



Growing Over Cover: A Kansas Specialty Crop Grower's Guide to Cover Crops

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A Kansas Rural Center publication
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Funding was provided by:

The Specialty Crop Grant Program at the U.S. Department of Agriculture (USDA) through Grant No. 16-SC-BGP-KS-0044. The report contents are solely the responsibility of the authors and do not necessarily reflect the official views of USDA.



Suggested Citation: J. French, K. Oxley, T. Buller, and C. Rivard. 2018. Growing Over Cover: A Kansas Specialty Crop Grower's Guide to Cover Crops, a Kansas Rural Center Publication, Topeka, KS.

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Guide designed by Kimberly Oxley, Research Associate, Kansas State University.

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INTRODUCTION

Beginning in 2014, the Kansas Rural Center published two guides in a series titled *Growing Under Cover* as introductions and guides to the use of season extension structures and hoop houses for Kansas specialty crops (fruit and vegetables). This follow-up guide is focused on building soil health using cover crops and is intended for the Kansas specialty crop grower. While the “cover” discussed in the first guide was made of plastic and metal, the cover in this publication is comprised of both living plants and plant residues. This guide is not about season extension, but rather improving soil health and farm resilience.

The use of cover crops in farming has a long history; however, of late the practice is gaining new attention for a variety of reasons. Keeping the land covered with living plants as much as possible is seen as a component of creating healthy soil. Second, the residue (mulch) left by cover crops can assist growers in controlling weeds and evaporation of soil moisture. Finally, incorporating cover crops into production can reduce erosion, absorb water, and assist in nutrient management.

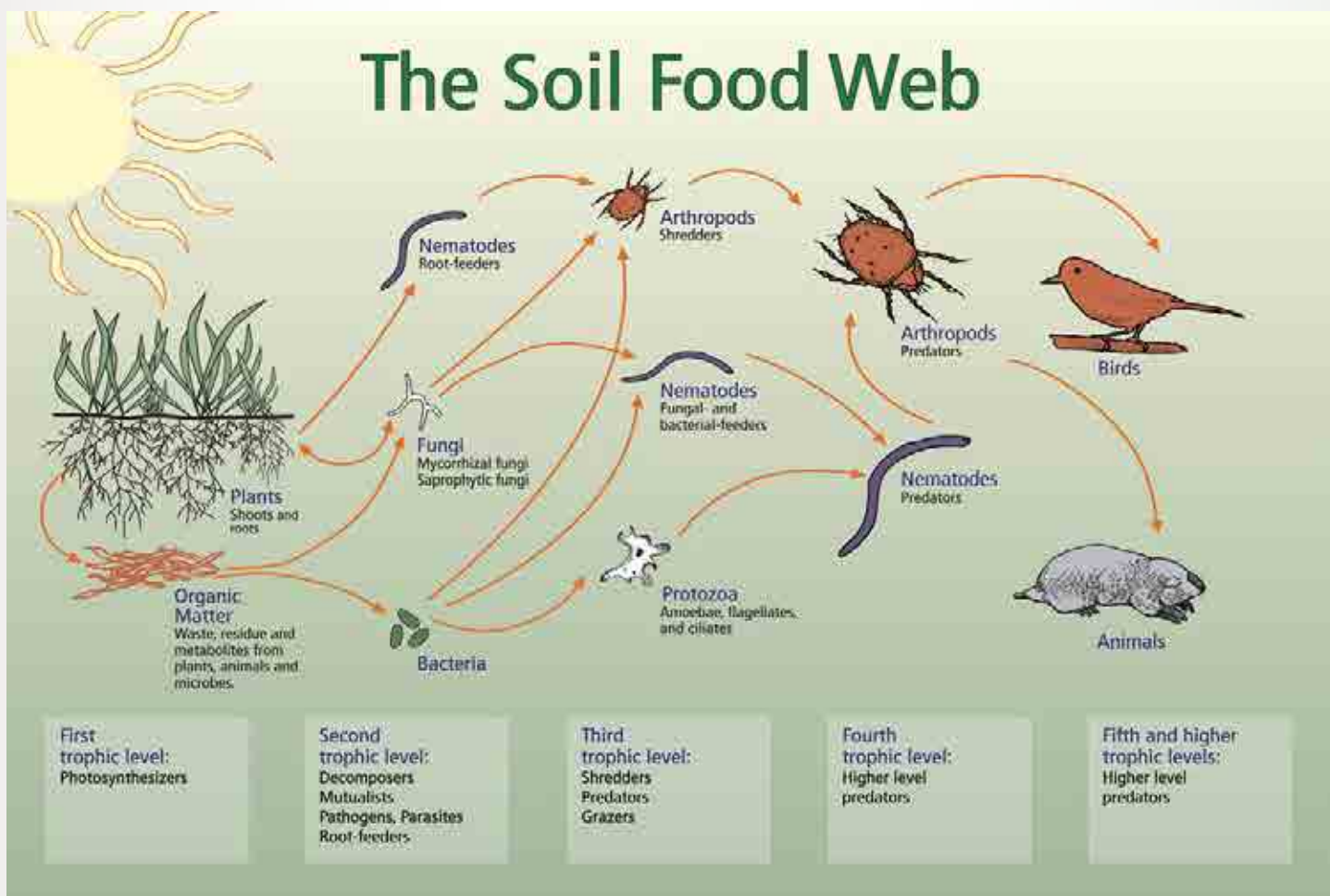
One of the primary indicators of healthy soil is an abundant and diverse ecosystem that feeds on soil organic matter and works to build soil structure. Therefore, these features of healthy soil can not only mean an operation where the costs of fertilizer and pesticides can decrease, but it also means the farm becomes more resilient – able to buffer the shocks that might come from prolonged periods of drought, heavy rains, or pests.

The first section of this guide will cover the general principles of soil health. The second section will go into more detail in how the management of appropriately selected cover crops can build soil health, increase resilience, and support production. Additionally, three specialty crop operations in Kansas will be highlighted. These growers employ cover crops in a variety of regions, approaches, and crop rotations. Since every region of Kansas has varying weather patterns and soils, the featured growers are in different parts of the state: Great Bend, Leavenworth, and Emporia. The operations also vary in production. Roger Long, Great Bend, grows corn, squash, and pumpkins using cover crops with conventional no-till practices. Paul Conway, Leavenworth, is an organic grower using an intensive rotation of vegetables with both warm and cool season legume and grass cover crops. Terry and Delores Turner, Emporia, produce grapes for Kansas wineries and utilizes living mulch including multi-species grasses, legumes, and forage for sheep. Finally, the guide will end with resources and tables useful to growers wishing to learn more about implementing cover crops and enhancing soil health.

SOIL HEALTH AND COVER CROPS

The soil is more than dirt or a place where plants can grow. It is an ecosystem containing minerals, air, and water, where plants and millions of other organisms interact, live, and die. A healthy soil will allow minerals, water, and energy to cycle and generate the means by which almost all life is fed and flourishes. The plants that we grow to feed us are only one visible part of a complex web of relationships.

The USDA Natural Resources Conservation Service has provided an informational diagram, pictured below, showing how the living community in the soil interacts with the environment, plants and animals. These organisms will live partially or all their lives in the soil and will eventually eat one another.



USDA Natural Resources Conservation Service: Soil Food Web

The concept of soil health has been popularized along with increased understanding of the importance of soil biology. If soil is understood as something alive with interacting components, then the word “health” makes more sense as only things that are living can have good or poor health. The USDA Natural Resources Conservation Service has provided a good working definition of healthy soil: “Soil health is the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.” Keys to the definition are recognition of soil as a vital living ecosystem, and the sense that soil can “continue” to provide these vital services. And by producing food, farmers can also play a role in maintaining and building healthy soils.

WHAT IS SOIL HEALTH?

The capacity of a soil function as a vital, living ecosystem that sustains plants, animals, and humans

To understand the dynamic nature of soils, one must consider all the things soils do in supporting agriculture, forests, grazing lands, and habitat. According to the USDA, soil has five functions:

- **Regulating water** - Soil helps control where rain, snowmelt, and irrigation water goes. Water and dissolved solutes flow over the land or into and through the soil.
- **Sustaining plant and animal life** - The diversity and productivity of living things depend on soil.
- **Filtering and buffering potential pollutants** - The minerals and microbes in soil are responsible for filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials, including industrial and municipal by-products and atmospheric deposits.
- **Cycling nutrients** - Carbon, nitrogen, phosphorus, and many other nutrients are stored, transformed, and cycled in the soil.
- **Physical stability and support** - Soil structure provides a medium for plant roots. Soils also provide support for human structures.

With these functions in mind, how can a grower assess the health of the soil that will support his or her production? Any evaluation of soil must consider **physical, biological, and chemical** properties. The physical properties of soil is typically described by its relative proportions of clay, sand, and silt/loam. This determines its resistance to erosion, ability to absorb and retain water, and potential for compaction. The biological properties of soil are the result of its ecosystem, which includes: nematodes, arthropods, protozoa, bacteria, and fungi. This living portion of the soil is supported by organic matter (OM) and other sources of carbon in the soil matrix like root exudates from cover crops. Chemical properties, such as the presence of plant nutrients, are commonly explored through soil testing for nitrogen, phosphorus, potassium and other micronutrients. A soil that has good structure, biology, and nutrient balance is one that is also resilient to extreme weather and the impacts that can occur from pests and machinery.

There are a variety of tests that help a grower determine the level of soil health in a field. The resources section of this guide provides examples. It could be more helpful to consider the basic principles that will support and build a healthy soil and follow best management practices. According to the NRCS, "Managing for soil health is one of the easiest and most effective ways for farmers to increase crop productivity and profitability while improving the environment. Results are often realized immediately, and last well into the future." (NRCS, *Healthy, Productive Soils Checklist for Growers factsheet*)

Four Basic Principles to Promote Soil Health

1. **Keep the soil covered as much as possible;**
2. **Disturb the soil as little as possible;**
3. **Keep plants growing throughout the year to feed the soil;**
4. **Diversify as much as possible using crop rotation and cover crops.**

While these four principles form the basics of soil health, growers can apply the management practices to their needs. For example, a growers principles would be to:

1. Utilize mulches, cover crops, and other methods to protect the living soil from erosion
2. Implement a long-term crop rotation that includes cropping diversity and/or livestock
3. Minimize tillage and rotate tillage systems over time and space
4. Identify and use cover crops that address your specific soil concerns

Goal: To create the most favorable habitat possible for the soil food web

The profiles of Kansas growers featured in this guide include examples of how they are translating the principles of soil health into effective grower practices.



A good soil looks like black cottage cheese. It displays distinct aggregate structure, presence of roots, porosity for water absorption, and a dark color indicating the presence of carbon.



Oilseed radish produces a large taproot to penetrate compacted soils., increase aeration and water infiltration.

COVER CROPPING FOR SOIL HEALTH AND PRODUCTIVITY

The benefits of utilizing ecosystem services for improved soil health and fertility

There is more than one tactic to achieving one or more of the principles of soil health. For example, heavy mulching and use of plastic mulch can keep the soil surface covered. Herbicides and mulching can reduce the disturbance of the soil. A succession of cash crops and perennials can help maintain living roots in the soil during a large portion of the year. Rotations employing diverse cropping patterns and the introduction of beneficial insect and plant companions may also assist in supporting biodiversity.

The use of cover crops in a specialty crop production system impacts all the principles of soil health, and can accelerate the process of building healthy soil. In short, cover cropping, can be a multi-functional component of a resilient and economically viable specialty crop production system.

The Multiple Functions of Cover Crops



Buckwheat cover crop, attracting pollinators such as bees and capturing phosphorus.

There are a variety of ecosystem services that cover crops can provide and many cover crops can play multiple roles simultaneously. For, example a legume can not only fix nitrogen, but also add root mass and structure to the soil as well as attracting pollinators or other beneficial insects.

Nutrient capture and recycling play a major role in certain cover crops. For instance, legumes can capture nitrogen from the atmosphere and convert it into available nitrogen in the soil. Buckwheat takes up phosphorus from its roots and releases it to later crops as the residue breaks down. Oilseed radishes (aka daikon, tillage, and forage) use their deep root to penetrate compacted soils and has the ability to scavenge nutrients that may be too deep in the soil profile for crop roots to access it.

Another major function of cover crops is to convert atmospheric carbon into plant tissue which becomes carbon in the soil -- the primary component of soil organic matter. Soil organic matter supports the soil food web which builds soil structure. Crops like cereal rye, oats, sorghum-sudangrass, and millet have the capacity to build soil carbon and structure while simultaneously suppressing weeds.

Specialty crop growers should not ignore the role that cover crops can play in attracting pollinators and beneficial insects. Flowering cover crops can have multiple benefits. For instance, buckwheat is known for capturing phosphorus, but is also well-known as a source of bee forage and is an attractant to hoverflies, predatory wasps, and lady beetles.

A comprehensive list of all the benefits of cover crops would be lengthy and complex as the diagram below demonstrates. However, the major benefits that should be acknowledged are the importance of controlling erosion, increasing water infiltration, building soil carbon, managing weeds, and alleviating compaction.

This does not mean there are not costs, trade-offs, and potential problems with cover crops. First, financial costs include equipment for planting and terminating cover crops. Planters and drills that can plant in thick residue can be expensive -- in many cases, too expensive for a smaller scale specialty crop operation. Second, cover crops add another layer of management to production. Time management will need to be considered when it comes to planting and terminating. Other challenges are covered in the sections on planning, establishment, and subsequent cash crops.

Nevertheless, the case studies in this guide demonstrate that cover crops can be successfully incorporated using creativity to keep costs low. For example, Roger Long at Long Pumpkin Patch modifies older equipment and rents other equipment; Terry and Delores Turner partner with a neighbor to add a sheep grazing enterprise that also assists in the management of the cover crops; and Paul Conway establishes strips of perennial covers that will be rotated to cash crops and annual covers every two to three years.

BENEFITS OF COVER CROPS



Kansas Rural Center, The Benefits of Cover Crops

Long employs a conventional no-till protocol; the Turners maintain a perennial cover base that they interseed with annual legumes and broadleaves; and Conway uses light tillage followed either with a cash crop or annual cover crop. If the diversity of these examples demonstrate anything, it is that the principles of building soil health and productivity with cover crops can be approached with almost any budget and most available equipment.

What does that mean for profit?

The answer to that will vary from operation to operation, but clearly, it is possible to build soil health without putting one's enterprise at a loss.

Other questions that should be asked:

- *What is the value of a soil that holds more water and decreases the yearly irrigation expense?*
- *What is gained when a well-protected soil can absorb two inches of rainfall in an hour allowing the farmer to be in the field without creating compaction?*
- *What are the savings associated with weed control or fertilizer if cover crop practices are working to provide more of those services?*

Public values like improved water quality, carbon sequestration, and pollinator habitat adds another dimension to the economic value of building soil health through cover crops.

Building profitability by incorporating cover crops should be viewed as an incremental process, and one where a clear budget should be established. But, over a period of time the improvements and benefits will definitely contribute not only to productivity but to resilience and economic viability as well.



A cover crop mix, including oats, at the farm of Lucinda Stuenkel near Palmer.



Spring oats grown in a pumpkin field in Manhattan. This cover crop does well in cool weather with wet conditions in well-drained soil.



MANAGEMENT OF COVER CROPS

PLANNING FOR A COVER CROP

Building a soil health management plan

Adding cover crops to a specialty crop production system provides opportunities for building soil health and fertility, weed control, and attracting pollinators and other beneficial insects, to name a few. However, integrating cover crops also adds a layer of complexity and requires planning and consideration of goals, costs, and time management in order to be successful.

Incorporating cover crops and cash crops

Unless one is working with perennials, specialty crops typically fall into two categories: cool and warm season. In Kansas, these crops are grown in the spring and fall, whereas warm season crops are grown in the summer. Similarly, cover crops include both cool and warm season plants and therefore can be complementary to cash crop production. The figure below shows an example of a crop rotation that systematically incorporates cool and warm season vegetable and cash crops along with cover crops.

WARM SEASON VEGETABLES



COOL SEASON VEGETABLES

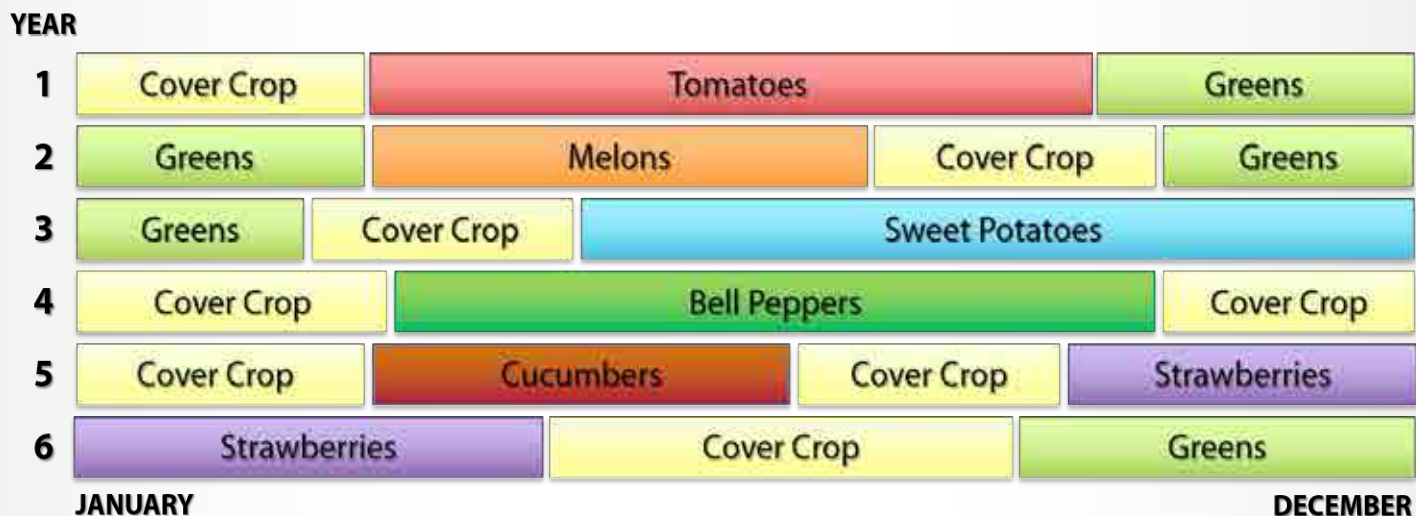


FALL COVER CROPS



Growers that are successful with cover crops for annual vegetables often pair individual cash crops (e.g., strawberries, tomatoes, corn, pumpkins) with specific and complementary cover crops (e.g., rye/tomato, strawberries/sorghum-sudangrass, oilseed radish/corn, etc.). The long-term goal of this process is to keep the soil covered with a cover crop whenever cash crops are not in production. The sequencing and spacing of crops provide opportunities for weeds to get a foothold if a bare soil is exposed for very long.

It is also important to note that cover crops should be incorporated into a long-term crop rotation that minimizes the amount of time when any given crop family is grown more than once in the same space at a three-year interval. Crop rotation is a useful practice for reducing diseases caused by soilborne plant pathogens in addition to managing fertility appropriately. The example below show where a cool- or warm-season cover crop is introduced in each year.



WHAT COVER CROP TO PLANT

Choosing the right cover crop to maximize soil health benefits

Many options are available for utilizing cover crops within a fruit or vegetable operation. The many choices offered in cover crop reference books can become overwhelming due to the large numbers of plants that make great cover crops. However, when one considers the growing season and climate, the purpose of the crop, and the geographical location, the options narrow.

Cover crops can be sown as a single species or as a mixture, and it's often very useful to grow mixtures of grasses and legumes. Most of the grasses provide high biomass (above and below-ground) production and their residue decomposes relatively slow. This also makes them useful for weed management and as a mulch in no-till systems. Conversely, legume cover crops provide added nitrogen, but are typically not as

competitive against weeds or grow as much biomass. By utilizing mixtures, growers can capture multiple ecosystem services within the same growing window.

When using cover crop mixtures, some important considerations should be taken. For example, not all crops flower at the same time. If planning to terminate by rolling the cover crop with a roller-crimper alone, use cover crops that will be mature at the same time for effective termination. This is particularly important in organic systems. Finally, it is also important to recognize that any cover crops in a mixture will be competing with each other. It is a good practice to reduce planting rates when using mixtures and recognize that tall grasses may outcompete smaller legumes and broadleaf plants, particularly during the summer or drought periods.

The table below highlights some of the cover crops that are appropriate for Kansas. It divides their ecosystem services into six different functions: nitrogen fixation, building soil, soil erosion, subsoil loosener, weed suppression, and pest management. If a grower is primarily interested in fixing nitrogen, consider a cover crop mixture weighted more toward legumes including winter peas and vetches, rather than a grass such as rye or barley.

Bioregion	N Source	Soil Builder	Erosion Fighter	Subsoil Loosener	Weed Fighter	Pest Fighter
Midwest Corn Belt	hairy vetch, red clover, berseem clover, crimson clover	rye, barley, sorghum-sudangrass hybrid, sweet clover	white clover, rye, annual ryegrass, barley	sorghum-sudangrass hybrid, sweet clover, forage radish	rye, annual ryegrass, wheat, buckwheat, oats	rye, sorghum-sudangrass hybrid
Northern Plains	hairy vetch, sweet clover, medic	rye, barley, medic, sweet clover	rye, barley	sorghum-sudangrass hybrid, sweet clover	medic, rye, barley	rye, sorghum-sudangrass hybrid
Southern Plains	Austrian winter pea, medic, hairy vetch	rye, barley, medic	rye, barley	sorghum-sudangrass hybrid, sweet clover	rye, barley	rye, sorghum-sudangrass hybrid

Source: Managing Cover Crops Profitably, 3rd ed., USDA-SARE, 66

The next important decision is to determine what the growing season is for the cover crop so that you can pair it with a complementary cash crop. Do you need a warm season or cool season cover crop? If it is a cool season crop, should it freeze out at first frost, or is it more cold hardy? Will it provide cover and survive the winter; or should it only be grown when the soil temperature is above a certain temperature? At what point (after how many days) will it be ideal for termination?

Potential problems with the cover crop reseeding or persisting and becoming a pest must also be considered. For example, if hairy vetch is allowed to go to seed, it can produce hard coated seed that can lay dormant over an extended period and then emerge when not desired. Alfalfa, while a good nitrogen fixer, can be particularly hard to terminate. So a grower should always think ahead when choosing varieties not only about the function of the covers, but how well they can be terminated or fit into the overall pattern of production.

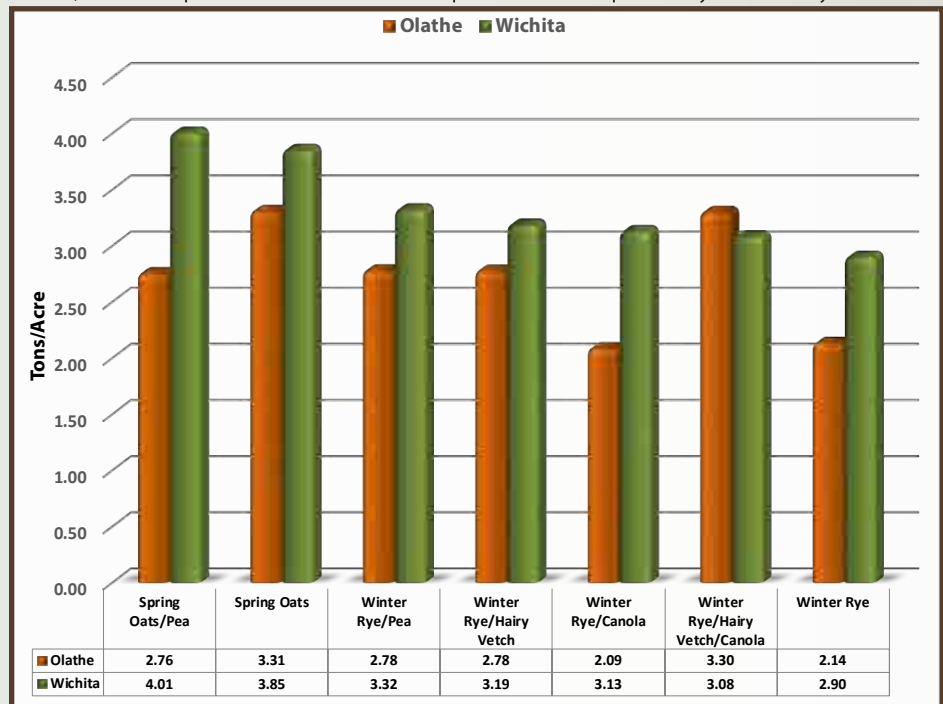
Finally, a grower should always consult with surrounding growers and seed dealers in their region. Remember, variations in climate and soil type can have a dramatic influence upon what can work at a particular operation. Similarly local research can provide information about cover crops that are successful in the region.

Development and Adoption of No-Till and Minimum Tillage Vegetable Production Systems in the Great Plains

A three-year study (2013-2015) evaluated the use of cover crops for no-till pumpkin production at Kansas State University at the Olathe and John C. Pair Horticulture Centers. Results have shown that specific cover crop mixtures are useful for this system including fall-planted spring oats/Austrian winter pea, winter rye/hairy vetch/canola, and spring-planted oats.

Table 1) 2014. Comparison of estimated cover crop biomass in tons per acre by treatment by location.

The study also showed that when a cover crop is used, the biomass residue also increases organic matter. When organic matter is regularly added to a soil, it feeds the microorganisms that help bind soil particles into larger aggregates. A well-aggregated soil slows down water infiltration and protects the soil aggregates from the impact of water erosion by reducing soil aggregate breakdown. Observations showed that the cover crop treatments had greater total aggregation, larger mean weight diameter, and a larger proportion of large aggregates (>4.75mm) when compared to conventional tillage (Davis et al. 2016).



Funding and work for this project was provided by United States Department of Agriculture Natural Resources Conservation Service

Table 2) Distribution of water stable aggregates retained by treatment in Olathe, 2014.

Treatment	Water Stable Aggregates (g sand-free 100g-1 soil)									Total Aggregation %	
	>4.75mm	2 to 4.75mm	1 to 2mm	0.5 to 1mm	0.25 to 0.5mm	<0.25mm					
Conventional Tillage	12.88	d	9.15	b	7.81	14.27	20.48	a	35.41	a	64.59
Winter Rye	28.94	abc	13.68	a	8.75	12.61	14.82	bc	21.18	bc	78.82
Winter Rye/Pea	30.99	abc	12.47	a	9.43	13.48	15.27	bc	18.36	c	81.64
Winter Rye/Hairy Vetch	27.13	bc	12.84	a	10.39	15.59	16.51	b	17.54	c	82.46
Winter Rye/Canola	40.61	a	13.44	a	7.44	10.66	11.84	c	16.01	c	83.99
Winter Rye/Hairy Vetch/Canola	34.17	ab	13.1	a	8.23	11.79	14.52	bc	18.19	c	81.81
Spring Oats	20.48	cd	12.96	a	7.11	12.37	18.07	ab	29.00	ab	71.00
Spring Oats/Pea	21.97	cd	12.32	a	7.52	12.72	17.3	ab	28.17	ab	71.83
p-value	0.01		0.04		0.5	0.38	0.01		0.001		0.001

Cover Crop Performance and Roles

The chart below is adapted from SARE’s resource “*Managing Cover Crops Profitably.*” It shows how cover crops perform at various ecosystem services: nitrogen scavenger, soil builder, erosion fighter, weed fighter, good grazing, quick growth and cash crop interseed. Some cover crops may be more successful in specific regions in Kansas than others within a given year. Seasonality may influence some of the ratings below. The ratings are based on the results and observations over the entire period it is most likely to be in the field.

	Species	Total N (lb/A)	Dry Matter (lb/A/yr)	N Scavenger	Soil Builder	Erosion Fighter	Weed Fighter	Good Grazing	Quick Growth	Cash Crop Interseed
NONLEGUMES	Annual Ryegrass		2,000-9,000	☉	☉	☉	☉	☉	☉	☉
	Barley		2,000-10,000	☉	☉	☉	☉	☉	☉	☉
	Oats		2,000-10,000	☉	☉	☉	☉	☉	☉	☉
	Rye		3,000-10,000	☉	☉	☉	☉	☉	☉	☉
	Wheat		3,000-8,000	☉	☉	☉	☉	☉	☉	☉
	Buckwheat		2,000-4,000	☉	☉	☉	☉	☉	☉	☉
	Sorghum-sudangrass		8,000-10,000	☉	☉	☉	☉	☉	☉	☉
BRASICAS	Mustards	30-120	3,000-9,000	☉	☉	☉	☉	☉	☉	☉
	Oilseed radish	50-200	4,000-7,000	☉	☉	☉	☉	☉	☉	☉
	Rapeseed	46-160	2,000-5,000	☉	☉	☉	☉	☉	☉	☉
LEGUMES	Cowpeas	100-150	2,500-4,500	☉	☉	☉	☉	☉	☉	☉
	Crimson clover	70-130	3,500-5,500	☉	☉	☉	☉	☉	☉	☉
	Field peas	90-150	4,000-5,000	☉	☉	☉	☉	☉	☉	☉
	Hairy Vetch	90-200	2,300-5,000	☉	☉	☉	☉	☉	☉	☉
	Red clover	70-150	2,000-5,000	☉	☉	☉	☉	☉	☉	☉
	Sweetclovers	90-170	3,000-5,000	☉	☉	☉	☉	☉	☉	☉
	White clover	80-200	2,000-6,000	☉	☉	☉	☉	☉	☉	☉
	Woollypod vetch	100-250	4,000-8,000	☉	☉	☉	☉	☉	☉	☉

Total N: Total nitrogen from the entire plant
N Scavenger: Ability to take up/store excess nitrogen
Soil Builder: Organic matter yield and soil structure
Erosion Fighter: Soil-holding ability of roots and total plant.
Good Grazing: Production, nutritional quality and palatability. Feeding pure legumes can cause bloat.
Cash Crop Interseed: Rates how well the cover crop will perform with an appropriate cover crop.

☉ = POOR ☉ = FAIR ☉ = GOOD ☉ = VERY GOOD ☉ = EXCELLENT

Source: Adapted from *Managing Cover Crops Profitably*, 3rd ed., SARE, 67-68.

Cool Season Covers

Winter Killed Annuals

- **Oats**
- **Oilseed Radish:**
Reduce compaction, nematocide
- **Barley**

Legumes

- **Chickling Vetch:**
Quick N fix

Overwintering:

Winter Annuals

- **Cereal Rye:**
biomass, allelopathy
- **Winter Wheat**
- **Triticale**
- **Legumes**
- **Austrian Winter Peas**
- **Hairy Vetch**
- **Crimson Clover**

Warm Season Covers

- **Buckwheat:**
quick to grow, and break down, bee forage
- **Sorghum-Sudangrass:**
Organic matter, weed suppression
- **Millet-Pearl and Japanese:**
Organic matter, weed suppression
- **Buckwheat:**
quick to grow and break down, bee forage

Legumes: N Fixation

- **Cowpeas**
- **Forage Soybeans**
- **Sunn Hemp:**
Expensive Seed, biomass, N Fixation

Cool Season Cover Crops

Cool season crops can be divided into two groups based on their functionality during cold weather. Some cover crops will successfully overwinter, and others will generally winter kill. Both will put on growth during the cool fall weather but have different implications for which cash crop will follow in the spring. For late summer and fall cover crop plantings, annual grasses such as cereal rye, triticale, winter oats, and wheat are good choices to overwinter for most areas of Kansas. Austrian winter peas and vetches are winter hardy legumes. These crops will put on some growth in the fall and then grow vigorously in the spring. Cover crops overwintering followed with vigorous spring growth allows the grower to maximize the value of the cover crops, but can make it challenging if preceded by an early spring cash crop. In that case, the grower would probably want to choose a cover crop that would winter kill. Such examples include oilseed radish and rape. Turnips will grow well into late fall and early winter. If planning to seed a cover crop by late August, consider adding buckwheat into the mix. This winter killed crop is fast growing, can help suppress weeds and attracts pollinators. Other cool season grasses and legumes can be planted in late winter and early spring once the threat of hard freezes has passed. These crops may include oats, spring forage peas, and oilseed radishes and rape.

Warm Season Cover Crops

After a spring cash crop, a grower should consider planting a warm season cover crop. Grasses in the sorghum-sudangrass and millet families can produce high amounts of biomass above and below the soil surface, provide wind protection, and shade in a hot Kansas summer. Buckwheat can be incorporated as a weed suppressor and for quick growth. Legumes in the cowpea family are considered a nitrogen fixer.

Whether broadcast or sown, warm season covers quickly germinate and grow when given adequate moisture. This advantage can also create challenges. A grower should consider the time and method of terminating the crops since they mature and set seed in a shorter period than cool season covers. Planned mowing or sequence of grazing is a consideration to incorporate into warm season cover crop planning.

Perennial Cover Crops

Perennial cover crops work well if a grower wishes to rotate a parcel of their land out of crop production for more than a season. Biennial and annual species are often combined. Two of the growers profiled in this guide use perennial species as cover crops.

There are several advantages of using perennial cover crops:

- Regeneration of soil structure and lessening of compaction;
- Nutrient building through fixation and mining;
- Increased surface and subsurface biomass;
- Longer term decrease in soil disturbance;
- Stimulation of microbial and fungal activity in the soil;
- Attraction of pollinators.

In Kansas, one of the most commonly used perennials is alfalfa. Alfalfa is a legume that establishes deep roots that can capture and recycle nutrients. Their terminated biomass adds significant amounts of nitrogen in the topsoil that will be available to subsequent crops. Alfalfa is a crop that is best managed by mowing or haying. Paul Conway, profiled later in this guide, uses alfalfa for building soil and hay production.

Caution should be used if a grower wishes to incorporate grazing animals, especially cattle, with alfalfa cover crops. It can cause bloating and death if not managed carefully. Stands of alfalfa are difficult to terminate, and often require a combination of methods including tillage and chemicals. Finally, it may be difficult to interseed other crops into a stand of alfalfa.

Perennial grasses like fescue and brome are good choices for covering the soil, establishing living roots, and helping to build soil structure. They are also better options for interseeding biennial clovers and other annual species. The profile of Terry Turner demonstrates on the use of fescue interseeded with clovers and an annual species like buckwheat to lessen compaction, build fertility and soil health, and provide a setting for grazing sheep.

Perennial Covers

- **Alfalfa:**
deep roots, N fixation, drought tolerant
- **Ryegrass:**
weed suppression, adds organic matter
- **Red Clover:**
short lived perennial, loosens heavy soils, N fixation, attracts pollinators, adds organic matter, easy to establish
- **White Clover:**
N fixation, attracts pollinators, adds organic matter, easy to establish



Alfalfa planted to use for hay production and as a cover crop at Conway's Produce, Leavenworth

COVER CROP ESTABLISHMENT

It is important for the specialty grower to keep the planning and planting process simple



Preparing to sow a summer cover crop with a hand-cranked broadcast seeder.



A mechanical broadcast seeder is used to sow 15 acres of buckwheat.



A cultipacker is used to increase seed to soil contact after broadcasting.

There are a variety of techniques to establish a cover crop. Cover crop seed can be broadcasted, planted with a traditional seeder (e.g., Brillion planter), or using a no-till seed drill. A seeder or a no-till drill result in better seed to soil contact and a more uniform and successful stand, therefore using a 5-20% lower seeding rate. If using a broadcast seeder, it is recommended to use a higher seeding rate combined with the use of light tillage, a harrow, rake, cultipacker, or very light disking post-sowing. See suggested seeding rates in Table A on page 17. Before planting a cover crop, consider the following: maximized seed-to-soil contact, provide adequate and timely moisture for germination and the plant residue on top of the soil that could inhibit seed establishment.

Broadcast Seeders

Broadcasting seeders, available by hand-cranked or mechanical, are the most common type of equipment to plant cover crops. Equipment broadcasting methods include drop tubes, spinners or air pressure. Mechanical models can be mounted to a tractor, tillage tools, ATVs or other implements. Smaller hand-cranked seeders are handy to apply in enclosed areas such as high tunnels or between plasticulture rows (pictured right). When using the broadcast method, use some type of incorporation tool to ensure good seed-to-soil contact.

In the cases of the growers profiled in section three of this guide, Paul Conway incorporates light tillage in strips to establish broadcasted seed, whereas Terry Turner broadcasts buckwheat and clover into a living cover of grass, and takes advantage of the hoof action of sheep to help incorporate seed.

No-till Drill Seeders

No-till drilling, considered one of the best methods to seed cover crops, provides numerous benefits including good seed-to-soil contact, better seed distribution, and a better stand resulting in consistent germination and emergence. This piece of equipment can be expensive and may not be practical for small-acreage specialty crop growers, but many counties in Kansas have equipment dealers or conservation district offices that offer no-till drill equipment rental services. Other options include joint ownership or hiring operations that offer these type of services.

Seeding Rates

Regardless of the cover crop, the amount of seed for the area is important in stand establishment and meeting the overall goal. Factors that influence seeding rates include weather, site location and history, and crop rotation. Table A on the next page gives recommended seeding rates for the most common cover crops. If a mix is used, the rate of the individual species will need to be adjusted. If using a broadcast seeder, plan to use the higher recommended rate for that crop. However, for mixes, the best recommendation would be to significantly reduce planting rates.

The Midwest Cover Crop Council has developed an online decision tool to help growers make sound cover crop decisions. This tool will offer crop information by state and down to the county level. The tool allows the user to enter plans for subsequent crops, soil quality goals, and drainage attributes. The results will show the recommended cover crops and planting date. You can find this calculator at mccc.msu.edu/covercroptool/covercroptool.php.



6 foot no-till fully mounted drill. Minimum of 40 horsepower required.



Small grain drill can be used to plant grass and legume mixtures.



A Scotts Easy Hand-Held Broadcast Spreader works well when seeding cover crops between rows.

This calculator is not the best for combining a nitrogen fixing goal with plans to build residue. However, it does include options for vegetable crops.

Table A: Cover crops suited for Kansas

COVER CROP	SEASON	PLANTING DATES	# SEED /1000 SQ. FT.	#SEED/ACRE (DRILLED)	#SEED/ACRE (BROADCAST)
Cereal rye	Cool, winter hardy	Sep. 1 – Nov. 15	1.5 - 3	60 - 120	90 - 160
Austrian Winter Pea	Cool, winter hardy	Sep. 1 – Nov. 15	2 – 4	50 - 80	90 - 100
Hairy vetch or crown vetch	Cool, winter hardy to 10°F	Sep. 1 – Oct. 15	1 - 2, 1 - 2 ratio with small grain nurse crop, or less.	15 - 20	25 - 40
Oats	Cool, tolerate light frost. Freezes	Feb. 1 - Apr. 15 (spring) or Aug. 15 - Sep. 15 (fall)	2 - 4	80 - 110	110 - 140
Oilseed radish (aka daikon, tillage, forage radish)	Cool season broadleaf, can tolerate light frost. Freezes	Aug. - mid-Sep. (not in spring)	Solid stands are not recommended; best in cereal mix. ¼ - ½	8 - 13	10 - 20
Spring peas – Arvica, Canadian forage pea	Cool season	Feb. - early Apr.	1 - 2, ratio of 1:3 when used with oats.	15 - 20	25 - 40
Sorghum-Sudangrass (aka Sudex)	Warm season grass. Not tolerant of frost/freeze.	Soil temperature reaches 70 °F and above.	1/3 - 1/2; reduce rate significantly in a mix. Good smother crop	35	40 - 50
Millet. Pearl, German R	Warm season grass. Not tolerant of frost/freeze.	Soil temperature reaches 70 °F and above.	½ - 1 reduce significantly in mixes.	20 - 40	20 - 40
Cowpeas	Warm season grass. Not tolerant of frost/freeze.	May - Aug.	2 - 3; reduce by 1/3 in mixes	30 - 90	70 - 120
Buckwheat	Warm season grass. Not tolerant of frost/freeze.	Late Apr. - early Sep.	1 - 2, 1:4 ration with mix or less	48 - 70	50 - 90

Other Considerations on Cover Crop Establishment



Terminated cover crops (winter rye and hairy vetch) using roller crimper in Wichita

Don't forget that nitrogen-fixing legumes rely on a symbiotic relationship with rhizobia bacteria. These bacteria "infect" the roots of legumes forming nodules where they fix nitrogen gas (N₂) from the atmosphere turning it into a more readily usable form of nitrogen. To facilitate this formation of nodules, a grower will need to inoculate the legume seed with the beneficial bacteria. Rhizobia often differ between species of legume, so it is important to use the proper inoculant for the species of legume.

TERMINATING THE COVER CROP

Balancing cover crop maturity with the needs of the cash crop

Cover crops form a living armor on top of the soil that reduces soil erosion, suppresses weeds and increases water infiltration, just to name a few benefits. Once terminated, these crops accelerate nutrient recycling and increase organic matter. Cover crops can be terminated by mowing, tilling, crimping, chemicals or a combination of any of the four mentioned. Conventional growers often utilize broad-spectrum herbicides in addition to mechanical termination.

In most specialty crop production systems, conventional or minimum tillage is used to incorporate the cover crop after termination. While any disturbance of the soil depletes soil health, soil structure, and organic matter, not all tillage is the same. Research has shown that deep plowing cannot only disrupt soil structure but result in soil organic matter (SOM) and carbon dioxide (CO₂) loss that is three times greater than shallow tillage.

In order to determine when to terminate the cover crop, first assess the growth of the crop. If the goal is fixing nitrogen, then nodule formation on the roots of legumes, biomass production, and maturity of the plant should be considered. If the goal is to smother weeds or provide a layer of residue, then the growth and biomass should be assessed. Many times, cover crops are providing more than one function and include more than one species (all of the growers profiled are using more than one species in their covers). Additionally, growers should consider whether the cover crop leaves behind any chemical residues that can inhibit the growth of subsequent cash crops, known as allelopathy. If so, allow adequate time after the termination of the cover crop for those to break down. Similarly, adequate time should be provided for cover crop residues to break down and decompose when using plasticulture or if a clean seed bed is needed. It takes approximately 30 days for nitrogen in cover crop tissues to break down in the soil and become available for the cash crop.



Terminated cover crops (spring oats and winter rye) are incorporated and the non-terminated cover crops are used as a windbreak.

Cover Crop Termination Options

Roller-Crimper

A roller-crimper is a long steel drum, often weighted with water, that has rows of steel fins that are welded onto the cylinder in a chevron pattern (to prevent bouncing). The roller-crimper is pulled over the cover crop to roll down the residue and break or “crimp” the stems while maintaining an anchored root and



Roller crimper terminating winter rye cover crop at the Kansas State University Olathe Horticulture Center.



Rolled cover crop using a roller crimper showing weed suppression and no-till.

residue on the soil surface. The roller-crimper works best on cool season cereal grains like rye and wheat once they have begun to reach reproductive maturity. It is also useful on warm season cover crops, although they may be more difficult to kill without the use of herbicides. Often growers will combine rolling with an herbicide as is the case with the profiled grower, Roger Long.

Roll the cover crop when it has a well-developed and maturing stem, but before the viable seed is developed. For example, on rye and oats, this would ideally take place at “soft dough stage,” which is before seed drying on the plant.

Chemical termination

Herbicides can be used in conjunction with rolling and/or mowing to terminate persistent cover crops. On the plus side, all the cover above and below the ground is left intact increasing residue and leaving the soil undisturbed. This reduces the rate of organic matter decomposition, but also means that nitrogen is not released nearly as quickly to subsequent crops. With many herbicides, especially broad-spectrum products, there is a chance of spray drift and/or damage to other plants, so caution must be used in application. In all cases, the chemical applicator should be trained and follow all labels for proper use.



Flail mower

Mowing and/or shredding

Mowing or shredding is currently the most common way that specialty crop growers are terminating cover crops. Cover crop biomass that is shredded into small pieces allows for faster incorporation and release of nutrients. It also allows the residue to move through a roto-tiller without causing tangles or equipment issues. Mowing is also the most effective mechanical method to terminate difficult-to-kill cover crops like hairy vetch. A flail mower is preferred as it can handle most cover crop residue with ease, and it more evenly distributes the clippings.

Mowing large grasses like rye, sorghum-sudangrass, and millet is extremely difficult with a rotary mower, but it can be used for smaller species like wheat, oats, buckwheat, and legumes. Rotary mowers can also be used for mowing larger species that are not at full height or mowed repeatedly during the season. Like rolling, timing of the mowing operation should coincide with the intended purpose of the cover. Regrowth can be both a challenge and an opportunity.



Rotary mower

With a warm-season cover crop like a sorghum-sudangrass, repeated mowing can stimulate additional root development which in turn can benefit soil structure and carbon sequestering. It should be noted that if you are planning to plant a subsequent cash crop using no-till methods, mowing is not recommended. The residues are not anchored to the soil or incorporated below-ground, which means they are very likely to cause equipment problems.

Shallow tilling or discing

Shallow tillage can be used for terminating some covers without much biomass like buckwheat, immature grasses, clovers and peas, but it is uncommon to terminate and incorporate cover crops with high biomass like sorghum-sudangrass, millet, and annual rye. With high biomass, mechanical tillage most often occurs after mowing and/or rolling sometimes in combination with a spray application.

Any disturbance of soil will damage soil structure and release carbon. However, if the tillage is shallow, new plant growth is quickly established, and adequate residue is maintained, the impact is greatly lessened. In the case of the profiled grower, Paul Conway, some cover strips with perennials are tilled and rotated every two to three years into strips using annual covers and vegetable crops. This provides a longer period for soil regeneration. Common tools in this category would be the roto-tiller or a disc.

Other Considerations for Going from a Cover Crop to a Cash Crop

Allelopathy

Some plants have the ability to inhibit the growth of other plants within close vicinity. Cereal rye is a popular cover crop choice in that it can suppress weeds both by its residue, but also by its allelopathic qualities. Most sources recommend terminating rye at least two weeks before trying to plant a new crop. This is usually a good recommendation for going from cover crops to a cash crop, particularly when seed is directly sown into the soil and transplants are not being used.

Residue

While a thick cover crop mulch on the soil helps control weeds and erosion, it can be a real impediment to planting, especially for direct seeding. Unless a grower owns or has access to no-till equipment built to cut through and plant in residue, other options will have to be employed. This could mean light tillage or the use of strip tillage.

The cover crop as a weed

If not controlled or terminated properly, almost any cover crop has the potential to be a former “good” plant in the wrong location -- more bluntly, a weed. Hairy vetch is one common example. It is an excellent nitrogen-fixer that can withstand cold winter temperatures and creates good cover. However, it’s vining capacity can overtake subsequent crops and its seeds can persist in the soil for years. Thus terminating before seed set is important or the grower may have inadvertently created a management headache for many seasons ahead.

GROWER PROFILES

Long Pumpkin Patch, Great Bend

Combining no-till and cover crops to enhance the customer experience and build soil health



Roger Long, Long Pumpkin Patch

After hearing Pennsylvania producer, Steve Groff, talk about no-till vegetable production using cover crops at a No-Till on the Plains conference, Roger Long knew the direction he wanted to go in developing a pumpkin and corn maze attraction in Barton County. Established in 2007, the Long Pumpkin Patch has become a successful destination point for Kansans looking for a fun and educational experience.

In 2011, Long moved the operation to its present location just west of the Barton Community College campus outside of Great Bend, Kansas. The families that visit the patch not only enjoy the fun of making their way through the paths mowed in towering rows of field corn, they can see the evidence of crops growing over a thick mat of rye below their feet.

Long, who is an experienced agronomist, knew the benefits of no-till farming in larger commodity operations. He also saw a potential benefit for combining his knowledge with the emerging use of cover crops with no-till techniques in a specialty crop and agri-tourism setting.

“I really liked the multiple benefits that cereal rye could provide in a pumpkin and corn rotation,” said Long. “A rolled and crimped layer of rye keeps the maturing pumpkins and squash from contacting bare soil, and has an allelopathic effect, which inhibits weeds.”

He also said that over the years there has been an increased ability of the soil to absorb water meaning less irrigation, and better soil structure. In addition, Long has observed that the heavy residue and better soil health, allows the fall crowds to be in the maze and picking the squash and pumpkins even in wet conditions without creating compaction.

“There is virtually no puddling or mud for people to contend with.” Long said that the rotation of pumpkins and corn with a cover crop, has perfectly complemented his commitment to a zero-till system.

The system of rotation

The sixty varieties of pumpkins and squash planted on the two-acre irrigated and one-acre dryland plot usually bring fifty cents a pound from the last weekend of September through Halloween. “After that it’s hard to give them away,” laughed Long. In like fashion, the season for the corn maze usually ends right after Halloween. “That’s the signal for moving from agritourism to planting a cover crop.”



Rolled rye residue in corn maze

Long said that another of cereal rye’s positive qualities is its ability to be established and continue growing in the cooler weather that comes in November. Once the pumpkins are terminated by frost and the corn is harvested, Long uses a no-till drill rented from the local conservation district to plant the rye directly into the residue. He also mixes hairy vetch seed with the rye.

He observed, “I’ve learned to not use over a 2% mix of vetch. Its capacity to vine and spread can be a challenge when I tried a higher percentage.”

In the spring, the planting dates for his corn and pumpkins are not that far apart. “If corn is planted too early there won’t be enough green left in the plants to create lush borders for the paths,” Long said. He also added that in recent years he hasn’t seen an impact on corn yields since the crop often benefits from the late summer rains that have been occurring lately. Planting for the pumpkins and squash takes place from June 1 to 10, and the corn is usually planted in a similar window.

Depending on the weather, Long said that he has terminated the rye anywhere from one day to three weeks before planting the corn and squash plots. “Ideally, I want to roll and spray the cereal rye in the early flowering stage to capture the greatest amount of residue without seed setting. In addition, it is at this stage that the stems are most easily broken and crimped,” he said. Each year, Long switches what is grown in the two-acre tracts to eliminate build-up of disease and pests in any one area.

The Hardware – Simple and Efficient

Successfully establishing crops can be tricky in any type of specialty crop operation. Long has found that while the thick residue from the rye cover means the use of more specialized planting tools, it also has helped create a soil that is conducive to the emerging crops.

As mentioned earlier, Long drills his rye with a rented no-till drill. In late spring he terminates the rye with a roller crimper in conjunction with a spray application of glyphosate and metolachlor (Dual) and possibly a



Roller crimper at Long Pumpkin Patch



Planter with mounted seat

follow-up application of clethodim (Select) to control grasses.

For planting corn, he uses a John Deere 7100 four-row no-till planter using a double disc opener with Thompson closers on thirty-inch rows. He observed that it is difficult to see where the planter has passed after five or ten minutes. In this way, the residue is preserved, and the soil is left covered which inhibits weeds and prevents compaction.

The same planter is used for planting the pumpkins and squash. Only this time, Long has removed two of the planting boxes and replaced them with a seat mounted on a plywood platform. The person on the seat has a seed tube located directly in front of them in which they drop a seed at approximately every thirty to thirty-six inches (see photo on left).

Long explained the process of planting: "The young folks riding on the planter have cups filled with a mixture of the fifty or so varieties of pumpkins and ornamental squash. The seeds are pre-counted to last for a single pass through the plot. At the beginning, we use flags to get them used to the interval for hand dropping the seed into the tube. After that, they soon learn the timing needed to make a cupful last until the end of the row."

For establishing the maze in the corn, Long uses a standard riding mower when the corn is knee high.

Long went 'underground' in 2012 after suffering through the 2011 drought with an irrigation system plagued by problems. "When we moved to this site, I was using an above ground drip tape but rodents looking for water and a chew toy created daily leaks to be repaired," he said. Long determined that if he was going to continue with the enterprise, he would need to go to a buried system.

Long says that the improved water holding capacity of the healthier soil combined with the drip irrigation, and very simple and low tech equipment, make this operation much more efficient, cost effective, and profitable in the long run.

Fitting the pieces together

The result of keeping living roots in the soil year-round, and maintaining a constant cover of living plants and residue is a perfect setting for the five weeks of public pumpkin picking and maze walking. This is Roger Long's "harvest."

In addition to the maze and harvesting of the cucurbits, Long also uses his plots to educate young people and adults about agriculture and the history of corn and squash planting among indigenous people. He has added some rows of historical varieties of corn interplanted with squash to demonstrate the companion

relationship these plants have shared for thousands of years in the Americas. The Patch also hosts musical events and other programs in those five weeks in the autumn.

And, Long Pumpkin Patch is also an educational testament to the future of cover crops and building soil health in a specialty crop operation.

Those interested in learning more about Roger Long and the Long Pumpkin Patch can visit the Facebook page at <https://www.facebook.com/LongPumpkinPatch/> where a phone number is listed and messaging is available.



Many varieties of squash and pumpkins on rye residue

Conway's Produce, Leavenworth

Leavenworth Vegetable Farmer Supports Production with Healthy Soils and Cover Crops

Paul Conway has grown vegetables on seven acres of land west of Leavenworth since 1996. From the beginning, he knew that planting vegetables alone would only lead to problems and restrict his goal to farm organically and build a healthy soil. After an initial plowdown of the clay based soil, he has rotated vegetable production with both perennial and annual cover crops with only light tillage as needed.

For Conway, cover crops were the tool that would allow the soil to rebuild both nutrients and organic matter after the depleting impact of vegetables. He also observed that "cover crops in rotation help control diseases and suppress weeds."

Conway employs a strip method of production. Out of the seven acres only two acres is annually producing vegetables. The producing acres are in strips alternating with perennial strips. The perennial strips will either be in alfalfa which a neighbor hays in exchange for manure from his horse barn, or in strips of a perennial grass and clover mix like fescue and red clover.

Conway stated that while alfalfa has been a useful crop, it does have the disadvantages of "not being easy to kill, and not suppressing Johnson grass which is a major pest on these acres."



Paul Conway, Conway's Produce, Leavenworth



Paul Conway plants alfalfa for a perennial cover often in place for 3 years.

Intervals between crops

In the beginning, Conway said he knew he had to start somewhere in developing a system using vegetables and covers, and “with experience I would learn to better manage the system.”

Generally, the alfalfa or grass mix stays in 3 years followed by 3 years of vegetable/annual cover crop rotations before returning to a perennial. The strips are generally twenty-four to thirty-two feet wide. In addition to building soil and suppressing weeds, the grass mix strips also provide additional benefits of reducing compaction while providing a place to drive small vehicles, and eliminating erosion.

Horse manure is applied after planting to keep it on top of the strips. Conway spreads a light application in the fall and winter. He said, “I only use manure on the off-season cover crops and perennials. This eliminates the potential for pollution and contamination.”

“While I look for opportunities to double-crop vegetables, I never let any strip go without a cover or live roots for any extended period. Since, I farm organically, I must till at times, so coming in with a crop or cover crop is essential for maintaining a healthy soil,” observed Conway.

Cover Crop Evaluations

Conway constantly experiments with different varieties of cool and warm season grasses and legumes, but mostly to fine tune what will work best on his own fields. As he stated in a presentation at the Great Plains Growers Conference in 2015, “One size does not fit all – be prepared to manage different fields differently”

With that rule of thumb in mind, Conway has some cover crops that he likes to work with. For the warm season, he likes sorghum-sudangrass and pearl millet for the biomass they produce, and they work well when mixed with cowpea varieties like Iron and Clay, and Red Ripper. However, he recommends that the mix not contain more than 25% of the summer grass in order that it not outcompete the legume.

For early spring plantings of cover crops, Conway will often choose to mix cool season grasses like oats, annual ryegrass, and buckwheat with legumes. The legumes he works with include chickling vetch, spring forage peas, and Lana Woollypod vetch either alone or mixed with oats. Conway stated that “for sheer biomass, nothing beats a forage pea/oat mix.” He also observed that the buckwheat did well to suppress early spring weeds, and it also slowed down the growth of Johnson grass.

While the spring and summer plantings are most often worked in with vegetable production, it is the late summer and fall planted cover crops that will set the stage for the next year’s cash crops. One sequence he described moved from a planting of cowpeas and oats in August, followed by an overseeding of cereal rye in November followed by bean, cabbage, and potatoes the following spring. Conway also has mixed legumes

like common and hairy vetch and Austrian Winter Peas, and oilseed radishes with the winter grasses.

Another late summer practice that Conway uses is planting cool season covers like oats and brassicas between September 1 to 15. These crops will develop good fall growth but will freeze out during the winter. He then can overseed with rye until early spring which will cover the ground until terminated in the spring.

The Larger Perspective

Paul Conway admits that his system has taken time to develop and that each grower should start where they are at and make gradual steps to develop what will work best in their setting. However, that doesn't change what Conway believes should be the guidelines for sustainable food production whether the grower is organic or not.

First, Conway says that continuous vegetable production is hard on the soil. To buffer that impact, he stated that "biologically active healthy soils are the key to growing good crops over the long run." He noted that healthy soils are more resilient and can better tolerate periods of drought, the erosion potential of hard rains and winds, and "healthy plants are more resistant to disease and pests" (Great Plains Growers Conference presentation).

During a visit in late July, he dug down with his hand and scooped up soil in a strip of planted cowpeas and sorghum-sudangrass. It resembled large curd cottage cheese, meaning it had a good aggregate structure and would hold together while allowing for water absorption and retention. The soil also showed no compaction meaning that roots could easily move downward and that there was a good percentage of organic matter and carbon.

Paul Conway is dedicated to the health and productivity of his farm. He is also a life-long learner ready to consider new approaches and innovations. In a summary e-mail of his cover crop experience in late 2016 and early 2017, he wrote:

"I was planting peas on ground where I had planted rye and spread manure over several years. I was suddenly struck by how friable and mellow the soil was. These strips had been clayey, with terrible tilth. Not any more. How much faster would the soil organic matter have increased if I had coupled the use of cover crops, especially Summer annual grasses with legumes, with intensive grazing?"



Cowpea, sorghum-sudangrass/pearl millet mix bordering corn.



After a spring cover of cool season grass species and legumes is ended, Conway follows with a mid-summer planting of potatoes.

During the growing season, when Conway is not working on the farm he can be found at the Leavenworth Farmers Market beside his stall with a sign reading Conway's Produce. He also runs a CSA off the farm as well as producing for the Rolling Prairie Farmers Alliance CSA. Conway produces summaries of his cover crop work which he shares by e-mail. Persons interested in receiving those summaries or to learn more about his experience with vegetable production and cover crops can contact him at pconway@wildblue.net or 913-775-2559.



Conway shows the structure of the soil on his market farm.

Broken Spoke Vineyard, Emporia

Integrating livestock into a perennial cover cropping system

Nearly a decade ago, Terry and Delores Turner had yet to realize that the vineyard they were establishing would be on the cutting edge of soil health and cover crop development in Kansas. Today, however, one look at the two acre Broken Spoke Vineyard only a few miles outside of Emporia gives light to the basic and expanded principles of creating and maintaining healthy soil.

Building and maintaining soil health can be broken down into a few basic principles: maintaining cover, having living plants growing all through the year, creating an ecosystem of biodiversity that reaches both above and below the soil, and minimum disturbance of the soil. The integration of livestock into this system is also recommended by many soil scientists. Together, these components help to grow and develop the soil-food web, one that is brought to life, particularly in early to mid-summer, under the vines at Broken Spoke.

Establishing a diverse mix of cover

Beginning in 2010, Terry began mowing under the vines in an attempt to control weeds and reduce herbicide costs. Erosion and issues of compaction also concerned the couple in the early stages of vineyard management. Not long after, Terry brought in perennial grasses, providing cover and stability to the soil under the rows of vines. The later addition of legumes and other broadleaves further revived the soil.

Continuing to diversify the vineyard, Terry added crimson, and red and white clover to fescue; broadcasting rye and barley in the fall, he would eventually begin including brassicas and buckwheat to the forage mix as well.



Terry and Delores Turner at Broken Spoke Vineyard

Today, Terry has shifted his aim, striving for a cover crop mix which hosts perennial grass species as the primary component, averaging seventy percent of his cover, while legumes and other broadleaves make up the remaining thirty percent.

“I have added Timothy because of its ability to foster mycorrhizal activity,” Terry said.

The initial addition of cover crops into the vineyard yielded an immediate reduction in the use of herbicides in the vineyard. Shortly after, the addition of grasses and legumes also eliminated the opportunity for non-desirable plants to establish themselves. This combination of results has allowed the vineyard to be herbicide free since 2012. An increase in water absorption and retention in the soil has also resulted from introducing cover crops. “We are using less water through the season, and puddling is non-existent,” Terry stated. “This also almost eliminates any compaction when our small tractor and equipment moves between the vines.”

In addition to compaction no longer being an issue, Terry has reported that the early concern of erosion is no longer present. Organic matter in the soil has also increased from 2.5 percent to 6.5 percent since the vineyard was started.

Integrating livestock and grazing

In 2011, the Turners sought to begin rotational grazing on the vineyard, adding yet another component to the soil-food web. At that time, they established a partnership with Lynette Miller of G & L Whole Foods. Both Miller and the Turners benefited; for Miller, the partnership granted her access to a diverse forage mix for finishing lambs, and sometimes an area for the rams as well. Having sheep on the vineyard helped to control undesirable plants like Palmer amaranth, and allowed nutrients to re-enter the soil.

To maximize these benefits, Miller uses electrified netting, and cordons off three to four rows at a time. When rotating grazing ground, there is never more than one-third of available forage removed from a paddock; this allows for the preservation of root mass of the cover crops in addition to enabling the soil to absorb and retain moisture, avoiding compaction.



A diversity of cover crops at Broken Spoke Vineyard.



Katahdin hair sheep graze the perennial cover between the vine rows.

As for just how much benefit the vineyard was receiving, Terry researched the possible volume of nutrients the sheep could provide over a season of rotation in the vineyard and reported his findings in a Facebook post:



Healthy soil structure reduces erosion and increases water absorption

... so this stage of the weed removal and fertilizer program for 2016 is complete. You can't believe the difference this is having on the vineyard. If you feed the soil, the soil will feed the plants.

As the sequencing and amount of grazing allowed is crucial to the success of rotational grazing, the sheep arrive in early spring and often remain until the vines are netted at grape set. After harvest in early fall, the sheep return to help clean up residue and graze the various cool season grasses and forbs.

After seven seasons of controlled grazing and cover crops, Terry observed an increase in the quality and quantity of his harvests. "No chemical fertilizer, just the sheep and cover crops under the vines. The only input you need," he noted.

Mycorrhizal and microbial action in the soil

Turner knows the importance of encouraging beneficial fungi or mycorrhizae and microbes in the soil. These organisms help the transfer of nutrients like nitrogen to the roots of plants, as well as creating zones for the capture of moisture. Mycorrhizae depend upon the living roots which they have a symbiotic relationship with, thus "having multiple species of plants growing throughout the year is important," said Turner.

Analyzing this relationship between these organisms, the soil, and the vines allows viticulturists to understand how these factors contribute to the unique taste qualities of the grapes as well. Terry offered research being done at UC-Davis as evidence; the study observes the relationship between microbes and fungi, and its effect on the qualities of a wine within a region – something that is called "terroir" (<http://www.npr.org/sections/thesalt/2016/06/17/482315073/demystifying-terroir-maybe-its-the-microbes-making-magic-in-your-wine>).

Well, the sheep went home today after 64 days of grazing. A market lamb weighing about 100 lbs produces 4 lbs of manure daily, the equivalent of about 0.06 cubic feet per day. We figured about 3328 lbs of manure was deposited on the vineyard during this time...

Manure contains valuable nutrients, like nitrogen (N), phosphorus (P), and potassium (K). In addition to the three major elements, manure also contains essential micro-nutrients (boron, calcium, copper, iron, magnesium, manganese, molybdenum, sulfur, and zinc. Manure nutrients come from the feed that the animals have eaten.

The organic matter in manure is also valuable because it makes soil easier to manage, less likely to erode, and more likely to absorb

Maintaining a diverse mix of annual, perennial, cool season, and warm season cover crops and grazing sheep on the vineyard are factors which Terry feels contribute to the quality of his grapes and eventual taste of the wine as well.

A model of cooperation and partnership

Symbiotic relationships and beneficial interaction are operating at many levels at Broken Spoke Vineyard. As the Turners concentrate on the management of their vines, they also work with Kansas wineries to move the grape to a final product.

Terry and Delores market their varieties of grapes like La Crescent, Noiret, and Crimson Cabernet to Glacier's Edge Winery in Topeka, and Crescent Moon Winery in Lawrence. They hope someday these wineries will be able to segregate his grapes to market wines boasting use of no herbicides and fertilizers in a biodynamic manner of management.

The Turners also partner with friends and community in the annual harvesting of grapes, bringing together work and good fellowship each year. While these relationships resurface each fall, the most beneficial relationships remain in the vineyard year-round.

Cover crops restore nutrients which builds healthy soil, reduces compaction and erosion, and holds moisture to benefit the grape vines; the variety of plants grown year-round support the "livestock" above, while the sheep nurture important microbial activity in the soil below.

"I see Broken Spoke Vineyard as a large, integrated loop. In this loop, plant, animal, and microbial life, aided by soil and water quality, contribute to the overall health of the environment and therefore the development and quality of the intended crop," Terry said.



The vineyard and cover crops.



RESOURCES

BOOKS AND ARTICLES

- Managing Cover Crops Profitably, 3rd ed., 2012. www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition
- Magdoff, Fred and Harold Van Ens. Building Soils for Better Crops, 3rd ed., SARE, 2009. www.sare.org/Learning-Center/Books/Building-Soils-for-Better-Crops-3rd-Edition
- Marr, Charles; Rhonda Janke, Paul Conway. Cover Crops for Vegetable Growers, Kansas State University Agricultural Experiment Station and Cooperative Extension Service, 1998. soilandhealth.org/wp-content/uploads/0302hsted/covercropskansasstate.pdf
- Midwest Cover Crops Field Guide, Midwest Cover Crops Council, 2012. ag.purdue.edu/agry/dtc/Pages/CCFG.aspx
- Reicosky, David. Tillage Induced Soil Properties and Gas Exchange. 2000. ars.usda.gov/research/publications/publication/?seqNo115=112367
- Soil Biology Primer, Soil and Water Conservation Society and USDA-NRCS, 2000. www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/biology/
- Buckwheat for Cover Cropping in Organic Farming, 2007. articles.extension.org/pages/18572/buckwheat-for-cover-cropping-in-organic-farming
- Davids, C.J. 2016. Cover crops for soil health and forage. Kansas State University.

SOIL HEALTH TESTING AND EVALUATION OPTIONS FOR KANSAS GROWERS

- Kansas State University, Agronomy Dept., request to organic matter analysis to indicate carbon levels in soil. www.agronomy.k-state.edu/services/soiltesting/farmer-services/soil-analysis/index.html
- Soil Health Tests, Ward Laboratories: PLFA, Haney Test, Solvita CO2 Burst Test. www.wardlab.com/soil-health-services.php

- Soil Quality Test Kit, guidelines and resources for on-farm tests. NRCS. www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/health/assessment/?cid=nrcs142p2_053873

ONLINE SITES AND VIDEOS

- HighTunnels.org. www.hightunnels.org
- Archuleta, Ray. Soil Slake and Infiltration Tests, YouTube, www.youtube.com/watch?v=cx_hmse9Se8
- Archuleta, Ray. Soil Health Principles. University of Missouri, 2014. YouTube, www.youtube.com/watch?v=9uMPuF5oCPA.
- Morse, Ron. Fitting Cover Crops in Vegetable Rotations. SARE presentation. 2016. YouTube, www.youtube.com/watch?v=77wQXZlYwSs.
- Unlock the Secrets of the Soil, NRCS soil health portal. www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/
- Conway, Paul. Tying it Together, a Farmer's Perspective. Great Plains Growers Conference. 2015. www.greatplainsgrowersconference.org/uploads/2/9/1/4/29140369/conway,_p_-_tying_it_all_together,_building_healthy_soil_and_profits_with_cover_crops.pdf

COVER CROP SEED SOURCES

- Green Cover Crop Seed, www.greencoverseed.com, 918 Road X Bladen, NE 68928, (402) 469-6784.
- Kauffman Seeds, Inc., www.kauffmanseed.com, 9218 S Halstead St, Hutchinson, KS 67501, (620) 465-2245



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