doi:10.2489/jswc.2021.0820A

FEATURE

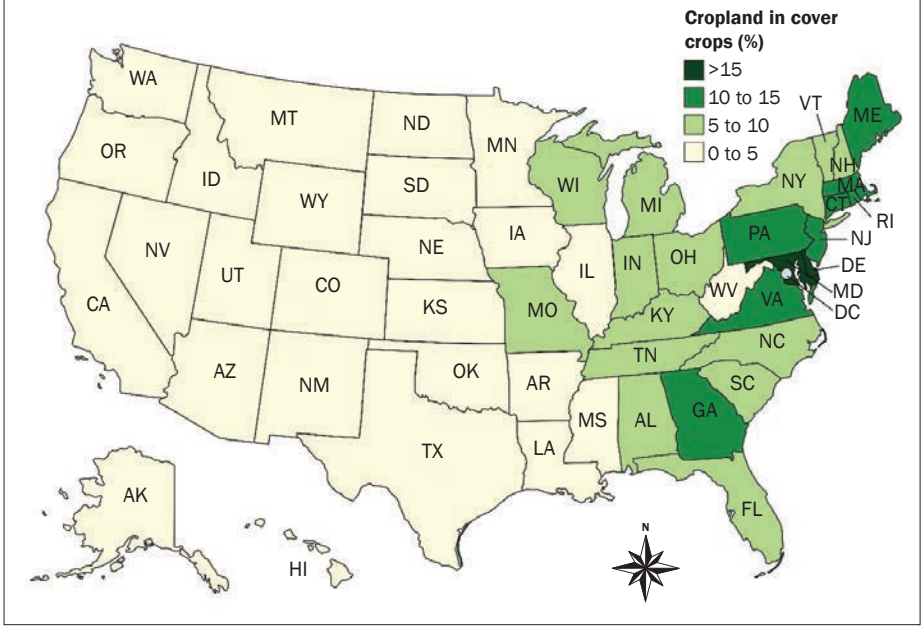
Understanding the market for cover crop seeds in the United States: Background and potential policy directions

Lais Bastos Martins, Roderick M. Rejesus, Chris Reberg-Horton, and Robert L. Myers

Previous literature has shown that cover crops have the potential to provide large-scale environmental benefits by reducing soil erosion, preventing nutrient leaching, sequestering carbon (C), and providing habitat for beneficial insects and pollinators (Snapp et al. 2005; Laloy and Bielders 2010; Castellano et al. 2012; Poeplau and Don 2015). In addition, cover crops can potentially generate private benefits to the farm operation by helping boost soil productivity (and subsequent cash crop yields), suppressing weeds, reducing fertilizer needs, and improving nutrient cycling (Bergtold et al. 2019; Myers and Watts 2015; Wittwer et al. 2017).

Given the potential economic and environmental benefits of cover crop adoption, cover crop acreage in the US grew from about 10.3 million ac (4.2 Mha) in 2012 to about 15.4 million ac (6.23 Mha) in 2017 (i.e., a 50% increase), based on data from the US Census of Agriculture (LaRose and Myers 2019). Nonetheless, even in light of these adoption increases, acres planted to cover crops only equal 3.9% of all US cropland in 2017 (Zulauf and Brown 2019) (figure 1). Although there are several possible reasons that overall cover crop adoption rates in the US remain relatively low, one of the main factors that influences the cost of adopting cover crops is cover crop seeds. For cover crops planted before corn (*Zea mays* L.) and soybeans (*Glycine max* [L.] Merr.) in the US Midwest, Plastina et al. (2018a, 2018b; 2020) find that cover crop seed is one of the main additional costs in using cover crops. Average seed costs reported in Plastina et al. (2018a, 2018b, 2020) ranged from US$14.17 to US$20.20 ac^{-1} (US$35.01 to US$49.92 ha^{-1}; under various production scenarios), while the most recent CTIC et al. survey in early 2020 indicated that the median price range for seed reported by surveyed farmers was US$16 to US$20 ac^{-1} (US$40 to US$49 ha^{-1}) (CTIC et al. 2020).

Figure 1
Proportion of cover crop acres relative to total crop acres in the United States based on the 2017 US Census of Agriculture.



With the importance of cover crop seed costs as a potential barrier in the uptake of cover crops, the objective of this paper is to examine the US cover crop seed industry, describe the potential seed demand and supply situation in the near future, and point to potential policy directions that can help the seed sector facilitate wider cover crop adoption in the country. As more farmers are planting cover crops, it is reasonable to expect that they will demand more cover crop seeds. Note that a recent survey by CTIC et al. (2020) suggests that 20% of the farmers who responded identified lack of available seed as a challenge in growing or using cover crops. Therefore, understanding of the cover crop seed industry, and its interactions with farmers who use it, is critical to developing policies that can help accelerate cover crop adoption and reduce the negative environmental footprint of US agriculture.

BACKGROUND: UNITED STATES COVER CROP SEED COMPANIES

Companies that sell cover crop seeds can be classified into three tiers based on the main clients they serve (figure 2). Tier 1 companies are those that sell exclusively to other companies (also called "B to B" companies). Tier 2 companies are those that sell to other companies and also to farmers ("B to B" and "B to C" companies). Finally, tier 3 companies are the ones that sell exclusively to the final user: farmers ("B to C" companies). Some of these companies exclusively

Lais Bastos Martins is a PhD candidate at North Carolina State University, Department of Crop and Soil Sciences, Raleigh, North Carolina. **Roderick M. Rejesus** is a professor and extension specialist at North Carolina State University, Department of Agricultural and Resource Economics, Raleigh, North Carolina. **Chris Reberg-Horton** is a professor at North Carolina State University, Department of Crop and Soil Sciences, Raleigh, North Carolina. **Robert L. Myers** is the regional director of extension programs with North Central Sustainable Agriculture Research and Education, University of Missouri, Columbia, Missouri.

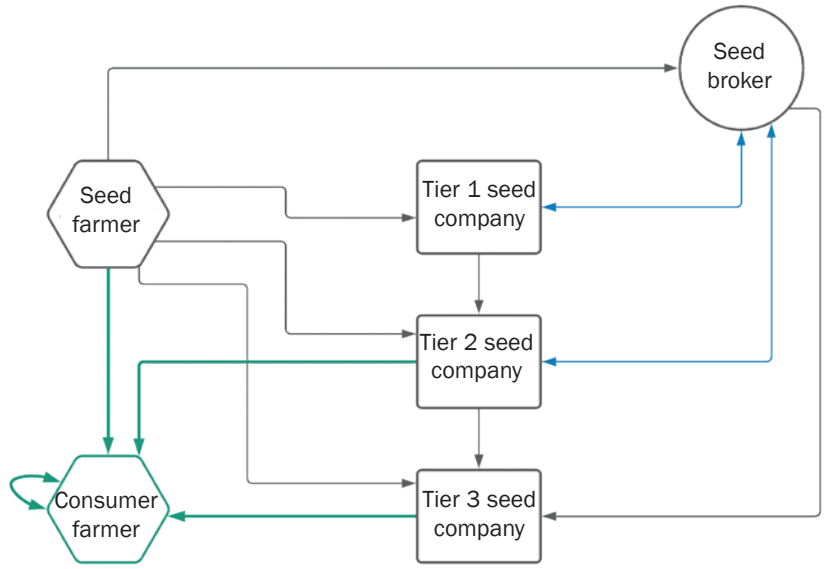
Received August 20, 2021.

sell cover crops, while others might sell forage, turf grass, and even cash crop seeds in addition to cover crops. Larger companies tend to be in tier 1 and 2. Currently, there are more than 40 companies in the United States in tiers 1 and 2 (table 1). The number of tier 3 companies is typically hard to accurately determine because it includes small local retailers. These companies are private, so there is no public record of the size of each company. In addition, the territory covered and served by a particular company can also vary from regional to international.

Besides paying for cover crop seed from seed growers, freight and storage are the largest costs incurred by cover crop seed companies for two main reasons. First, the locations where cover crop seeds are produced are often far from major cover crop using regions. This implies that freight costs are a major expense item for cover crop seed companies. Second, for many cover crop species, the seeds produced are typically not harvested in time for farmers to plant them in the same year they were produced. Hence, storage facilities are necessary, and companies need to invest and/or incur the cost of storing cover crop seeds (for at least one year). Note that there may be competition for warehouse space in this case because cash crop seeds (e.g., corn) also require storage and tend to be more valuable than cover crop seeds.

With the central role of freight and storage costs in cover crop seed companies' operations, the geographical location of the company is of extreme importance. A good location is critical so that the cover crop seeds can be strategically distributed and storage can be feasible for the companies. For example, the Willamette Valley in western Oregon is a region known as the "grass seed capital of the world" (Larson 2019). The region is also known for seed production of different clover (*Trifolium*) species. On the other hand, other cover crop seeds are produced in specific regions of the country. Winter pea (*Pisum sativum*) seeds are commonly produced in Washington and North Dakota. Note that tier 1 companies are in key locations between seed production and distribution hubs. In addition, cover crop seed companies typically strive for producing smaller seeds to make storage and transport more efficient. Since seed size can affect initial growth and biomass, research and breeding efforts to minimize seed size while keeping biomass are needed (Chacón and Bustamante 2001; Aparicio et al. 2002).

Figure 2
Typology and supply chain schematic of cover crop seed companies in the United States.



Cover crop seed companies can either grow their own seed, contract production with farmers, buy from other companies, or buy on the open market using a broker. The seed purchase source will vary widely among companies, some getting most of their seed through contract production and others using various methods. To contract with a farmer, the company needs to make sure the farmer has the equipment needed, the knowledge of the crop, and that the cover crop seed price is competitive with other crops that the farmer could be planting. For example, if the farmer could plant winter wheat (*Triticum aestivum*) instead of producing cover crop seeds for the company, then the cover crop seed price offered by the company to the farmer must be at least the same as the expected winter wheat price, or often a little more given the greater risk of growing a less familiar seed crop. That being said, some farmers like to grow cover crop seed on a portion of their land in order to diversify their crop rotation even with lower revenue. In addition, if the farmer has the proper equipment, they will probably handle cover crop seed cleaning. If not, then the company will likely do the cleaning and processing.

Notwithstanding the tier of a particular cover crop seed company, some companies commonly sell more than 20 species and may have more than one option available for some of the species. However, unlike cash crops, a significant number of cover crops on the market are sold as "common" or "variety not stated." This means that there is no rigorous control and oversight on the seed's genetics, even though genetic purity standards are established by state seed laws and seed certification agencies to assure growers that the seed they buy is labeled accurately by crop and variety (White 2014). For example, seed sold as "Austrian winter pea," which is a winter hardy pea type, could be a spring type, which could lead to a very poor performance depending on where/when it was planted. Not knowing the true genetics of a cultivar can result in a farmer having a bad experience with cover crops, making them less likely to plant cover crops in the future. If the seed sold is a named and registered cultivar (that meets genetic standards), the company knows where the selection was made, the characteristics of that material, and can therefore give better recommendations to the consumer.

The seed companies can also be more competitive in the market by being the only ones to offer a specific cultivar. There

Table 1
Sample of cover crop seed companies and locations in the United States, grouped by tiers. Content was provided by Jonathan Rupert, who works at Smith Seeds.

Company name	City	State	Website
Tier 1			
Allied Seed		Multistate	www.AlliedSeed.com
Barenbrug USA	Tangent	Oregon	www.barusa.com
Columbia Seed		Multistate	www.columbiaseeds.com
Desert Sun Marketing	Phoenix	Arizona	www.desertsunmarketing.com
DLF International	Halsey	Oregon	www.dlfis.com
GS3 Quality Seed	Monmouth	Oregon	www.tilthpro.com
Grassland Oregon	Salem	Oregon	www.grasslandoregon.com
KB Seed Solutions	Harrisburg	Oregon	www.kbseedsolutions.com
Lewis Seed	Shedd	Oregon	www.lewisseed.com
Mountain View Seed	Salem	Oregon	www.mtviewseeds.com
OreGro Seeds	Albany	Oregon	www.Oregroseeds.com
Saddle Butte Ag	Tangent	Oregon	www.saddlebutte.com
Tier 2			
Albert Lea Seed House	Albert Lea	Minnesota	www.alseed.com
Alforex	Jordan	Minnesota	www.alforexseeds.com
Arkansas Valley	Denver	Colorado	www.arkansasvalleyseed.com
Arrow Seed	Broken Bow	Nebraska	www.arrowseed.com
Byron Seed	Rockville	Indiana	www.byronseed.us
Caudill Seed	Louisville	Kentucky	www.caudillseed.com
Center Seed	Celina	Ohio	www.centerseeds.com
CISCO Seed	Indianapolis	Indiana	www.ciscoseeds.com
Clearwater Seed	Spokane	Washington	www.clearwaterseed.com
Curtis & Curtis	Clovis	New Mexico	www.curtisseed.com
Dakotas Best Seed	Platte	South Dakota	www.dakotasbestseed.com
Deer Cree Seeds	Ashland	Wisconsin	www.deercreekseed.com
Des Moines Feed Company	Des Moines	Iowa	www.desmoinesfeed.com
Featherstone Farm	Amelia	Virginia	www.featehrstoneseed.com
Green Cover Seeds	Blanden	Nebraska	www.greencoverseed.com
Growmark		Multistate	www.growmarkfs.com
Hearne Seeds	King City	California	www.hearneseed.com
Integrity Seeds	Mohnton	Pennsylvania	www.integrityseeds.com
Kamprath Seed	Manteca	California	www.kamprathseed.com
Kaufmann Seeds	Haven	Kansas	www.kauffmanseed.com
La Crosse Seed	La Crosse	Wisconsin	www.laxseed.com
Johnston Seed	Enid	Oklahoma	www.johnstonseed.com
MBS Seeds	Denton	Texas	www.mbsseed.com
Millborn Seed	Brookings	South Dakota	www.millbornseeds.com
Missouri Southern Seed	Roll	Missouri	www.missourisouthernseed.com
Prairie Creek Seed	Worthington	Iowa	www.prairiecreekseed.com
Prairie States Seeds	Bloomfield	Nebraska	www.prairiestateseed.com
Preferred Seed Company	Buffalo	New York	www.preferredseed.com
Seedway		Multistate	www.seedway.com
Walnut Creek Seeds	Carroll	Ohio	www.walnutcreekseeds.com
Welter Seed and Honey	Onslow	Iowa	www.welterseed.com

are a few breeding programs that focus on cover crop species and uses, mostly in Europe and in the public sector. In the United States, there is a recent nationwide effort to breed plants that can be used as cover crops (i.e., through the Cover Crop Breeding Network). Some smaller public programs that look at local adaptation of particular species can also be found. The companies that license cultivars developed on another continent can also perform trials to ensure performance in the United States. Nonetheless, domestic testing of foreign cultivars does not necessarily mean that the cultivars provide the best possible genetics for the country.

It is also important to mention here that farmers sometimes will also sell seeds to other farmers. This is more common in cereal rye (*Secale cereale*), for example, because equipment to plant and harvest cereal rye is the same as for wheat and rye is widely adopted. Although there is no official record or account of this farmer-to-farmer selling practice, a recent CTIC et al. survey reported that 19.1% of the 2019 to 2020 respondents purchased at least some of their seed from another farmer (CTIC et al. 2020). Farmer-to-farmer selling can help farmers earn some extra income (White 2014), but there is also typically no seed label to guarantee purity, germination, or genetics, which may lead to a bad experience for the end-user farmer. However, note that some cover crop seed companies also offer the service of cleaning farmer-produced cover crop seeds (i.e., clean them from impurities and weed seeds, so the farmer can sell their own seed more effectively).

To meet a variety of cover crop seed demands, with various soil health enhancing characteristics, a mixture of species can be planted by cash crop farmers in the same field (referred to as cover crop "mixes"). Examples of common cover crop mixes are peas and oats (*Avena sativa*), annual ryegrass (*Lolium multiflorum*) and crimson clover (*Trifolium incarnatum*), and/or mixes that contain several species such as clover, pea, rye, and canola (*Brassica napus*). Some companies sell only premade mixes, while others can have a specific mix "prescription" made based on the farmer's goals and may allow the farmer to choose their own mix. The practice of using mixes, and the fact that companies normally have a plethora of species and cultivars, can sometimes mitigate seed shortage of a specific cover crop cultivar or species, especially if the particular seed with a shortage can be replaced with another species that can give similar benefits. For example, both oats and barley

(*Hordeum vulgare*) can give high biomass, and cowpeas (*Vigna unguiculata*) and mung beans (*Vigna radiate*) are legumes that can both add nitrogen (N) to the soil.

Overall, because cover crop companies are private and the financial information about the markets they serve are proprietary, one can only provide estimates of the size and magnitude of the cover crop seed industry using publicly available data. According to the 2017 Census of Agriculture, there were 17 million ac (6.9 Mha) of cover crops planted in the United States. Based on typical cover crop seed cost estimates ranging from US$16 to US$20 ac^{-1} (US$40 to US$49 ha^{-1}), the size and extent of the US cover crop seed market would be about US$272 to US$340 million in 2017. If we expect that the cover crop seed market will grow between 2017 and 2022 by 50%, the same rate as between 2012 and 2017, we could potentially see the size of the cover crop seed market to be around US$510 million by 2022, and it could in theory become a billion dollar market by the end of the decade.

EXPECTED COVER CROP SEED DEMAND AND SUPPLY

The cover crop seed supply industry is still in its infancy, and yet demand for cover crop seeds by cash crop farmers is rapidly increasing over time. For example, in an informal interview, Jonathan Ruppert, who works at Smith Seed with marketing and sales, reported that cover crop seed sales have tripled (on average) over several years in his company. Therefore, it is important for cover crop seed companies to estimate potential demand for particular cover crop seeds in the future and prepare for eventual fluctuations in the supply-demand calculus. (Cover crop demand by farmers is also largely influenced by weather fluctuations. For instance, the spring of 2019 was extremely wet in the Midwest, which resulted in a large number of cash crop acres not planted on time. In this case, farmers with crop insurance coverage for the cash crop typically filed a "prevented planting" claim and, instead of planting the cash crop late, some planted cover crops. This lead to an unexpected increase in demand for cover crop seeds that the cover crop seed companies were not able to effectively meet.) Oats, cereal rye, radish (*Raphanus sativus*), and vetch (*Vicia sativa*) are commonly used in the Midwest, where corn and soybean crops are grown, and where the potential for market increase is large. Availability of financial incentives for farmers can also increase cover crop acreage according to response from farmers that do not currently use cover crops in the 2017 and 2020 CTIC et al. surveys (CTIC et al. 2017, 2020). It is expected that cover crop acreage will increase in proportion to the steady rise of investment in public cost-share programs (Wallander et al. 2021).

To better contextualize the additional cover crop seed production area that is likely needed to meet future demand, Runck et al. (2020) conducted an analysis to estimate land use requirements that would adequately supply total US corn production area with cover crop seed. Table 2 draws from the analysis in Runck et al. (2020) and shows estimates of how many acres would need to be dedicated to cover crop seed production (of different species) to supply all 91.7 million corn ac (37.1 Mha) planted in 2019. The estimates in table 2 suggest that, on average, about 3.5 million ac (1.4 Mha) in cover crop seed production is needed (~3.77% of all US corn area) to have enough cover crops seeds to serve the number of acres of US corn grown in 2019. Admittedly the estimates in table 2 may be too "ambitious" in the sense that it may be unrealistic to target 100% of corn acres to be planted with cover crops. Nonetheless, even if the goal is 50% of corn acres to be planted with cover crops, this would still entail an additional 1.75 million ac (0.7 Mha) of new cover crop seed production.

Therefore, taking the conservative 1.75 million acres (0.7 Mha) of new cover crop seed production needed, and assuming that at a minimum US$300 ac^{-1} (US$741 ha^{-1}) is needed to contract with farmers to produce cover crop seeds, this means that cover crop seed companies need to collectively invest US$525 million in seed production contracts alone (plus the needed additional investments in the storage and freight infrastructure, as well as other costs). These figures imply that cover crop seed companies likely need to make large investments in the future in order to meet the rising demand for cover crop seeds. However, making substantial investments in a volatile cover crop seed market (that is still in its infancy) is considered to be a risky proposition and may have limited expansion of the cover crop seed supply industry to date. Government policies that can help alleviate the inherent risks in investing in the cover crop seed supply industry might help facilitate increased availability of cover crop seeds to meet future demand.

POTENTIAL POLICY DIRECTIONS

Increasing awareness about the direct benefits of cover crops to farm productivity and the environment, plus availability of more subsidy-based financial assistance that encourages adoption, would likely result in further growth in demand for cover crop seeds. However, several policy enhancements are likely needed for the cover crop seed industry to successfully meet this future demand and ensure sustainable growth in cover crop use in the United States. We discuss several of these potential policy directions below.

Policies for Genetic Standards, Seed Monitoring, and Testing. The same seed labeling law that is followed by corn and soybeans should apply for cover crop seeds. However, this is not always followed and there are no policies that ensure genetic standards in cover crop seeds. Farmers need to be aware that buying "variety not stated" seed is riskier than buying named varieties since no one can attest to the performance or quality of it. Transparency about seed genetic characteristics (and whether or not they meet standards) gives the farmer appropriate information for making seed choice decisions and allows them to have peace of mind that the cover crop seeds they purchase have been tested. Therefore, policies and rules that enforce the inspection of seed bags and labels are still needed. An institutional structure should be put in place so that companies that do not adhere to seed label laws are penalized.

Reporting of Cover Crop Seed Price Information and Developing Market Forecasts. To date there is no public institution responsible for tracking seed prices across the United States, for cash crops or cover crops. This means that each company

Table 2
Different species of cover crop average seeding rate, seed yield, acres yield, acres needed for seed production, and percentage of corn area needed for cover crop seed production. Adapted from Runck et al. (2020).

Crop	Seeding rate (bu ac^{-1})	Seed yield (bu ac^{-1})	Area plantable from a single acre seed harvested (ac)	Total area needed for cover crop seed production to cover whole US corn area (ac)*	Percentage of corn area needed for cover crop seed production (%)†
Canola	0.09	64.00	711.1	128,953.1	0.14
Forage turnip	0.07	31.75	453.6	202,173.2	0.22
Annual ryegrass	0.36	45.35	126.0	727,938.3	0.79
Radish	0.14	12.30	87.9	1,043,739.8	1.14
Mustard	0.14	11.30	80.7	1,136,106.2	1.24
White clover	0.14	10.72	76.6	1,197,574.6	1.31
Winter pea	0.89	58.15	65.3	1,403,491.0	1.53
Barley	1.56	93.00	59.6	1,538,193.5	1.68
Red clover	0.21	11.98	57.0	1,608,100.2	1.75
Wheat	1.61	71.00	44.1	2,079,394.4	2.27
Oats	1.56	68.00	43.6	2,103,705.9	2.29
Buckwheat	0.8	30.00	37.5	2,445,333.3	2.67
Triticale	1.61	55.00	34.2	2,684,309.1	2.93
Flax	1.39	40.00	28.8	3,186,575.0	3.48
Cereal rye	1.79	50.00	27.9	3,282,860.0	3.58
Crimson clover	0.27	5.90	21.9	4,196,440.7	4.58
Hairy vetch	0.44	8.10	18.4	4,981,234.6	5.43
Berseem clover	0.27	0.88	3.2	28,296,000.0	30.86
Mean across cover crops			109.9	3,457,895.7	3.77
Median across cover crops			50.6	1,843,747.3	2.01

*Considering as the only cover crop planted. Not in mixes.
†Based on the 2019 data: 91,700,000 ac of corn with seeding rate of 0.39 bu ac^{-1}.

tracks their own price and needs to make their own forecasts of future demand. Without public information, it is difficult to track cover crop seed prices, and companies can charge different prices for the same cultivar depending on location (Krueger 2019). To overcome this potential informational barrier, and advocate for better prices, farmers started the Farmers Business Network, a platform that has evolved through the years but started as a self-reporting seed price tool where other farmers could see how much their colleagues were paying for seeds at different locations. Thus, for sustainable growth of the cover crop seed market, we believe that it would be beneficial for a public agency, such as the USDA, to create a unit responsible for tracking the prices of cover crop seeds. Having a cover crop seed price database could help stakeholders, farmers, researchers, and the private seed companies better understand the variables that affect demand and supply of cover crop seeds. Consequently, more precise forecast models could be constructed, which would likely result in more market stability and less risk for the cover crop seed growers and companies.

Financial Incentives for Cover Crop Companies. As discussed in the previous section, cover crop seed companies have to absorb substantial risks when investing in the cover crop seed industry. Hence, to encourage further investment in the cover crop seed market it may be important to provide financial incentives for cover crop seed production companies. Some possible ways of financially helping the cover crop market include tax benefits to companies, direct subsidies to new cover crop seed companies entering the industry, and cheaper financing that would allow seed companies to invest in key machinery, storage, and freight infrastructure. Another option would be to have the government subsidize seed stock up to three years, so seed would be available in high demand years due to weather fluctuations. Financial incentives for cover crop companies may also help encourage them to diversify the number of growing regions where cover crop seeds are produced (i.e., contracting with cover crop seed farmers in new locations closer to cover crop seed users).

Private-Public Cover Crop Seed Collaboration and Information Dissemination. The dissemination of information about best seed practices and the importance of having named cultivars from accredited locations would benefit the farmer and the industry. Private and public agents can work together to conduct research, provide training programs, and generate information campaigns about cover crop seeds. Currently, partnerships exist in the form of the four regional Cover Crop Councils, whose priorities include policy, communication, research, outreach, and fundraising (e.g., the Midwest, Southern, Northeast, and Western Cover Crop Councils). These kinds of public-private partnerships can

also help disseminate information about the importance of cover crop seed quality, labels, genetics, and seed sources.

Support for Cover Crop Seed Breeding and Seed Production Research. To date, there has been little private capital and government support dedicated to improving plant species to be grown specifically for cover crop use. Breeding programs that focus on cover crop use and perform multiple years of testing, as it is done for cash crops, will ensure that the farmer gets the best cover crop performance possible, and can result in more adoption in the future. A public effort to increase availability of cultivars bred specifically for cover crop use started in 2015, with what is now called the Cover Crop Breeding Network. The network currently focuses on hairy vetch, crimson clover, and winter peas, and consists of more than 10 public institutions that include universities, USDA, Public Material Centers, and farmers. Although the network has been successful in securing a modest amount of funding through grants, a long-term, secure funding source would give stability and help the network expand their efforts to provide the best varieties for the farmers. Improved breeding for higher cover crop yields would help reduce the amount of land needed for cover crop seed production that would meet future demand. Moreover, continued support for cover crop seed production research would allow for development of better agronomic practices for cover crop seed production and may help expand the areas where cover crop seed could profitably be produced (i.e., expand major cover crop seed production areas beyond the Northeast United States).

SUMMARY

Cover crops are increasingly becoming a key component in the development of sustainable farming systems in the United States. With continued demand for cover crops in the future, it is important to have a robust cover crop seed sector that can adequately and consistently supply farmers year-after-year. Pursuing the policy directions described above can help facilitate further strengthening of the cover crop seed industry and would likely improve cover crop adoption in the future—generating benefits for farmers, the environment, and the overall economy.

ACKNOWLEDGEMENTS

The authors wish to thank Keith Berns, Green Cover Seed; Jay Brandt, Walnut Creek Seed; Dan Foor, LaCrosse Seed; and Jonathan Ruppert, Smith Seed, for sharing their time and knowledge about the topic. Your insight and experiences were essential.

REFERENCES

Aparicio, N., D. Villegas, J.L. Araus, R. Blanco, and C Royo. 2002. Seedling development and biomass as affected by seed size and morphology in durum wheat. Journal of Agricultural Science 139(2):143–50. https://doi.org/10.1017/S0021859602002411.

Bergtold, J.S, S. Ramsey, L. Maddy, and J.R. Williams. 2019. A review of economic considerations for cover crops as a conservation practice. Renewable Agriculture and Food Systems 34(1):62–76. https://doi.org/10.1017/S1742170517000278.

Castellano, M.J., M.J. Helmers, J.E. Sawyer, D.W. Barker, and L. Christianson. 2012. Nitrogen, carbon, and phosphorus balances in Iowa cropping systems: Sustaining the soil resource. Proceedings of the 24th Integrated Crop Management Conference, pp. 145–56. Ames: Iowa State University Digital Repository.

Chacón, P., and R. O Bustamante. 2001. The effects of seed size and pericarp on seedling recruitment and biomass in *Cryptocarya alba* (Lauraceae) under two contrasting moisture regimes. Plant Ecology 152(2):137–44. https://doi.org/10.1023/A:1011463127918.

CTIC, SARE, and ASTA (Conservation Technology Information Center, North Central Region Sustainable Agriculture Research and Education Program, and American Seed Trade Association). 2017. National Cover Crop Survey Annual Report 2016-2017. CTIC, SARE, and ASTA. https://www.sare.org/publications/cover-crops/national-cover-crop-surveys/.

CTIC, SARE, and ASTA. 2020. National Cover Crop Survey Annual Report 2019-2020. TIC, SARE, and ASTA. https://www.sare.org/wp-content/uploads/2019-2020-National-Cover-Crop-Survey.pdf.

Krueger, S. 2019. 2019 U.S. Seed Price Transparency Report: Farmers Pay Radically Different Prices for the Exact Same Seed. FBN Network, September 5, 2019. https://emergence.fbn.com/resources/2019-us-seed-price-transparency-report.

Laloy, E., and C.L. Bielders. 2010. Effect of intercropping period management on runoff and erosion in a maize cropping system. Journal of Environmental Quality 39(3):1001–8. https://doi.org/10.2134/jeq2009.0239.

LaRose, J., and R. Myers. 2019. Progress Report: Adoption of Soil Health Systems Based on Data from the 2017 U.S. Census of Agriculture. Soil Health Institute Report. Morrisville, NC: Soil Health Institute.

Larson, Z. 2019. Where Does My Cover Crop Come From? Part 1. University Park, PA: Penn State Extension. https://extension.psu.edu/where-does-my-cover-crop-come-from-part-1.

Myers, R., and C. Watts. 2015. Progress and perspectives with cover crops: Interpreting three years of farmer surveys on cover crops. Journal of Soil and Water Conservation 70(6):125A-129A. https://doi.org/10.2489/jswc.70.6.125A.

Plastina, A., F. Liu, F. Miguez, and S. Carlson. 2020. Cover crops use in Midwestern US agriculture: Perceived benefits and net returns. Renewable Agriculture and Food Systems 35(1):38–48. https://doi.org/10.1017/S1742170518000194.

Plastina, A., F. Liu, W. Sawadgo, F. Miguez, and S. Carlson. 2018a. Partial budgets for cover crops in Midwest row crop farming. Journal of the ASFMRA 90–106.

Plastina, A., F. Liu, W. Sawadgo, F. Miguez, S. Carlson, and G. Marcillo. 2018b. Annual net returns to cover crops in Iowa. Journal of Applied Farm Economics 2:19–36.

Poeplau, C., and A. Don. 2015. Carbon sequestration in agricultural soils via cultivation of cover crops - A meta-analysis. Agriculture, Ecosystems and Environment 200:33-41. https://doi.org/10.1016/j.agee.2014.10.024.

Runck, B.C., C.K. Khoury, P.M. Ewing, and M. Kantar. 2020. The hidden land use cost of upscaling cover crops. Communications Biology 3:300. https://doi.org/10.1038/s42003-020-1022-1.

Snapp, S.S., S.M. Swinton, R. Labarta, D. Mutch, J.R. Black, R. Leep, J. Nyiraneza, and K. O'neil. 2005. Evaluating cover crops for benefits, costs and performance within cropping system niches. Agronomy Journal 97(1):322-332.

Wallander, S., D. Smith, M. Bowman, and R. Claassen. 2021. Cover Crop Trends, Programs, and Practices in the United States. Economic Information Bulletin 222. USDA Economic Research Service.

White, P.A. 2014. The Growing Business of Cover Crops. National Wildlife Federation.

Wittwer, R.A., B. Dorn, W. Jossi, and M.G.A. van der Heijden. 2017. Cover crops support ecological intensification of arable cropping systems. Scientific Reports 7:41911. https://doi.org/10.1038/srep41911.

Zulauf, C., and B. Brown. 2019. Cover Crops, 2017 US Census of Agriculture. farmdoc daily (9):135.