cost of land] up?' Ya, you've shot yourself in the foot kind of.

Another distinct part of the cost conversation was concerns about reduced yields. For some farmers, this was a critical issue and they were very concerned about these impacts. The yield concern was expressed by a farmer who stated, 'I have not tried [cover crops] on soybeans going to corn and probably for obvious reasons….it could be a five bushel decline so that gives me a little bit of concern.' However for others, there was less concern about yield decline, and many producers who had been using cover crops noted that they had not experienced yield declines but instead saw improvements to their yield. For some farmers, the benefits of cover crops were seen as far outstripping their potential costs, finding a synergy of benefits to their production system, as evidenced by a farmer who claimed,

- The number one reason I do cover crops is for soil erosion. And then number two is for building the soil tilth. But I also don't want to give up yield. I don't necessarily think I'm going to increase yields by using cover crops but I want to make whatever management changes I have to make, [but] I definitely [don't want to] give up on yields and, you know, if we learn enough over the years we, hopefully, [are] "going to increase them [yields] too."

Finally, most focus group participants articulated a conservation ethic and a passion for soil protection as a way to provide long-term sustainability on their land, as expressed by two farmers,

- It's hard to sort out farming as a business and farming as a way of life and the stewardship of taking care of the asset and leaving it for the next generations to come, whether it's our own relatives or whether it's someone else. And you look at any farm that's got pictures that were taken 50–60 years ago, the erosion that's taken place on some of these, like farmstead pictures or whatever, it's just unbelievable the amount of dirt that's been going.
- And I think the cover crops really served as the kicker to get me thinking differently about, really, farming in general and to start thinking about something other than yield. If your medium is gone [soil], there's no point in farming… even if you're … I mean, [maybe] you're giving up five bushels 1 year, but you could be giving up your entire way of living in short order, 40 years maybe.

This reorientation in perspective, translated in their opinion that the benefits of cover crops to their farm operation outpace both direct and opportunity costs, is a clear way that these farmers overcame apparent barriers to integrating cover crops. Yet, these farmers were still cognizant that costs may be prohibitive for other farmers in the region without some kind of incentive, at least to provide an opportunity to experiment with cover crops and experience some successes before absorbing the costs themselves. Indeed, as one farmer said, 'most guys are going to not do it because it is US$30 an acre and they say, where's my US$30 return?'

Discussion

Farmers in our focus groups navigated complex barriers that make cover crop integration more difficult and yet many had found ways to overcome these barriers and had successfully incorporated cover crops in their operations. The results from these conversations suggest that there is a complex interplay between farmers' agency and the barriers that constrain their actions or the collective actions of others in their farming community. Our results further illustrate how structural as well as field-level barriers constrain individual actions, as it is not simply the basic agronomic challenges of seeding and terminating cover crops that pose a challenge to their use, but also a series of broader economic and market drivers. This interplay between farmer agency and structural barriers is further underscored by the reality that these individual decisions that farmers are making on their farms, which help them to overcome barriers to

adoption, do not fundamentally transform or reduce the broader structural barriers that might help other individuals adopt cover crops in the region. In other words, many of these farmers are doing little to dismantle structural barriers that might enable other farmers to more successfully integrate cover crops while simultaneously using their agency to successfully overcome barriers to adoption on their farms.

The dialectical relationship between agency and structural barriers described by our focus group participants is characteristic of Fuenfschilling and Truffer's (2014) concept of embedded agency, where actors are constrained and enabled by structural drivers that are reconstructed and, arguably, contested through an iterative approach to decision making. Farmer participants employed innovative cover crop management strategies as part of a whole system approach to overcome structural constraints such as a lack of facilitating infrastructure for alternative crops. However, it is clear that row crop farmers are embedded in larger commodity value chains that limit flexibility and shape the choices that they can make (Bartels et al., 2013). Prior research affirms that farmers can often feel constrained by larger barriers that 'exist beyond the farm gate' that shape farm management strategies (Bartels et al., 2013, p. S52). However, some farmers, such as the ones who participated in the focus group discussions are rethinking their management to more directly address these challenges.

Our study suggests that farmers are rethinking their management system by emphasizing a whole systems approach to management that includes cultivating a soil conservation ethic despite high costs of production and low profit margins. The direct and opportunity costs of cover crops across time are variable (e.g. cover crop seeds, planting and commodity prices) and may serve as a disincentive for utilizing cover crops annually (Snapp et al., 2005; CTIC, 2015; Roley et al., 2016). Further complicating the economic barriers to cover crop use are high input costs associated with production, which tend to rise with commodity prices and remain high even when commodity prices fall (NASS, 2014). As a result, Iowa farmers have experienced volatile earnings in the last several years, arguably making it more difficult to justify an increase in their direct management costs. Illustrative quotes about why non-owner operators and grain-only producers may not readily use cover crops demonstrates that many participants were discouraged because they thought that their innovative approach to management would not be matched by the broader producer population in Iowa and therefore might lead to less cover crop adoption in the region.

As illustrated in the conversation with farmer participants, some articulated that landowners have a greater incentive to consistently utilize cover crops, and thus improve their soil resources, than those who are renting land. There is concern that a growing number of non-operator landowners who own agricultural land, but who do not manage the land may not be incentivized to adopt conservation practices (Carolan, 2005; Petrzelka et al., 2009). Given that there are more than four times as many non-operator landlords than operator landlords in the state of Iowa (NASS, 2015) further work might more thoroughly explore this dynamic.

The results of this study also add a new dimension to the assessments of cover crop impacts on cash crop yields, as it showed that farmers' concerns about yield impacts vary depending on their approach to assessing the costs and benefits of adopting cover crops. For some producers, concerns that a winter rye cover crop could reduce corn yields, combined with perceived high direct and opportunity costs (Snapp et al., 2005; Bergtold et al., 2012), represented a major impediment to cover crop adoption. On the other hand, many farmers were less concerned about potential yield drags and high costs over the short-term.

These results complement the work of Dunn et al. (2016) who confirmed that farmers do not necessarily need cost-share or financial incentives to continue to use cover crops in their operation. Rather, these farmers focused their discussions on how they were able to effectively manage the cover crop and in turn experience yield improvements, through a kind of trial and error approach. Similarly, in a multi-year national cover crop survey, farmers continue to report yield improvements (CTIC, 2013, 2014, 2015, 2016) on cash crops such as corn and soybeans following cover crop use. Further, there is evidence that some farmers in the Corn Belt are finding ways to resolve tensions between short-term profit maximization goals and longer term goals of soil and water conservation through the adoption of practices that enhance soil health and reduce erosion (Roesch-McNally et al., In review); this is complementary to the findings from this study as farmer participants discussed the value of soil resources and noted that they were motivated to adopt and maintain the use of cover crops because of the benefits to the soil as well as productivity. Further, this resolution between the apparent tradeoffs associated with production and conservation goals may enable farmers to adopt a new identity associated with greater conservation (Coughenour, 2003), which might allow them to further overcome barriers to using conservation practices such as cover crops.

Farmers' frequent statements about benefits proving to be greater than associated costs, particularly with regards to soil protection, is in alignment with other research indicating that farmers who believe cover crops to be effective for reducing soil erosion and building soil health, are more likely to adopt the practice (Singer et al., 2007; Reimer et al., 2012; Arbuckle and Roesch-McNally, 2015). Additionally, a number of the farmers maintained that having livestock as a part of their operation helped them to reap additional benefits from their cover crops

by providing feed for animals that would otherwise need to be purchased, particularly in late fall and early spring, which is also in alignment with prior research (Singer et al., 2007; Arbuckle and Roesch-McNally, 2015). This suggests that farmers who had more diverse operations, either livestock or additional crops, despite the increasingly homogenized agricultural system in the region (Stuart and Gillon, 2013), experienced multiple benefits and more successfully integrated cover crops in their operations.

Focus group participants had a great deal of management experience to share with other farmers and discussions illustrated the desire, on behalf of farmers, to engage with farmer networks where they can learn about and share creative approaches to management and allows them to engage in a trial and error approach to cover crop adoption. Further engagement with networks that include industry representatives, public agencies and policymakers may also expand the options available to farmers, particularly as these may help to reduce structural barriers (Bartels et al., 2013). The focus group discussion illustrated the importance of farmer opinion leaders and conservation professionals and provided further evidence that support networks can help increase the acceptance and use of key conservation practices and assist in the social learning necessary for farmers to adopt new practices (Coughenour, 2003; Carolan, 2006; Blesh and Wolf, 2014; Anil et al., 2015). Nerbonne and Lentz (2003), in a study on pasture management and participatory action research in Minnesota, found that networks built on trust and mutual knowledge exchange can change how farmers (and researchers) think about their practices, which can facilitate a shift toward more sustainable production practices.

Despite the many benefits of cover crops, their integration into a corn–soybean crop rotation is perceived as a complicated and risky action in Iowa; therefore we suggest policy interventions related to reducing structural barriers. First, cost-share or other financial mechanisms could be instituted in such a way as to allow farmers adequate time to experiment with cover crops in order to successfully integrate them into their operations over the long-term. Further, if cover crops are to be increased in agriculturally intensive regions such as Iowa, the facilitating infrastructure beyond cost-share options should be investigated, including, but not limited to, the creation of markets for additional crops that could be included in the rotation as well as facilitation of integrated crop/livestock systems that would make management of a winter cover crop more economically suitable on more farms. Finally, more attention should be paid to increasing the types of economic incentives (e.g. cost/accessibility of insurance and value of rental rates) available to farmers to engage in behaviors that emphasize soil health and erosion prevention. Additionally, it may be important to increase the flexibility of government programs, such as crop insurance, to allow for maximum participation among farmers who are integrating cover crops into their operation.

Conclusions

Despite the numerous environmental and production benefits to using cover crops, their adoption across agriculturally intensive regions such as Iowa is quite low. Although much social science research has analyzed predictors of cover crop use, few studies have answered the questions as to how producers make the practice work on their operations. To better understand this knowledge gap, we conducted four focus groups across Iowa to examine research questions concerning field-level and structural barriers to cover crop adoption and strategies that farmers have used to overcome barriers in order to integrate cover crops in their management system. The analysis of these conversations uncovers a complex set of field-level and structural factors that farmers must navigate to make cover crop use effective in their operation. Farmers expressed a determination to incorporate cover crops through a 'whole system' approach that requires altering several different aspects of management. Additionally, many expressed the value of peer networks to learn more about management strategies. Further emphasis should be placed on promoting farmer-to-farmer networks to assist in the successful adoption of cover crops over a sufficient time horizon that allows them time to experiment with cover crops on their farms.

Farmers, ultimately, have little individual power to dismantle structural barriers that might enable other farmers to more successfully integrate cover crops; yet many are able to exercise their agency to successfully overcome barriers to cover crop use on their farms. In order to facilitate greater adoption of cover crops, more efforts should be made to assist farmers in integrating them into their current production system or find viable ways to modify production systems in order to facilitate greater cover crop use (e.g. including a third or fourth crop to add to crop rotation or integrating livestock). These efforts may require changes to policies that can reduce structural barriers to adoption (e.g. crop insurance requirements).

Cover crops may indeed be one critical way that greater field and landscape-scale diversification is enhanced across the region, particularly because cover crops are a complimentary practice to extended rotations and crop and livestock integration. The practice of cover crops may also have an important role to play in helping to achieve the goal of building a more diverse and multifunctional agricultural system as called for by many in the agricultural research and policy sectors (Robertson and Swinton, 2005; Jordan and Warner, 2010; Foley et al., 2011; Schipanski et al., 2014; Blanco-Canqui et al., 2015). Therefore, broader efforts may be necessary to enable farmers to overcome field-level as well as structural

barriers in order to achieve adoption across a larger extent of the landscape.

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