IOWA STATE UNIVERSITY
Extension and Outreach

Cover Crops in Vegetable Production Systems

CEREAL RYE

Current vegetable production systems require an intensive amount of work and inputs, and if not properly managed could have detrimental effects on soil and the environment. Practices such as intensive tillage, increased herbicide use, and reduced organic matter inputs add additional stress to the sustain ability of vegetable production systems. Growers need the tools and best practices to make production systems sustainable without compromising farm productivity and profitability. Cover crops serve as a valuable production tool in preserving environmental sustainability of vegetable cropping systems and render numerous benefits to soil, vegetable crops, and the grower.

What is a cover crop?

A cover crop is a crop that is not intended for harvest and is managed to maintain and improve soil fertility, water quality, and help manage weeds, pests, and diseases. Cover crops often are planted after harvesting a vegetable crop and then terminated before the planting of the next vegetable crop. There also are production systems where cover crops are used as living mulch, growing at the same time as the vegetable crop.

Benefits of cover crops

Cover crops provide a wide range of ecological and environmental benefits. Depending on cover crop type and grower needs, each cover crop can be utilized to provide a specific ecological benefit. Table 1 provides a list of cover crops used in vegetable cropping systems. Some of the primary benefits which cover crop provide include:

Soil and water conservation

With the use of intensive tillage in vegetable production systems, there is a constant threat of soil erosion due to rain and wind. Cover crops prevent soil erosion by providing ground cover and plant roots to hold the soil.

Both the living foliage and the residue from dead cover crop plants protect the soil from rain drop impact and slow water and air flow across the soil surface, which reduces dislodging and movement of soil particles. The cover crop root system helps to hold soil in place by enmeshing and anchoring soil aggregates. Successive years of cover crop plantings can indirectly contribute to water conservation by

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TABLE 1. Cover crop characteristics for vegetable cropping systems

Cover crop	Seeding rate* (lb/A)	Planting times	Expected biomass (lb/A)
Brassicas			
Oilseed radish	10-12	Spring, late summer, early fall	4,000-6,000
Rapeseed	10-15	Fall, spring	2,000-4,000
Yellow mustard	10-12	Spring, late summer	4,000-8,000
Legumes			
Cowpeas	75-100	Early summer	2,500-5,000
Crimson clover	25-30	Early/late summer	3,500-5,000
Field peas	90-100	Fall, early spring	4,000-5,000
Hairy vetch	25-40	Early fall	2,500-5,000
Red clover	10-12	Early spring, late summer	2,000-5,000
Sweet clover	10-20	Spring	3,000-5,000
White clover	10-12	Spring, early fall	2,000-5,000
Non-legumes			
Annual ryegrass	20-30	Late summer, fall	3,000-5,000
Barley	75-125	Fall, spring	4,000-6,000
Buckwheat	50-80	Spring, late summer	2,000-5,000
Cereal rye	100-120	Late summer, fall	4,000-8,000
Oats	100-120	Early spring, late summer	4,000-8,000
Sorghum sudangrass	40-50	Late spring, early summer	8,000-12,000

* Seeds broadcasted

increasing soil organic matter, which improves soil water holding capacity and infiltration. Successive years of cover crop plantings can indirectly contribute to water conservation by increasing soil organic matter, which improves soil water holding capacity and infiltration.

Organic matter input

A primary advantage of growing cover crops is the addition of organic matter to the soil. Organic matter improves the physical condition of the soil by improving the structure, aggregate stability, water holding capacity, and porosity of the soil. Also, organic matter from cover crops improves nutrient cycling by increasing soil microbial population and activity. Examples of cover crops that can add substantial organic matter to soil include cereal rye, oats, sorghum-sudangrass, and triticale.

Nitrogen fixation

Leguminous cover crops such as clovers and vetches, have the added advantage of fixing atmospheric nitrogen for their growth and the following crops. This nitrogen fixation occurs through a symbiotic

relationship between the leguminous plant and nitrogen-fixing bacteria that live in nodules (knobs) on the plant's roots. While the bacteria fix nitrogen for plant growth, the plant provides food and shelter to the bacteria. Upon death of the legume the nitrogen is released and around 40%–60% of the nitrogen in the legume cover crop is available to the next crop. The amount of nitrogen contributed by legumes varies by species (see Table 2). There are specific species of bacterium that form symbiotic relationship with individual legume cover crop species. It is advisable to inoculate legume seeds with the proper nitrogen-fixing bacterium strain for efficient nitrogen fixation. The cost for the inoculum packet is $5–$10 and can usually treat 50 pounds of seeds. Research has shown significant increase in cover crop biomass and nitrogen-fixing potential in inoculated legume cover crop systems.

TABLE 2. Nitrogen fixation estimates by leguminous cover crops

Cover crop	Nitrogen contributed (lb/A)
Crimson clover	50-125
Hairy vetch	100-120
Red clover	75-130
Sweet clover	50-125
White clover	80-130

Nutrient scavenging
Cover crops planted in the fall can scavenge and use unused soil nitrogen left at the end of the growing season, which may have otherwise leached during the fall or the spring. Certain cover crops tend to be very efficient at recycling or scavenging excess nutrients such as oilseed radish, cereal rye, yellow mustard, etc. These species are well adapted to cool, fall and spring conditions, and continue growing after nutrient absorption by the crop has slowed or stopped. When the cover crop dies, most of the nitrogen used by the plant during growth will be released and reused by future crops.

Break soil compaction
Cover crop roots can help alleviate the effects of soil compaction by penetrating a compacted layer and creating macropores or root channels that allow air, water and crop roots to penetrate deeper in the soil profile. Although all cover crop species contribute to loosening of soil, cover species differ in their capacity to penetrate compacted soils. In general, cover crops, such as oilseed radish, have large diameter taproots and are more effective at penetrating compacted soil layers than species that have small diameter roots. Once these taproots penetrate the restricting soil layer they are able to bring up nutrients from deep soil layers to upper layers of the soil.

Enhance soil biology
Soil is a living entity and is home to hundreds of thousands of different worms, insects, nematodes, and microorganisms. To keep soils healthy and improve soil quality, the value of cover crop root and shoot residues that help feed the soil throughout the entire year should be recognized.

The top 6 inches of soil can contain over 2,500 to 5,000 lbs./acre of living organisms. Cover crops improve the soil environment for both macro- and microorganisms, of which the majority are beneficial or not a problem for a vegetable crop. Cover crop residues increase soil organic matter, improve water holding capacity, provide a food source, and moderate soil temperature, all of which benefit soil macro- and microorganism communities. Several studies have shown higher soil microbial biomass and diverse soil microbial populations under cover-cropped systems. Cover crops also promote populations of soil macrofauna such as earthworms, millipedes, beetles, and spiders, which help create air pore spaces in the soil.

Bio-fumigation

Cover crops can be used to suppress problematic plant pathogenic nematodes, bacteria, and fungi in the soil. Certain cover crops in the Brassicaceae family (plants with cross-shaped petals) produce biologically active compounds, called glucosinolates, that have shown activity on soil-borne pests. Glucosinolates are present in plant roots, shoots, stems, and leaves and when incorporated into the soil they break down into compounds called isothiocyanates (ITCs) and other chemicals. The ITCs are known to suppress soil-borne diseases, nematodes, and weed seeds. Some cover crops that belong to the Brassicaceae family include oilseed radish, canola, Indian mustard, brown mustard, and yellow mustard. It is important to note that these cover crops cannot be used as a sole control measure to mitigate soil pest problems; rather they should be used to enhance management strategies. Additionally, there is variability in the biofumigation capabilities, a technique of incorporating a plant's biomass into the soil, which will release toxic volatiles that suppress pests, among varieties of cover crops. For example, oilseed radish cultivars such as Adagio and Ultimo which have European origin, are reported to give better nematode suppression (especially cyst nematodes) than other cultivars. Oilseed radish cultivars commercially available and commonly grown in United States include Defender and Daikon.

Weed suppression

Cover crops can be used to manage weeds in vegetable production systems. Cover crops can reduce weed germination and establishment by competing and/or producing allelochemicals, which suppress weed seed germination. Cover crops such as cereal grains and grasses establish quickly in the fall, cover the soil, and grow throughout the winter, thereby suppressing fall and winter weeds. Small-seeded legumes that are seeded in the fall are sometimes not a good choice for weed suppression as they grow slowly during cold weather and can be outcompeted by weeds. Cover crops can influence weeds either in the form of living plants or as plant residue remaining after the cover crop is killed.


HAIRY VETCH

Crop rotation

Crop rotation is a planned system of growing different crops in succession on the same land. Benefits of crop rotation in terms of weed, pest, and disease management are well documented. Cover crops can be used in crop rotation plans to break pest cycles, add organic matter, and improve soil quality and health. Vegetables have many potential seasons of production, and given the choices available with long- and short-term cover crop life cycles, cover crops can easily fit into any crop rotation plan. Periods of 1–2 months between harvest of early planted spring crops and planting of fall crops can be filled using fast-growing, warm-season cover crops, such as buckwheat, cowpea, oats, and sorghum-sudangrass. Table 3 (page 6) provides a few examples and scenarios of how cover crops could be integrated with vegetable cropping systems.


INSPECTING ROOTS


COVER CROP FIELD DAY

CLASSROOM WORKSHOP

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TABLE 3. Examples of integrating cover crops in vegetable cropping systems

Year	Month*	Season	Example 1	Example 2	Example 3	Example 4	Example 5	Season	Month*	Year
		Fall (previous year)	Oats + peas	Cereal rye + hairy vetch	Oilseed radish	Cowpea	Yellow mustard	Fall (previous year)		
YEAR 1	March	Spring	Winter-killed field peas		Winter-killed oilseed radish	Winter-killed cowpea	Winter-killed yellow mustard	Spring	March	YEAR 1
	April		Onion						April	
	May				Lettuce	Sweet corn	Muskmelon		May	
	June	Summer		Pumpkin				Summer	June	
	July								July	
	August		Crimson clover		Buckwheat	Buckwheat			August	
	Sep	Fall			Cauliflower		Cereal rye + hairy vetch	Fall	Sep	
	Oct					Garlic			Oct	
	Nov			Cereal rye	Cereal rye				Nov	
YEAR 2	March	Spring	Winter-killed crimson clover					Spring	March	YEAR 2
	April		Potato						April	
	May			Broccoli					May	
	June	Summer			Eggplant or pepper		Sweet potato	Summer	June	
	July								July	
	August		Sorghum sudangrass			Sorghum sudangrass			August	
	Sep	Fall		Buckwheat				Fall	Sep	
	Oct				Triticale		Triticale		Oct	
	Nov								Nov	
YEAR 3	March	Spring	Winter-killed sorghum sudangrass	Winter-killed buckwheat		Winter-killed sorghum sudangrass		Spring	March	YEAR 3
	April			Carrot			Cauliflower		April	
	May		Sweet potato		Onion				May	
	June	Summer				Pumpkin or winter squash		Summer	June	
	July						Buckwheat		July	
	August			Crimson clover			Lettuce or spinach		August	
	Sep	Fall			Oats + field peas			Fall	Sep	
	Oct		Cereal rye				Cereal rye		Oct	
	Nov					Cereal rye			Nov	
YEAR 4	March	Spring		Winter-killed crimson clover	Winter-killed oats + field peas			Spring	March	YEAR 4
	April					Potato			April	
	May			Sweet corn	Cucumber		Pepper		May	
	June	Summer	Cucumber					Summer	June	
	July								July	
	August					Cowpea			August	
	Sep	Fall	Oats + field peas	Cereal rye + hairy vetch	Oilseed radish		Yellow mustard	Fall	Sep	
	Oct								Oct	
	Nov								Nov	
YEAR 5			Return to Year 1	Return to Year 1	Return to Year 1	Return to Year 1	Return to Year 1			YEAR 5

* Months indicate planting time for crops. Planting time within a month may vary based on weather conditions.

Conclusion

Cover crops are gaining importance and are becoming an integral part of vegetable cropping systems. They improve the sustainability of vegetable production systems by reducing soil erosion, compaction and synthetic nitrogen inputs, suppressing weeds, increasing soil organic matter and water infiltration, enhancing soil biology, and providing habitat for beneficial insects and natural enemies of pests.

Resources

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Page 3, crimson clover illustration (Source: Britton, N.L., and A. Brown. 1913. An illustrated flora of the northern United States, Canada and the British Possessions. 3 vols. Charles Scribner's Sons, New York. Vol. 2: 355.

Page 5, buckwheat illustration by Spline_x (iStock.com)

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