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AE488

Agricultural Management Options for Climate Variability and Change: High-Residue Cover Crops[1]

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This series of EDIS publications provides information about different agricultural management options available to improve resource-use efficiency and adapt to climate variability and change. To see the complete series of publications, visit http://edis.ifas.ufl.edu/topic_series_agricultural_management_options.

Introduction

Adapting to climate variability and change can be achieved through a broad range of management alternatives and technological advances. While decision making in agriculture involves many aspects beyond climate, including economics, social factors, and policy considerations, climate-related risks are a primary source of yield and income variability. Existing strategies can help producers minimize the risks associated with climate variability and change as well as improve their resource-use efficiency. This series of EDIS publications gives information on these existing technologies, and this publication focuses on the use of high-biomass winter cover crops to improve production systems.

What are high-residue cover crops?

High-residue cover cropping is an adaptation of conservation tillage in which a high-biomass cover crop is grown during the winter and is rolled or cut down prior to no-till or strip-till planting in spring. Winter cereals typically used as high-residue cover crops include rye (*Secale cereal*), black oats (*Avena strigosa*), wheat (*Triticum*), or triticale (*Triticosecale*). A high-residue cover cropping system can enhance the normal benefits of conservation tillage (e.g., reduced erosion, improved infiltration, better nutrient cycling, etc.) because of the increased biomass of the cover crop. The cover crop is managed more intensively than a traditional cover, and fertilizer is applied to maximize biomass production. Rye usually results in the largest amount of biomass produced before spring planting, having total above-ground biomass ranging from 2 to 5 tons per acre, depending on rates of applied nitrogen, winter temperatures, and rainfall (Price et al. 2007).

Similar to other cover crops, high-residue cover crops require a termination operation to kill the crop before planting the cash crop. A roller/crimper is an important piece of equipment needed for successful application of high-residue cover crops. It is designed specifically to terminate the cover crop and reduce the interference of plant residues with planting operations. Rolling-down the cover crop in a direction parallel to planting helps terminate the cover crop and helps with residue management. The high-biomass cover crop creates a substantial mulch when rolled down, providing nearly complete soil coverage. Planting is done with minimal or no tillage; if required, subsoil tillage

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Figure 1. Cereal rye cover crop rolling/crimping in late March 2011 at Brock Farm in Monticello, Florida. Custom roller/crimper design and fabrication by Kirk Brock. Credits: Danielle Treadwell

Figure 2. Custom roller/strip-till implement by Myron Johnson of Headland, Alabama. Credits: Brian Kahn

or strip tillage can be combined with the roll-down operation. A GPS-based guidance system is optional but can be used to ensure proper orientation of planting operations with roll-down direction and tillage locations. See Figures 1, 2, and 3 for examples of roller designs.

How do high-residue cover crops reduce climate-related risks?

High-residue cover crops and reduced tillage can lessen some negative impacts from climate and weather, such as high-intensity rainfall events, spring and summer dry spells, droughts, and extreme soil temperatures during critical crop reproduction periods. Keeping soil covered year-round with crop residue can reduce soil erosion, improve water infiltration, reduce evaporative moisture loss, and moderate soil temperature. Some benefits depend on the climate and soil types of the system, and these positive impacts can increase with repeated use of high-residue cover crops.

The main differences between high-residue cover crops and traditional winter cover crops are the types of crops selected and the amount of fertilizer applied. A high-residue system uses winter cereals with fertilizer applications, resulting in greater production of biomass than a traditional cover crop system. Many producers find the cost of high-residue cover crops are justified in dryland systems because of the improved water management and soil quality that result from the large amount of crop residues. The amount of plant residues covering the soil surface is directly related to the increased infiltration and reduced soil loss. This happens in two ways: 1) Crop residues intercept raindrops and significantly lower their impact energy, reducing soil detachment and surface sealing that result from rainfall impact, and 2) crop residues increase the ponding depth by slowing the flow of ponded water, allowing more time for infiltration (Blanco-Canqui et al. 2009).

Timely termination of cover crops in the spring is important for conservation of soil moisture. If the cover crops are not killed early enough, they can deplete soil moisture, creating dry conditions and stress for subsequent crop growth. To optimally manage high-residue cover crops, producers can adjust when they establish and terminate the crops in response to a seasonal forecast. For example,

Figure 3. From left to right: straight-bar, curved-bar, and smooth/crimper-bar roller designs. Credits: Ted Kornecki, USDA-ARS

in a La Niña year, winter and spring are usually drier and warmer than normal in parts of the Southeast, so producers may hurry operations in the fall to establish the cover crop to ensure sufficient biomass production before early termination in the spring. In a dry winter and spring, an early termination of the cover crop results in a large amount of residues covering the soil surface, which can reduce runoff from scarce rain events and decrease evapotranspiration, increasing soil moisture for planting of the cash crop. Climate-related risks can be reduced under high-residue cover cropping as follows:

- Decreased soil erosion and rainfall runoff in high rainfall years (El Niño)
- Reduced evaporative moisture loss in low rainfall years and short drought periods (La Niña), along with improved effectiveness of scarce rainfall
- Lower soil temperature during critical crop reproduction periods (i.e., peanut pegging, corn pollination)

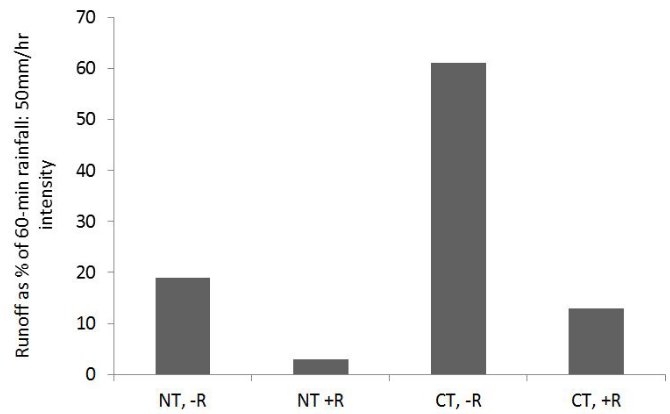

Figure 4. This figure illustrates that the increased infiltration of rainfall (less runoff) is a result of both no tillage and residue cover. NT indicates no tillage; CT indicates conventional tillage. The symbols + and – R mean with or without plant residues. In this experiment in Alabama, black oat residues were removed from one of the NT treatments and added to one of the CT treatments. The results were much less runoff under NT compared to CT, and even less runoff for the added residue treatments. These results suggest that no tillage with high-residue cover crops provide optimum rainfall runoff reduction (data from Truman, Shaw, and Reeves 2005). Credits: Figure by Daniel Dourte

What are the agronomic benefits?

The main agronomic benefits of high-residue cover crops include the following:

- Increased rainfall infiltration, resulting in improved yields in some seasons
- Less soil erosion, maintaining or improving existing soil quality
- Reduced evaporative water loss, resulting in increased soil moisture at planting in dry years
- Reduced soil temperature in summer
- Less weed pressure because of thick cover crop residue

These benefits are closely related to the hydrologic impacts mentioned earlier. A number of plot-scale studies have demonstrated these agronomic benefits, but some research has shown that the infiltration and erosion advantages from residue cover are scale-dependent, meaning that the benefits in large croplands are more significant than those in small plots (Leys et al. 2010). Figure 4 is an example of a plot-scale study in Alabama (Truman, Shaw, and Reeves 2005) in which greater amounts of residue in no-tillage systems are shown to significantly decrease runoff. Similar results can be seen in a variety of studies (Tapia-Vargas et al. 2001), highlighting the importance of the amount of residue cover at the soil surface. Also, high-residue cover crops have been recommended as a leading way to improve the management of glyphosate-resistant weed species (Price et al. 2011) because this system can reduce germination of weed seeds.

What are the impacts on production costs?

The weed-suppression impacts of high-residue winter cereals can reduce the required herbicide application rates in some systems. Using a roller/crimper to terminate cover crops can substantially decrease the rates of weed seed germination and the herbicides required for cover crop termination (Price et al. 2009). Additional nitrogen (approximately 60 lb/acre) should be applied to the winter cereal crop to maximize biomass. This large investment in a crop that will not be harvested may present a challenge, but the nitrogen application for the cover crop can result in much lower rates of nitrogen applied to the spring cash crop (Reiter et al. 2008).

Producers using a high-residue cover cropping system can expect these impacts on production costs:

- They will have costs for cover crop seed, fertilizer, and herbicide for cover crop termination.
- Resource allocation will move from machinery depreciation to soil appreciation.
- Labor cost will be spread more throughout the year when compared to conventional tillage.

What is the investment cost?

- Cost for roller/crimper ($5,000 – $20,000)
- Guidance system cost (optional, variable)

What are the impacts on greenhouse gas emissions?

As a type of conservation tillage, high-residue cover cropping reduces fuel consumption associated with tillage operations. The substantial biomass produced from well-managed cover crops can improve the carbon balance of a system by sequestering atmospheric carbon to grow a large crop that is rolled or cut down into thick mulch. The large amount of residue from the cover crops can suppress weed growth and reduce soil loss and water runoff; this may decrease the frequency of operations for weed control and nutrient application, resulting in less energy-related CO^2 emissions.

What are the barriers and incentives for implementation?

Barriers

- The right attitude! (Do I want to make this work?)
- Mindset to manage cover crop like cash crop or grazing crop
- Timeliness of cover crop planting (harvesting vs. cover crop planting priorities)
- Knowing when to terminate cover crop (La Niña, El Niño, or neutral years)

Incentives

- Tired of hauling topsoil back up the hill
- Potentially higher yields and decreased yield variability (lower year-to-year risks from climate variability)
- Decreased risk of total crop loss
- Potential availability of emergency forage for livestock
- Cost-share assistance for cover crops/residue management equipment modifications and acquisitions

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References

Blanco-Canqui, H., R.J. Stephenson, N.O. Nelson, and D.R. Presley. 2009. "Wheat and Sorghum Residue Removal for Expanded Uses Increases Sediment and Nutrient Loss in Runoff." *J. Environ. Qual.* 38:2365-72.

Leys, A., G. Govers, K. Gillijns, E. Berckmoes, and I. Takken. 2010. "Scale Effects on Runoff and Erosion Losses from Arable Land under Conservation and Conventional Tillage: The Role of Residue Cover." *Journal of Hydrology* 390(3–4):143-54.

Price, A.J., F.J. Arriaga, R.L. Raper, K.S. Balkcom, T.S. Kornecki, and D.W. Reeves. 2009. "Comparison of Mechanical and Chemical Winter Cereal Cover Crop Termination Systems and Cotton Yield in Conservation Agriculture." *Cotton Science* 13:238-45.

Price, A.J., D.W. Reeves, M.G. Patterson, B.E. Gamble, K.S. Balkcom, F.J. Arriaga, and C.D. Monks. 2007. "Weed Control in Peanut Grown in a High-Residue Conservation-Tillage System." *Peanut Sci.* 34:59-64.

Price, A.J., K.S. Balkcom, S.A. Culpepper, J.A. Kelton, R.L. Nichols, and H. Schomberg. 2011. "Glyphosate-Resistant Palmer Amaranth: A Threat to Conservation Tillage." *Journal of Soil and Water Conservation* 66:265-75.

Reiter, M.S., D.W. Reeves, C.H. Burmester, and H.A. Torbert. 2008. "Cotton Nitrogen Management in a High-Residue Conservation System: Cover Crop Fertilization." *Soil Science Society of America Journal* 72:1321-9.

Tapia-Vargas, M., M. Tiscareño-López, J.J. Stone, J.L. Oropeza-Mota, and M. Velázquez-Valle. 2001. "Tillage System Effects on Runoff and Sediment Yield in Hillslope Agriculture." *Field Crop Res* 69:173-82.

Truman, C.C., J.N. Shaw, and D.W. Reeves. 2005. "Tillage Effects on Rainfall Partitioning and Sediment Yield from an Ultisol in Central Alabama." *Journal of Soil & Water Conservation* 60:89-98.