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STRIP-TILLAGE FOR ONIONS AND SWEET CORN, LORIN GRIGG

Farmer-to-Farmer Case Study Series: Increasing resilience among farmers in the Pacific Northwest

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STRIP-TILLAGE FOR ONIONS AND SWEET CORN, LORIN GRIGG

By

Georgine Yorgey, Center for Sustaining Agriculture and Natural Resources, Washington State University. **Andrew McGuire**, Irrigated Cropping Systems Agronomist, Washington State University Extension.

Abstract

Lorin Grigg grows onions and sweet corn under sprinkler irrigation in Quincy, Washington. In this publication, Grigg discusses his strategy for cover cropping to protect seedlings from windblown sand and reduce wind erosion.

This case study is part of the Farmer-to-Farmer Case Study project, which explores innovative approaches regional farmers are using that may increase their resilience in the face of a changing climate.

Case study information presented is based on growers' experiences and expertise and should not be considered as university recommendations. Mention of trade names or commercial products is solely for the purpose of providing specific information and does not imply recommendation or endorsement. Grower quotes have been edited slightly for clarity, without changing the meaning.

Readers interested in other case studies in this series can access them on the [REACCH](#) website or in the [WSU Extension Learning Library](#).

Strip-Tillage for Onions and Sweet Corn, Lorin Grigg



Photo: Darrell Kilgore

Location: Quincy, WA

Average precipitation: 8 inches (irrigated cropping)

Cropping system: Onions in rotation with corn. They also lease ground to other farmers to grow vegetable crops including potatoes and dry edible beans.

Watch the companion video, [Strip-Tillage in Onions, Farmer-to-Farmer Case Study Series](#), which introduces Grigg and his strip-tillage system.



Map: Kaelin Hamel-Rieken, Washington State University

In partnership with his father, Lorin Grigg produces onions, sweet corn and sometimes other vegetables in Quincy, Washington. As with many other farms in the area, he trades ground with other growers who grow crops such as potatoes and dry edible beans to diversify cropping sequences. The majority of their acreage is irrigated from wells, with some additional acreage receiving surface water from the Columbia River via the Columbia Basin Irrigation Project. They also own and operate an onion packing operation.

The farm's fine sandy soils (Quincy fine sand, NRCS 2016) are highly susceptible to wind erosion. Particularly in the spring and fall, fine windblown dust can create conditions that are a public health and safety concern. In the spring, windblown sand can also destroy young seedlings. When this happens, farmers have to replant at significant expense, or, if the planting window for the primary crop has passed, convert to another, generally less profitable, crop.

In response to this issue, Grigg and his father developed a strip cover cropping system that reduces wind erosion and protects seedlings during the spring.

Developing Cover Cropping Strategies through Trial and Error

Because almost all of the farm's 3,000 acres are fine sand, Grigg and his father knew that windblown sand would likely be a concern for slow-growing onion seedlings. Furthermore, onion seed is expensive and small, with demanding requirements for successful stand establishment. The shallow planted seed needs a fine-tilled seedbed for emergence, without crop residues or clods. This leaves the soil, especially sands, even more prone to wind erosion.

The Grigg strip-till system is a response to the exacting needs of onions. Grigg and his father adopted cover cropping the first year they grew onions, in 1993. The system drew on strategies Grigg's father had used for sugar beets in the 1970's, as well as a system their neighbor was already using for onions.

Initially, they broadcast the wheat seed for the cover crop across the field in the fall, and then strip-tilled the area that would become the onion beds prior to planting in the spring. However, this left too much residue in the area where the onions were being planted. To address this, they developed an air seeding system that would broadcast the cover crop in strips (Figure 1). In the spring, they strip-till the unplanted area, and then run the planter behind the strip-tiller (Figure 2).



Figure 1. The custom air strip-seeder that Grigg uses for planting his wheat cover crop. Note that the planter is broadcasting the seed, not drilling it. They have found that they get wider coverage with this system. Photo: Andrew McGuire



Figure 2. Onion planting in spring 2016 after strip-tillage of the cover crop system. Photo: Darrell Kilgore

Current System

Grigg currently uses a strip-tilled wheat cover crop before both onions and sweet corn. (See the video “[Field Operations for Strip-Tillage](#)” for additional detail about the field operations used in Grigg’s strip-tillage system.) The strip-tillage system that Grigg uses is quite different than the strip-tillage generally used in the Midwest, where these systems were first developed in the U.S. (See the *Comparison of Strip-Tillage in the Western and Midwestern United States and Additional Resources for Irrigated Strip-Tillage in the West* sidebars for more information.)

Comparison of Strip-Tillage in the Western and Midwestern United States

In the United States, strip-tillage systems were first used widely in the Midwest. There, the system is designed to overcome some of the challenges of no-till planting in heavy or poorly drained soils and in northern corn fields. The tillage in the strip can help dry and warm the soil and improve drainage. However, for these goals, it is best done in the fall, with the strip left rough. Overwinter freeze and thaw breaks up clods and smooths the strip surface, leaving it ready for planting in the spring. Between the tilled strips, residue covers the soil and lessens the risk of severe water erosion.

In contrast, strip-tillage in Western irrigated regions is mainly done in the spring to reduce wind erosion, as described in this publication.

Additional Resources for Irrigated Strip-Tillage in the West

Growers seeking to adapt Grigg's system to their own irrigated crops may find the High Residue Farming Under Irrigation Series helpful. Among the five publications that are part of this series, High Residue Farming Under Irrigation: Strip-Till (McGuire 2014a), may be particularly relevant.

- [*High Residue Farming Under Irrigation: What and Why*](#) (McGuire 2014b) provides an overview of high residue farming, including its benefits and challenges. It also discusses some special considerations for high residue farming in the irrigated agriculture regions of the far western United States.
- [*High Residue Farming Under Irrigation: Crop Rotation*](#) (McGuire 2014c) covers choosing a cropping sequence, specific cover crops, and special considerations for irrigated cropping systems in the far western United States.
- [*High Residue Farming Under Irrigation: Residue Management through Planting*](#) (McGuire 2014d) explains how to plant crops into high residue conditions with a planter or drill. It covers residue management, planter and drill modifications, and soil fertility adjustments.
- [*High Residue Farming Under Irrigation: Pest Management Considerations*](#) (McGuire 2014e) gives an overview of the effects of adopting high residue farming on the management of weeds, insects, and diseases.
- [*High Residue Farming Under Irrigation: Strip-till*](#) (McGuire 2014a) covers the benefits, challenges, and implementation of strip-till planting. This particular high residue farming system combines some of the benefits of clean tillage systems with those of high residue cover.

Generating Cover Crop Residue for Onions

Growing the right amount of residue is one of the keys to Grigg's successful cover cropping.

Too little residue, and the cover crop will not act as a sufficient wind break. Too much residue, and the planting equipment for the main crop has trouble getting through the field. Grigg has found that he wants the wheat to be about 18 inches tall when it is killed. He aims to achieve this through choosing the type of cover crop grown (spring or winter wheat), to match the timing of onion planting. Though this gives him some control, there is always a bit of variability because of differences in weather that affects growth of the cover crop.

The timing of planting the cover crop is constrained by the harvest of the previous crop, which is often determined by another grower. Grigg explains, "When their crop is harvested, we take over the ground so that we can prepare it the way we want to see it prepared." They used to trade ground with a fresh pea grower, whose crop came off early, giving them more flexibility to plant an early cover crop that could generate significant biomass before winter.

In that system, Grigg planted spring wheat, killing it in the fall when it reached about 18 inches with a fumigant (metam sodium), delivered through the irrigation system. Grigg liked that the spring wheat developed a head and a stem before it was killed, because this stiff residue provided good wind resistance in the following spring.

Since they have had to move away from fumigants delivered through the irrigation system late in the season, Grigg has not yet found a system that provides equivalent residue production, wind resistance, and disease control. Another complication is that by the 2010s, the farm was most often trading ground with potato and dry bean growers, whose crops are harvested later, shortening the window for growing a cover crop in the fall. This has created an ongoing challenge of achieving adequate residue prior to planting onions.

First, Grigg experimented with winter wheat killed with glyphosate in the spring. However, even when they left a two- to three-week window between spraying out the wheat and planting onions, soil temperatures were too cold in their early-planted fields to achieve effective reductions in *Rhizoctonia* stunting and *Fusarium* basal rot. Thus, their early-planted onion fields had greater levels of these diseases. (For more information on onion stunting related to *Rhizoctonia* spp., see the sidebars *Onion Stunting After Cereal Cover Crops*, *Timing of Glyphosate Applications to Wheat Cover Crops to Reduce Onion Stunting Caused by *Rhizoctonia solani**, and *Efficacy of Fungicide Applications to Manage Onion Stunting Caused by *Rhizoctonia* spp.*)

Onion Stunting After Cereal Cover Crops

Lindsey du Toit, Department of Plant Pathology, Washington State University.

Georgine Yorgey, Center for Sustaining Agriculture and Natural Resources, Washington State University.

Herbicide application (most often with glyphosate) carried out to kill a preceding cover crop can aggravate some soil-borne plant diseases of onions, including stunting caused by *Rhizoctonia* spp., which are common soil-inhabiting fungi. When glyphosate acts on plants, the plants' defense responses are compromised, and *Rhizoctonia* spp. colonize rapidly the dying roots and crowns of the cover crop. Therefore, the subsequent onion crop, planted in close proximity to the dead or dying cereal roots and crowns, can suffer increased severity of stunting (Babiker et al. 2011; Sharma-Poudyal et al. 2013a, 2015a).

In onion crops grown in coarse, sandy soils in the Columbia Basin, patches of stunted plants can develop following glyphosate application to a preceding cereal cover crop. The stunting is not usually observed in fields with heavier soils and higher levels of organic matter. The stunted patches appear to be caused primarily by isolates of *Rhizoctonia solani* anastomosis group (AG) 3 and AG 8, although a broader diversity of AGs has been associated with stunted onion plants. The spectrum of AGs involved can be influenced by the crop rotation history in a field (Sharma-Poudyal et al. 2016).

Onion stunting associated with herbicide applications to cereal cover crops first becomes visible as patches of stunted onion plants at the three- to five-true-leaf stage of growth. The diameter of these patches can range from <1 to >25 m, and may account for up to 15% of the area of a crop (du Toit et al. 2012, and Wicks et al. 2011). Stunting can cause up to 78% reduction in onion bulb yield within the stunted patches in the Columbia Basin, reducing bulb size and marketable yield significantly (Sharma-Poudyal et al. 2013b, 2015a).

Onion cultivars grown commonly in the Columbia Basin appear to be susceptible to stunting caused by *R. solani* following herbicide application to the previous cover crop (Sharma-Poudyal et al. 2015a). As of 2015, the majority of advanced onion breeding lines screened in a greenhouse trial also appeared susceptible (Sharma-Poudyal et al. 2015b). Deep tillage has been shown to reduce the severity of stunting compared to shallow tillage, but this practice has potentially negative impacts on soil quality and erosion (Sharma-Poudyal et al. 2014a).

More promising strategies for limiting the severity of onion stunting include the timing of herbicide application to the cover crop prior to onion planting (see sidebar *Timing of Glyphosate Application to Wheat Cover Crops to Reduce Onion Stunting Caused by Rhizoctonia solani*), and a pre-planting, incorporated application of a fungicide (see sidebar *Efficacy of Fungicide Applications to Manage Onion Stunting Caused by Rhizoctonia spp.*).

Additional research is in progress to investigate whether application of arbuscular mycorrhizae to the soil prior to planting can limit stunting caused by *Rhizoctonia* spp. Initial greenhouse studies with commercial mycorrhizal inoculants have shown promising results, though studies are needed in growers' fields using their onion production equipment and practices (Knerr et al. 2016; Sharma-Poudyal et al. 2014b).

Timing of Glyphosate Applications to Wheat Cover Crops to Reduce Onion Stunting Caused by *Rhizoctonia solani*

Lindsey du Toit, Department of Plant Pathology, Washington State University

Georgine Yorgey, Center for Sustaining Agriculture and Natural Resources, Washington State University

Cereal cover crops in the Columbia Basin normally are killed with a herbicide, usually glyphosate, when the cover crop reaches an optimal height – tall enough to provide a physical barrier to sand blasting during windy spring conditions, but not tall enough to shade and compete with the developing onion seedlings. Depending on the planting date for the cover crop, winter weather conditions, and the resulting growth of the cover crop, the timing of herbicide application can range from more than a month prior to seeding to up to two weeks after onion planting.

In 2012 and 2014, field experiments were carried out in growers' fields to assess the effects of three different intervals between glyphosate application to a winter wheat cover crop and planting of onion. The 2012 trial was carried out near Paterson, WA, with glyphosate applied 27, 17, and 3 days before the grower planted onion seed. The 2014 trial was carried out near Benton City, WA, with glyphosate applied 19, 10, and 3 days before the grower planted onion seed.

As the interval between herbicide application and onion planting increased from 3 to 19 and 27 days, the number of patches of stunted onion plants decreased by >55%, total area of stunted patches decreased by 54 to 63%, and patch severity index decreased by 59 to 65%.

When possible, increasing the interval between herbicide application to the cover crop and onion planting, ideally to 3 to 4 weeks, provides a practical management tool for controlling stunting in onion; however, this may not always be feasible based on the size of the cover crop in early spring. Further details of the study and the results are available in Sharma-Poudyal et al. (2016).

Efficacy of Fungicide Applications to Manage Onion Stunting Caused by *Rhizoctonia* spp.

Lindsey du Toit, Department of Plant Pathology, Washington State University

Georgine Yorgey, Center for Sustaining Agriculture and Natural Resources, Washington State University

Three experiments in grower-cooperator fields in 2011 and 2012 examined whether pre-plant, banded, incorporated fungicide sprays could be used to manage onion stunting caused by *Rhizoctonia* spp:

- In 2011, two rates of application of Quadris Flowable Fungicide (azoxystrobin), 9.5 and 19.0 fl oz/acre, were compared with non-treated control plots.
- In one of the 2012 trials, Quadris (19.0 fl oz/acre) and Fontelis (penthiopyrad, 24.0 fl oz/acre) were compared to non-treated control plots.
- In the second 2012 trial, the following applications were compared:
 - Quadris (12.0 fl oz/acre)
 - Quadris (12.0 fl oz/acre) + Rhizoburst (1,280 fl oz/acre, 10-34-0 +0-0-19 + humic acid)
 - ReZist (1,280 fl oz/acre, Cu 1.75%, Mn 1.75%, and Zn 1.75%, with polyamines and natural plant extracts)
 - A non-treated control treatment

In all experiments, applications were banded over the bed, and the fungicide incorporated 4 to 5 inches into the soil with a rototiller about one day prior to onion seeding. Additional details of the study and results are available in Sharma-Poudyal et al. (2013c).

In the 2011 study, plots treated with either rate of Quadris had significantly fewer patches of stunted plants, less total area stunted, and less severe stunting compared to non-treated control plots (Figure 10). The differences in disease ratings between the two rates of Quadris application were not significant.

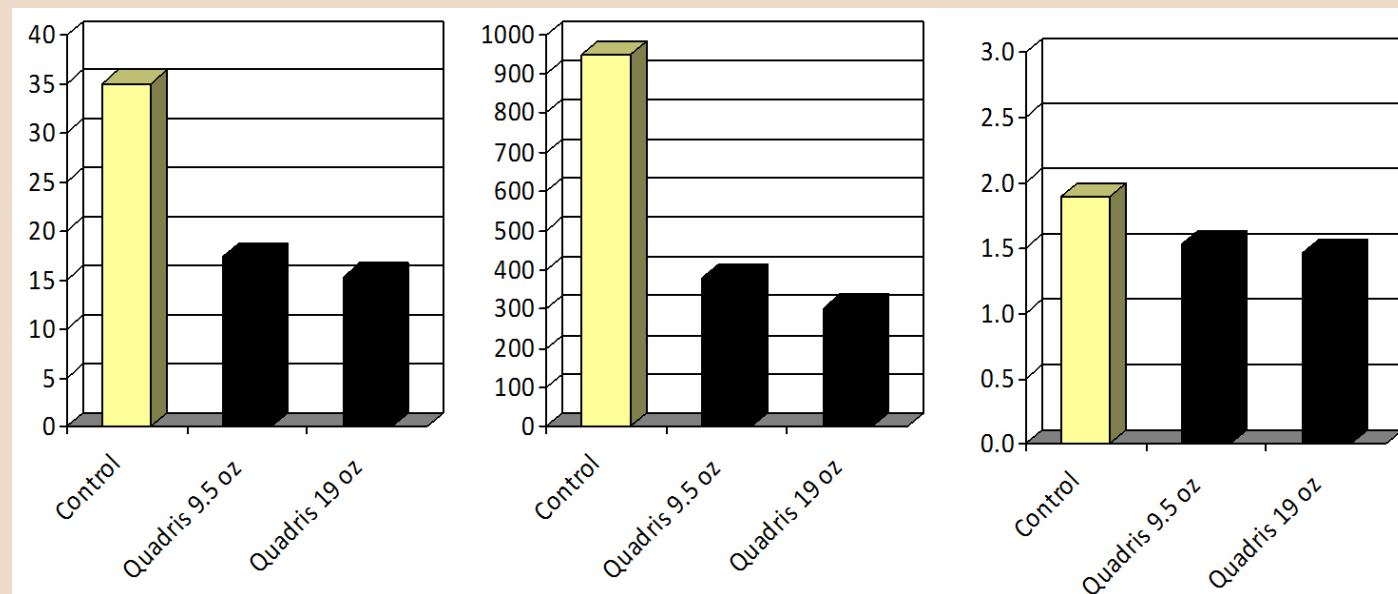


Figure 10. Patches of stunting per acre (left), total area stunted (ft²) (center), and severity of stunting within patches (right) for onions grown with or without a banded, incorporated application of Quadris at one of two rates, 9.5 or 19 fl oz/acre, prior to planting in 2011.

In the first 2012 study, plots treated with Quadris had significantly fewer stunted patches, less stunted area, less severe stunting, and reduced patch severity index (area x severity) compared to non-treated control plots (data not shown). In contrast, plots treated with Fontelis did not exhibit a significant reduction in incidence or severity ratings compared to control plots.

In the second 2012 study, Quadris alone or in combination with Rhizoburst effectively reduced the number of stunted patches, cumulative patch area, severity of stunted patches, and stunting index (data not shown). There was no significant difference in the efficacy of Quadris alone compared to Quadris + Rhizoburst. Plots treated with ReZist did not differ significantly from the non-treated control plots in terms of disease measurements.

Based on these large-scale grower-cooperator field experiments in the Columbia Basin, a pre-plant, banded, and incorporated application of Quadris may effectively decrease onion stunting by reducing the incidence and cumulative area of stunted patches, and the severity of stunting.

In 2014, they returned to planting spring wheat in the fall. Results were variable. Earlier planted spring wheat did well, achieving sufficient height and then dying during a killing frost in late November (Figure 3). The later-planted spring wheat made it through the winter since plants were small, but didn't achieve enough height to provide full protection from wind erosion. Seedlings on some of the field edges, and in small areas within the field, were damaged.



Figure 3. Spring wheat residues prior to planting onions in early April 2016. Photo: Darrell Kilgore

Generating Cover Crop Residue for Corn

For sweet corn, Grigg uses a similar cover cropping system. However, because the seed is larger, the seedbed does not have to be prepared as carefully as for onions. This gives him more flexibility to plant the preceding cover crop later in the fall.

If the timing is later into the fall, they use a grain drill system for planting, in place of the strip planter. The solid stand of wheat that results from the grain drill provides better protection against wind erosion, so it is effective even with less growth achieved through late fall planting. When they use a grain drill, they come back in early spring with a ripper-stripper, tilling strips for planting sweet corn before the wheat gets too big for the ripper-stripper to work effectively.

As Grigg says, "I prefer to plant with the strip planter, because it leaves the bed clean, we don't have the residue to deal with, and we get a better planting job (Figures 4 and 5). But we also like to have flexibility depending on the time of year."



Figure 4. Planting the wheat cover crop in strips makes planting corn easier, as the planter does not encounter roots and leaves in the planting strip. Photo: Darrell Kilgore



Figure 5. Wheat residues remaining after corn planting in early April 2016. Note that the wheat residues are green in the photo, but died shortly after the photo was taken due to herbicide application. Photo: Darrell Kilgore

Management of Cover Crop Residue

Once the cover crop is killed, managing the residue helps minimize problems that can occur during planting of the main crop. Grigg explains, "In the beginning, we would just kill it and let it fall where it would fall in a wind storm. Well, it would fall across into the next row, and so we had to build all these fancy fingers and spiders for our strip-tiller to try to move that material out of the way to have the rotor tiller go through so that the bed would be clean where we would plant onions."

They have also used rollers in the past to help manage the dead wheat. This was especially helpful when they were growing spring wheat, with a more substantial stem and wheat head.

“We built these rollers so that once we fumigated and the wheat started weakening, we would roll the cover crops the direction we would plant, and that helped out quite a bit. It still sometimes would pop back up, and then fall to the side, but that operation, at that time, worked really well for us for wind management.”

Precision Guidance Tools

Grigg has also found cover cropping easier with GPS guidance on his tractor. “In the fall, we plant with the GPS system on the tractor, and then when we use our strip-tiller in the spring, we come back with the same line.” This improves their accuracy, especially on hilly areas, and minimizes plugging issues during planting. They do not currently have GPS guidance on the tiller itself, or on their planter, though they are considering adding these tools.

Planting and Managing the Main Crop

In areas where cover crops were planted in strips, cash crop planting is done by strip-tilling the row between the cover crop, followed by planting (Figure 6).



A wide shot (above) and close up (below) showing the strips of residue and onion beds after onion planting in early April 2016. Photos: Darrell Kilgore

Although GPS on the tractor helps line up the strip-tillage with the unplanted rows, planting can still be somewhat challenging. The residues can be tough for the planter to get through, particularly if it is dead, or if there is dew or rain. “It’s hard for the planters to go through with stuff plugging up and it slows down planting in the early spring quite a bit. As it warms up, things go a lot easier.” Planting the wheat late enough that there is not too much residue also helps things go smoothly.

Weed management in the main crop can also be more of a challenge. Because of the cover crop residues in the early season, they cannot cultivate (Figure 7). Therefore, they rely on a mixture of hand weeding, chemical control, and fumigation.

Given the irrigation and warm temperatures in this region, little cover crop residue remains on the surface by the middle of the season (Figure 8).



Figure 7. Corn seedlings in the tilled strips, with residues on either side, in early April 2016. Photo: Darrell Kilgore



Figure 8. By late June 2015, little wheat residue is left in onions (left), and little to no residue in corn (right). Photos: Darrell Kilgore

Benefits

The primary benefit of Grigg's system is that it protects his soil from wind erosion, reduces the risk of having to replant in the spring – and increases his peace of mind (Figure 9). As Grigg says, “If we don't plant a cover crop, we're pretty much guaranteed we'll lose the crop in the spring from high winds.... Once in a while we may not have a windy spring, but most of the years it's very windy here. If I put a cover crop in, I'm pretty much guaranteed that I can sleep at night and let the wind blow and not have to turn the water on.”



Figure 9. Onion plants with remaining residues in late May 2015. Note that there is variability from field-to-field and from year-to-year in residue production, and thus in protection from wind erosion. Compare, for example, this photo with residues in Figure 6. Photo: Andrew McGuire

In the absence of cover cropping, watering is the major method for protecting seedlings from wind erosion, but Grigg feels that his cover cropping system is more reliable. “If we didn't have the cover, we'd be turning the water on two days before [wind was predicted] and then it still dries out. It just doesn't provide control.” The immediate economic impact of replanting, even when the timing allows for this, is significant. In 2015, Grigg estimated the cost of onion seed at roughly \$600 to \$700 per acre.

Grigg also sees benefits later in the season, when the cover crop improves water infiltration and reduces runoff and the associated soil erosion, especially on hilly ground. While this benefit occurs for both onions and corn, it has been especially notable for the corn, where Grigg sees an additional impact from eliminating cultivation. “I believe that when we cover crop, the water moves down the shank mark right where the corn's planted, and in between, the cover crop helps some of that water sub better. When we were cultivating, all the water was running down into the cultivated ditch, and it wasn't getting over to where the corn roots were, and so it was always drier, and we would water quite a bit more. When we were cultivating, we watered steadily during a heat period, whereas now we'll water three days and maybe we're off one day.”

Challenges

The biggest ongoing challenge that Grigg has with his cover cropping system is managing the amount of residue produced by the cover crop. If he doesn't get enough residue, then seedlings won't be protected adequately from wind damage. On the other hand, too much residue can be a problem for planting, especially for onions, which require a well-prepared seedbed.

Achieving the right amount of residue means choosing the right cover crop – for Grigg, this is usually the choice between winter and spring wheat. It also means choosing the timing for planting and killing the cover crop (unless it is spring wheat that has been winter-killed). With significant weather variability from year-to-year, his timing decisions depend on that year's conditions.

Managing Risk

Grigg sees cover cropping as an essential tool that lowers his risk of cropping in an area prone to windstorms. "There's definitely added cost in putting the cover crop systems in, but I treat it as insurance. It's the best thing we have going for us, to guarantee that we're going to get a crop out of the ground in the spring."

For onions, the vulnerable period extends from planting in March through early June. Even for the corn, which is planted later and grows faster, he feels that the cover crop is clearly worth the added cost and labor. Grigg sees it as "just a cost of doing business, no different than fertilizer or the water I use."

Looking Forward

For Grigg, having a flexible mindset is critical to continue to adapt his farm to changing conditions. He is hopeful that new tools will be developed by manufacturers that continue to make strip-tillage, or other types of minimum till, easier for growers. "As far as what future tools might be out there for helping with wind erosion or strip-tilling or minimum till, I feel like I need to be open to change and new ideas. I know what I know today, but I don't know what tomorrow will look like. And I believe that there are ideas out there that will make it better, simpler, and more cost effective."

Advice for Others

Grigg was asked what advice he would give to others who are seeking to reduce tillage in irrigated systems.

Be aggressive in seeking out new ways to do things.

Grigg says that travelling to other areas has been an essential tool that has helped him get new ideas for strategies that might work on his farm.

Be willing to make adjustments until you get a new system to work. Grigg has found that troubleshooting a new system is critical to success. For example, when Grigg was developing his strip-tillage system, he and his dad designed a grain drill system that planted the wheat in rows. However, in the spring, sometimes the wheat rows would match the direction of the winds. After two circles of onions were blown out that spring, Grigg could have given up on the entire system. Instead, they adjusted their system to go back to a broadcast, scatter planting within the strips, which minimized the effect of winds from any direction.

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