

Organic Cool-Season Vegetable Crop Rotations FOR THE SOUTHEAST



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Over the past 20 years, interest in organic food has grown continuously. Data from the U.S. Department of Agriculture (USDA) Economic Research Service indicates that fruits and vegetables are by far the greatest organic products purchased by consumers. This has led to increased demand in farmers markets, CSAs (community supported agriculture), grocery stores, restaurants, and other institutions supplying organic produce. Along with the growing interest in organic food, many consumers are interested in locally grown produce and supporting smaller-scale growers. Many indicate that they believe local produce is fresher, tastes better, and has better nutrition. This local food trend has resulted in a rapid increase in farm-to-school programs where school nutrition directors buy from local farms. Wholesalers are also looking for local produce, and in many cases, this has led to increased demand for local organic produce.



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Why focus on cool-season vegetables?

In Georgia, growing conditions during the summer are particularly difficult for organic producers due to high insect, disease, and weed pressure. However, pest pressures are significantly reduced when the weather cools. The moderate conditions of late fall to spring are ideal for the production of many cool-season crops in the Southeast, including many crops that are traditionally grown as summer crops in other parts of the country. Shifting cash crop production to the fall through spring season may allow farmers to produce high-value crops more efficiently. This strategy may be particularly effective for those interested in wholesale production.

This production shift also leaves a window in the summer for cover crops that provide many benefits. Cover crops are an integral part of an organic vegetable production system. One requirement of the USDA's National Organic Program (NOP) is that the farmer "maintain or improve the physical, chemical and biological condition of the soil and minimize soil erosion." Cover crops can help organic farmers meet these requirements. Using cover crops to build and maintain soil organic matter is particularly important for organic farms larger than 5 acres because using compost as a soil amendment to build or maintain soil health can become expensive.

The key to maintaining soil organic matter is adding more carbon than is lost from the soil. Carbon is the major component of soil organic matter. This can be challenging for farmers in the Southeastern U.S. where the relatively warm and moist climate creates conditions conducive to microbiological activity nearly year-round. Most soil carbon is lost as carbon dioxide as the soil's microbial community breaks down organic matter. Summer cover crops such as sorghum-sudangrass hybrids or sunn hemp can produce 10,000 pounds per acre of aboveground biomass, which is about 4,000 pounds per acre of carbon, plus a similar amount of belowground biomass in the roots. Even cover crops that produce lower biomass, such as buckwheat or millet, still add carbon to the soil. Consequently, cover cropping is a critical practice for maintaining soil organic matter.

Cover Crop Functions

- ▶ Prevent soil erosion
- ▶ Add carbon to build soil organic matter and maintain soil health
- ▶ Reduce fertilizer costs, particularly for nitrogen
- ▶ Reduce weed pressure
- ▶ Discourage plant disease
- ▶ Suppress plant parasitic nematodes
- ▶ Conserve soil moisture

Factors to consider when planning cool-season vegetable rotations

The NOP rules specify that crop rotations are implemented to improve soil organic matter, manage deficient or excess plant nutrients, break pathogen and pest life cycles and provide erosion control. There is no specific number of years required for a crop rotation, but most organic growers have three- to eight-year rotations. Georgia farmers have many potential crops from which to choose. Designing a good rotation can be complex and may take time to find what works best for your farm. A good resource for principles of crop rotation is "Crop Rotation on Organic Farms: A Planning Manual," but this resource was developed for the Northeast U.S. and crops and timing of planting will be much different in the Southeast (see resources).

There are several key considerations for developing a cool-season rotation in Georgia. First, identify your markets. Although successful farms often find crops that work best for their particular farm and situation, it is really not a matter of what you want to grow but what people want to buy. Be sure to prepare by having buyers for your crops.

Second, a good rotation will include cash crops and cover crops from different plant families (Tables 1 and 2). For example, following a cowpea summer cover crop with a fall broccoli crop, then a spring lettuce crop, and finally a summer tomato crop illustrates rotating plant families among crops to break pest cycles.

Table 1. Plant families and approximate planting times for common cool-season cash crops in the Southeast.

Scientific Name	Common Name	Cool-season Cash Crop	Planting Times
Amaranthaceae	Amaranths	Beets, chard, spinach	Sept – Oct; Mar – Apr
Asteraceae	Asters	Lettuce	Sept – Oct; Mar – Apr
Brassicaceae	Brassicas	Broccoli, bok choy, collards, kale, mustard greens, radishes, turnips	Sept – Oct; Mar – Apr
Fabaceae	Legumes	Peas, Snap beans	Mar – Apr; Mid Aug
Liliaceae	Alliums	Onions, garlic, leeks	Late Oct – Early Dec
Rosaceae	Rose	Strawberries	Sept
Solanaceae	Nightshade	Potatoes	Feb – Mar
Umbelliferae	Carrot	Carrots, parsley	Sept – Oct; Mar – Apr

Table 2. Plant families and approximate planting times for commonly used cover crops in the Southeast.

Scientific Name	Common Name	Cover Crops			
		Summer	Planting Times	Winter	Planting Times
Asteraceae	Aster	Sunflowers	Late Apr – Aug		
Brassicaceae	Brassicas			Canola, mustards, daikon radish	Late Aug – Oct
Poaceae	Grains/grass	Millet, sorghum, sudangrass, sorghum-sudangrass hybrids	Late Apr – Aug	Cereal rye, black oats, oats, wheat	
Fabaceae	Legumes	Cowpeas, sunn hemp, soybeans	Late Apr – Aug	Austrian winter peas, clovers, lablab, lupin, vetch	Late Sept – Oct
Polygonaceae	Polygonum	Buckwheat	Late Apr – June; Late Aug – Sept		

Third, as you look at the cool-season vegetables that you want to grow, identify planting dates and final harvest dates to determine the window of opportunity for a spring, summer, or early fall cover crop. This window will change with different fall- or winter-planted cash crops.

Fourth, what are the functions you want the cover crop to perform? Different cover crop and cover crop mixtures provide different functions. Grains, such as sorghum-sudangrass hybrids, are good scavengers of nutrients from a previous cash crop. Legumes, such as forage soybeans or sunn hemp, provide nitrogen to the following cash crop. Cover crop mixtures, such as sorghum-sudangrass and cowpeas, provide excellent weed control during the summer while also providing nitrogen and building soil organic matter. These are just a few examples; see the resources list for an excellent resource on cover crops, *Managing Cover Crops Profitably*.

Identifying potentially profitable cool-season crops for wholesale markets

Can cool-season vegetables be profitable? Your bottom line depends on the specifics of your farm, your production practices, and your markets. Identifying markets requires legwork. One of your first steps should be talking with buyers:

- ▶ What kinds of produce are they interested in buying?
- ▶ Is there a particular time, such as early or late season, that they need particular produce?
- ▶ How much do they anticipate needing?
- ▶ How much or little are they willing to buy?
- ▶ What are their food safety and postharvest handling requirements?

Beginning these kinds of conversations with buyers can help you narrow down potential crops or identify potential niche markets. Don't forget to contact the various food hub organizations around the state. These organizations facilitate the aggregation and distribution of local food, and they also recruit producers to grow certain amounts of particular crops based on their research on buyer demand. Sometimes food hubs can take smaller amounts of produce than large wholesale buyers or terminal wholesale markets. For a deeper discussion of food hubs, see UGA Extension Bulletin 1488, "Food Hubs in Georgia: A Potential Market for Small-Scale and MidScale Farms."

There are also Georgia-based resources that may help you identify potential crops. The Center for Agribusiness and Economic Development, a unit of the UGA College of Agricultural and Environmental Sciences, issues yearly farm gate reports. These annual reports provide information about the amount of production that takes place for different vegetable crops by county. In 2010, the center produced "Local Food Impact: What if Georgians Ate Georgia Produce?" to address the gap between what Georgia produces and what Georgians consume.

Once you identify potential crops, you should put pencil to paper and see if that particular crop is profitable. Enterprise budgets are a good way to do this. An enterprise budget looks at all the variable and fixed costs for a particular crop and the price for the crop based on a specific unit of measurement. For example, the budget will list costs on a 1-acre basis for broccoli production, including transplants or seeds, fertilizer, pest control, irrigation, and labor as well as land cost and depreciation on tractors and other equipment used in production.

There are several sources for enterprise budgets for the Southeastern United States. MALTAG published organic vegetable enterprise budgets in 2009 and the Carolina Farm Stewardship Association has more recent enterprise budgets for several crops (See resources). The University of Florida's Small Farms and Alternative Enterprises website also publishes enterprise budgets based on 100-foot rows, although these are not for organic production.

These enterprise budgets are general guidelines on the cost of production for a particular crop. They can be modified to use costs from your farm if you have those numbers. You can also find current wholesale prices on sites like the USDA Agricultural Marketing Services custom report tool (See resources).

Organic wholesale vegetables can be produced profitably, and there is an increasing number of larger farms in Georgia that have at least part of their production fields certified organic. A recent study of cool-season vegetable production on a midscale farm in the Georgia Piedmont indicated that fall broccoli, potatoes, and strawberries could produce net returns over \$3,000 or more per acre (Boyhan *et al.*, 2016). Head lettuce and onions could produce net returns of over \$10,000 per acre. The Carolina Farm Stewardship Organic Enterprise budgets identified profit potential for wholesale broccoli, spring greens, spring cabbage, Irish potatoes, and leaf lettuce.

Profitability comes from understanding market demands as well as your particular growing conditions, and looking for ways to grow efficiently within a well-planned rotation. In organic production particularly, long-term success requires attention to the business side of production as well as the technical side of growing.

Planning a cool-season rotation

Now that you have a list of potential crops, it's time to plan how these might fit together with cover crops in a rotation. You can develop a simple table for each long-term rotation using the season and/or months as headings for columns and years as the labels for rows (Table 3a). Write the planting date and harvest date in the months they occur, write the crop name after the planting date, and draw a line across connecting the planting date to the harvest date to show how long a particular crop will be grown (Table 3b). There are examples of worksheets you can use in *Crop Rotation on Organic Farms* (See Resources).

Table 3a. Create a simple table with which to begin rotation planning. These can be developed in electronic or paper spreadsheets.

Year	Fall			Winter			Spring			Summer		
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Year 1												
Year 2												
Year 3												

Table 3b. An example of a single-field, cool-season vegetable rotation with summer cover crops that might work well in the Southeast.

Year	Fall	Winter	Spring	Summer
Year 1	Broccoli	Head lettuce		Millet
Year 2	Carrots			Sunn hemp
Year 3	Onions			Buckwheat
Year 4	Strawberries			Cowpeas

The example rotation in Table 3b includes cool-season crops from five plant families. Several of the cash crops were selected based on information from a study on local foods published in 2010 that evaluated how much of a particular crop Georgians ate compared to what the state produces (Table 4). The 2010 study indicated that broccoli, carrots, lettuce, and strawberries were crops that Georgians ate more of than the state produces, indicating that there is a potential demand. It should be noted that this is only a rough estimate of potential demand and additional market research should be conducted. For example, there has been an increase in broccoli production in Georgia since this report was produced, and it is now estimated that 26 million pounds of broccoli are produced each year.

Table 4. Cool-season vegetable crops that Georgians eat more of than the state produces according to a 2010 study, "What if Georgians Ate More Local Food?"

Crop	Amount Produced (million pounds)	Amount Consumed (million pounds)	Deficit (million pounds)
Broccoli	6.3	80	74
Carrots	39	100	61
English Peas	0.53	28	27
Lettuce	0.24	285	285
Potatoes	13	1,188	1,174
Spinach	10	26	16
Strawberries	3.8	76	72

Our example rotation also includes onions, which are a high-value crop that performs well in Georgia. Although Georgia produces more onions than we consume, there are indications that there is a demand for local organic onions.

One consideration in choosing crops is also how perishable a crop is and how the rotation might affect cash flow. Crops like lettuce and strawberries will require immediate buyers, while carrots and onions give you a little more flexibility if you have the proper storage conditions. In our example, if the rotation was implemented on four fields and each field had a different starting point in the rotation, the farmer would have a fall broccoli crop followed by carrots in late fall and early winter, then head lettuce in the late winter and early spring, strawberries in spring, and onions in early summer. This example does not have any income from cash crops during the heat of the summer until broccoli harvest in the fall.

The cover crops in our example rotation were chosen to provide particular functions. Broccoli is a high nitrogen-demand crop. Head size is strongly correlated with nitrogen, so an adequate nitrogen supply is necessary for good marketable yields. A summer legume cover crop provides some of this nitrogen and is a good cover crop choice before broccoli. In this case, we chose cowpeas. Recent research shows a cowpea cover crop before fall broccoli can supply anywhere from 30 to 90 pounds of available nitrogen per acre, which is 20 to 60% of the recommended nitrogen application of 150 pounds per acre. Using a cover crop to supply nitrogen can save organic farmers a considerable amount of money. If the cowpeas supply 60 pounds of available nitrogen, based on a seed cost of \$56 per acre when seeding at 80 pounds per acre and an establishment cost of \$15 per acre (\$71 per acre total cost), the cost of the nitrogen supplied is \$1.18 per pound. This cost is considerably cheaper than most organic fertilizers. For comparison, feather meal costs about \$6 per pound of nitrogen. In this example, the cowpea cover crop effectively replaces about \$360 of nitrogen fertilizer per acre. In addition to supplying nitrogen, a cowpea cover crop can help build soil and suppress weeds. Similarly, sunn hemp can be a good summer cover crop to provide nitrogen and provide other benefits, including increased suppression of root knot nematodes.

Continuing with the example above, a millet cover crop was used before the carrot cash crop. The millet prevents erosion and provides some weed suppression. It also matures quickly and fits well in the window between the lettuce harvest in the spring and carrot sowing in August to September. The disadvantage of millet is that it does not provide much biomass. A good stand of millet will supply about 4,700 pounds per acre of biomass. The other commonly used summer grains are in the sorghum family. Sorghum and sorghum-sudangrass hybrids can produce from 8,000 to 10,000 pounds per acre of biomass. This means that these summer cover crops are adding about double the carbon to the soil compared to millet, which is beneficial



A sunn hemp cover crop was planted before fall broccoli.

in building or maintaining soil organic matter. However, as the sorghum crop residue decomposes, it releases chemicals that inhibit the germination of small seeds. This process is called allelopathy. A direct-seeded crop with small seeds is particularly vulnerable to allelopathic chemicals. In some of our research on cool-season vegetable rotations (Boyhan *et al.*, 2016), we saw very poor carrot germination after a summer cover crop in the

sorghum family; consequently, these summer cover crops should be used with caution before carrots and other direct-seeded crops. If cover crops in the sorghum family are used before direct-seeded crops, wait four weeks for the cover crop to decompose and irrigate at least one inch to leach any allelopathic chemicals out of the soil surface. Another concern with cover crops in the sorghum family is sugarcane aphid. This is a new pest that can create a severe infestation.

In our example, we included onions. Similar to broccoli, onions have a high nitrogen demand. We chose a sunn hemp cover crop before this cash crop. Sunn hemp is a tropical legume that can produce 8,000 to 10,000 pounds per acre of biomass and fix as much as 200 pounds per acre of nitrogen over a 90-day period. Sunn hemp is excellent for suppressing summer weeds and is also reported to suppress plant parasitic nematodes. All these characteristics made this summer cover crop a good fit before onions. However, a good mower and harrow or spader is needed to manage this high biomass cover crop. Research at the University of Florida indicates sunn hemp can inhibit the germination and growth of some vegetable seeds, including lettuce. Transplanting onions into the beds avoided this potential problem. Many growers direct seed onions into a high-density plant bed from which they transplant to their final spacing and in some cases onions are direct seeded in their final spacing. In such cases, the above-mentioned cautions concerning allelopathic effects should be followed.

In recent research (Boyhan *et al.*, 2016), we planted sunn hemp in June. The sunn hemp was mowed and incorporated in September, and 30 pounds of nitrogen per acre were applied as an organic fertilizer before black plastic was laid over the beds. Onions were transplanted into these beds in December. The sunn hemp effectively supplied 90 pounds of nitrogen per acre for the onion crop. Yields were good, above the reported county averages in the Vidalia onion-producing counties. The onions produced were medium-sized with very few large or jumbo onions. This work indicated that sunn hemp could replace 75% of the recommended nitrogen (at a recommended rate of 120 pounds nitrogen per acre) without reducing expected yields in the clayey soils of the Piedmont of north Georgia. Results could be different in sandy soils that do not retain nitrogen as long as do clayey soils.

Sunn hemp is not the only legume that works well as a cover crop before onions. A study by Volmer and others in North Carolina used cowpeas before onions with good results (Volmer *et al.*, 2010).

In our example, we chose a buckwheat summer cover crop before the strawberry cash crop. Research in North Carolina by Garland and others indicates that buckwheat is a cover crop that can be used before strawberry production (Garland *et al.*, 2011).

Buckwheat is a short-lived summer cover crop that will produce from 2,000 to 4,000 pounds per acre of biomass in about 60 days. Buckwheat provides both habitat and food for pollinators and beneficial insects. It is reported to help suppress weeds, but a thick stand is necessary to perform this function. Buckwheat is also reported to help solubilize phosphorus, but research results on this function are mixed, with some studies reporting no effect on available phosphorus.

Other cover crops that have been used successfully before strawberry production are soybeans, sudangrass, and pearl millet. All of these cover crops were shown by Garland and others to reduce weed populations.



A mixture of sudangrass-sorghum and cowpeas is used to help suppress weeds before fall vegetables.

Cover crop mixtures can also be useful, particularly mixtures of grains and legumes, such as pearl millet and cowpeas. Grain/legume mixtures can increase the total biomass, increase weed suppression, and provide nitrogen.

Soil fertility is an important consideration when developing crop rotations. For example, soils that are higher in organic matter (>2.5%) and/or have higher clay content may perform better initially than sandier soils with little organic matter. It may take three to five years before your soil has built up the organic matter and fertility reserves needed to provide good yields, particularly if it has been in intensive conventional production. Farmers that are just beginning to build their soil organic matter, have low fertility in their fields, or have very sandy soils have to provide more nutrients than more fertile soils as they build their fertility reserves. Compost applications and/or increasing the frequency of cover cropping will help increase soil organic matter and fertility.

Our example illustrates the many factors that need to be considered when developing a good crop rotation. These include planting crops from different plant families, understanding your markets, focusing on cash crops that are profitable in the particular farm situation, considering cash flow, understanding soil management, identifying the window of time between cash crops available for cover cropping, and making sure that you have the equipment to manage a specific cash crop or cover crop. There is no one right answer. Most farmers have to experiment to find the right combinations and rotations for their particular farm.

Considerations for cool-season production

Soil organic matter

Maintaining and building soil quality is the foundation of organic production. Many people express this by saying, “Feed the soil, not the plant.” Soil quality encompasses the chemical, physical, and biological properties of the soil. These properties are interrelated and strongly dependent on the amount of soil organic matter present. Soil organic matter develops from things that are or once were living and is largely composed of carbon. Soils with good soil organic matter content for the region have higher biological activity, higher fertility, better structure, greater water holding capacity, and less tendency to crust. In Georgia, a soil organic matter content of around 2.5% to 3% is considered good. Our hot, humid environment creates favorable conditions for organic matter decomposition, so building and maintaining soil organic matter can be difficult. The idea is to build soil organic matter and the overall soil fertility through cover crops and organic amendments, reducing tillage to help slow organic matter decomposition. This bank of fertility is slowly made available to the crop by biological activity in the soil.

Cover crops are the foundation of building and maintaining soil quality. Recent research indicates that roots are very important for building and maintaining soil organic matter, and they may be more important than the aboveground biomass. As roots grow and then die back, root exudates and the microbial community that grows around roots creates soil organic matter. This means to maintain soil organic matter in your soil, you should keep something growing for as much of the year as possible. Also, because aboveground biomass is often roughly equivalent to belowground biomass, maximizing cover crop biomass will help add as much carbon to the soil as possible.

To maximize cover crop biomass, treat the cover crop like a cash crop. This requires timely planting, getting good seed-soil contact, reducing weed pressures, irrigating to get the cover crop up and growing quickly, and letting the cover crop grow to optimum maturity before termination. Summer cover crops can produce large amounts of biomass quickly, which will help maintain your soil organic matter if you have the equipment to manage high biomass.

Fertility management

Providing needed fertility is critical to maximizing yields and quality. One component of fertility that many organic growers do not consider is the soil pH. Keeping the soil pH in the 6 to 6.5 range maximizes the availability of nutrients, particularly phosphorus, potassium, sulfur, and many micronutrients. Most organic farmers recognize that the biological activity of the soil is critically important for cycling nutrients and keeping them available for their crops, but we can't ignore the chemistry. Liming your soils to obtain the proper pH is one way to get the most “bang for your buck” from the fertilizers you apply and also keeps the soil in a pH range where the microbial community functions best. For example, the rhizobia bacteria that are symbiotic with legumes and fix nitrogen gas from the atmosphere to make it available to plants prefer a more neutral pH (6.0 to 7.0). The capacity of many soil microorganisms to reproduce and function effectively decreases as the soil pH decreases below 5.5.

How do you find out what the soil pH is? Submit a soil sample. Test your soil every year if you are bringing new ground into production and every two to three years once your field has developed good soil organic matter and high fertility. A soil test is only as good as the soil sample. Instructions on how to take a proper soil sample can be found in *Soil Testing for Home Lawns, Gardens, and Wildlife Food Plots* (see resources). Soil testing will not only indicate the soil pH and how to correct it, but it will also give information on a range of nutrients with specific recommendations based on the crop grown.

Nitrogen is the nutrient needed most by crops and too little will certainly decrease your yields. Nitrogen also has the most complicated cycle, having organic, inorganic and gas forms. This can make nitrogen difficult to manage. In an organic production system, nitrogen is supplied by the mineralization of soil organic matter as well as decomposition of cover crop residues and organic fertilizers. One important fact to keep in mind with cool-season vegetable production is that the decomposition processes that release nitrogen for crop use from all these sources are driven by moisture and temperature. With irrigation, you can keep soils moist to promote decomposition; however, with cool-season production, you can encounter lower temperatures that slow decomposition. This situation is most often encountered in the spring, where cool soil temperatures can inhibit nitrogen and sometimes phosphorus availability behind the needs of a growing crop. This is one reason that black plastic is used by some growers to warm the soil. If you are not using plastic, you may need to wait and plant when soil temperatures are more optimal. In many cases, the temporary lack of nutrients is quickly overcome as temperatures increase.

All of the potential sources of nitrogen in your field should be considered when deciding how much nitrogen fertilizer to apply. Currently, there is not a good way to quantify the amount of nitrogen released from the soil. A very rough rule of thumb is that you can expect 10 pounds of nitrogen per acre for every 1% of soil organic matter. If you have high soil organic matter, you might expect 20 to 30 pounds nitrogen per acre.

As we have discussed, legume cover crops can be a substantial source of nitrogen. Cover crop mixtures of grains and legumes can also provide nitrogen. Grain/legume mixtures are very responsive to the amount of inorganic nitrogen in the soil. If there is high residual nitrogen from a previous crop, the grain will dominate the legume in the mixture. Conversely, if nitrogen in the soil is low, the legume will outperform the grain.

The amount of nitrogen that will be available to the following crop from a cover crop is not the same as the total amount of nitrogen in the cover crop, which is determined by the amount of aboveground biomass (pounds per acre) and the percent total nitrogen in that biomass. The amount of available nitrogen is roughly half the total nitrogen, but this is dependent on the quality of the cover crop (C:N ratio or the amount of carbohydrate, cellulose, and lignin present). Available nitrogen is also dependent on the soil moisture and temperature. Further information on estimating cover crop nitrogen and on how to measure cover crop biomass can be found in “Predicting Nitrogen Release from Cover Crops: The Cover Crop Nitrogen Availability Calculator and Cover Crop Biomass Sampling” (see resources).

Organic growers often use various processed animal manures or byproducts as a primary fertility source. One example is pelleted poultry manure. These products can supply sufficient nitrogen, however, phosphorus tends to accumulate in the soil because manures typically have as much phosphorus as they do nitrogen. Crops generally need two to four times more nitrogen than phosphorus, and when these fertilizers are applied at a higher nitrogen rate than a crop needs, it leads to an overapplication of phosphorus. A similar problem can occur when relying on compost as a fertility source. Once you build up the phosphorus levels in your soils, you should try to use low-phosphorus fertilizers with cover crops to recycle and keep phosphorus available for your crops.

Organic farmers tend to struggle with keeping enough potassium in the soil, particularly in sandy soils. Potassium is mobile in the soil and can be lost through leaching with the high rainfall we have in Georgia. Potassium is a critical nutrient for crops in that it helps with photosynthesis, stomata regulation, and protein synthesis. Low potassium levels are associated with decreased growth and yield. Potatoes and brassicas are susceptible to potassium deficiency. Organic fertilizers typically do not have very high potassium concentrations. Additions of a mined potash such as Langbeinite (potassium-magnesium sulfate) or Silvite (KCl) may be necessary to manage potassium requirements. If you are using the mined KCl, you must have a plan to avoid excess chloride concentrations in the soil. Greensand is used by some farmers as a potassium source, but the solubility of this product is extremely low, and it is difficult to maintain adequate available potassium levels with greensand.

The difficulty of maintaining adequate available potassium is illustrated by our experience in Watkinsville, Georgia. According to soil testing, potassium values for the organic vegetable rotation study were initially in the medium range, but those levels decreased over time in the two rotations evaluated despite additions of an organic fertilizer with 8% potassium and some mined potassium sulfate (Boyhan *et al.*, 2016). The biggest decline occurred from the fall of 2012 to the fall of 2013. This was an extremely wet period in the Watkinsville area, with a total rainfall of 61 inches, which is almost 14 inches above normal. These extremely wet conditions likely caused a loss of potassium through leaching despite the efforts to retain nutrients. Farmers should be aware that extremely wet conditions or drought can quickly change soil fertility even in well-managed soil.

With the current growth in organic production, there are more organic fertilizers available at reasonable costs in the quantities that commercial growers require. Certified organic growers should check with their certifier to make sure that the fertilizers they use are allowed by the National Organic Program (NOP) rules. Many organic fertilizers are complete, meaning that they contain nitrogen, phosphorus, and potassium. Although many more organic fertilizer choices are available, growers should keep in mind that these options will not perform the same as conventional fertilizers. They must undergo a process of mineralization to release nutrients and therefore are slow acting and not immediately available. This requires greater management concerning the time of application. Typically, organic fertilizers should be applied two to three weeks earlier than a conventional fertilizer.

Weeds

Weeds are the most difficult problem to deal with in organic production. Weeds may be easier to manage in winter production as compared to summer weeds, but winter weeds still need to be managed. There are several approaches organic growers can and should use. Using a multipronged approach will ensure the most satisfactory results.

Using a stale seedbed can be very effective at reducing the number of weeds. To use this technique, prepare fields for planting, but delay planting for a week or two to allow a flush of weed seedlings to germinate. After, shallowly cultivate the field to kill these emerging seedlings. Implementing this technique



A tine weeder is used to prepare a stale seed bed before planting.

will dramatically reduce the number of subsequent weeds. After the initial preparation, deep-turning the soil is counterproductive because weed seed that are in the deeper soil strata are brought to the surface.

The stale seedbed technique can be used after initial incorporation of the summer cover crop and bed preparation. After cover crop incorporation, you should wait **at least** two weeks before planting. This time can be used to allow weeds to begin to grow, when you'll kill them with shallow cultivation on the top ½-inch of the soil. Cultivation should begin **before** you see the weeds. Once weeds have small leaves that are easily seen, they usually have deeper roots and may not be killed with shallow cultivation.

Plastic mulch can be very effective at controlling weeds, and it offers other benefits such as conserving soil moisture, improving soil fertility, and ameliorating soil temperatures. Black plastic will warm the soil, while white plastic can help cool the soil. The downside is that plastic mulches are made from fossil fuels, not biodegradable, and must be removed and disposed of properly.

Finally, physical methods of control are probably the most effective method. Good cultivating equipment such as sweeps, tine weeders, or brush weeders can control weeds over a large area. Equipment selection and use will be site and crop specific.

Diseases

In general, plant disease and pest pressure is lower in cool-season crops, which gives them an advantage over warm-season crops in terms of the ease of organic production. One caution is not to overwater cool-season crops. Soilborne diseases are exacerbated by high soil moisture conditions and there may be a tendency to overwater when evapotranspiration rates are low.

There are a few diseases that may occur in cool-season crops, especially when temperatures are warmer in early fall and late spring.

Onions: Leaf spot diseases such as botrytis (*Botrytis cineria*) and purple blotch (*Alternaria porri*) occur before harvest as the weather warms up in the spring, but these diseases are generally not damaging to the crop.

Lettuce: Lettuce drop (*Sclerotinia sclerotiorum*) can be the most serious disease of lettuce, but occurrence is sporadic. Mild, wet spring weather favors development of the disease. The pathogen infects many different crops including brassicas, tomatoes, and legumes, and it survives between crops as sclerotia that can persist in the soil for up to 10 years. In a cool-season rotation study at the Durham Horticultural Farm, lettuce drop only occurred one spring out of three and resulted in a 4% loss of plants.



Lettuce drop, *Sclerotinia sclerotiorum*, causes soft rot at the soil line and plants quickly fall over and die.

Bacterial leaf spot (*Xanthomonas campestris* pv. *vitians*) causes a blight on the edges of the leaves. Keep foliage as dry as possible. This disease is not too damaging to the plant but will reduce market value.

Strawberries: Strawberry leaf spot (*Mycosphaerella fragariae*) causes numerous spots and death of the older leaves, but it is generally not a serious disease. The fungus overwinters on infected leaves and will spread any time of year when there are mild temperatures and wet conditions. Damage can be kept to a minimum with good air circulation and the removal of infected leaves. Overhead irrigation should be avoided.

Botrytis fruit rot (*B. cineria*) or gray mold occurs mainly in wet weather. Promote good air circulation around the fruit and use mulch under the plants. Discard any affected fruit and avoid the use of overhead irrigation.

Brassicas (*crucifers*): Black rot (*Xanthomonas campestris* pv. *campestris*) is a seedborne bacterium that starts as a distinctive v-shaped marginal leaf spot but can eventually spread down into the main stem causing death. Use seed that has been tested for the bacterium and inspect transplants for marginal leaf yellowing before planting in the field.

Potatoes: Blackleg (*Pectobacterium atrosepticum*) is a soft rot bacterium that will kill young plants, especially in wet soils. Seed pieces are the most common source of the infection. Use good quality seed and avoid cutting seed potatoes or allow cut edges to suberize before planting. Keep watering to a minimum while seeds are sprouting and growing, and avoid overhead irrigation. Remove old crop debris and rotate.

Root knot nematodes (RKN) are a major problem in organic vegetable production in the Southeast. Most vegetable crops are hosts for this parasitic nematode. Keeping nematode numbers low takes an integrated approach. Maintaining adequate levels of soil organic matter combined with proper selection of rotations and cover crops can suppress RKN populations and other soilborne diseases.

For more information about identifying and managing diseases and insects, contact your county Extension agent.

Summary

The demand for locally produced certified organic vegetables currently exceeds supply, particularly in wholesale and institutional markets. Many smaller organic producers think that they need to obtain a retail price to be profitable and consequently sell directly to the consumer. This requires that they grow upwards of 50 to 100 varieties in order to have a wide variety of produce each week from April to November. There may be a wholesale niche for midscale producers (greater than 5 acres) to develop cool-season rotations that focus on four to eight cash crops in rotation with cover crops. Studies indicate that such a rotation can be profitable.

Organic cool-season vegetable production offers many advantages. These advantages include fewer pest and weed problems, off-season production, and the potential to maintain and increase soil organic matter. Properly managed summer cover crops can help to maintain soil organic matter, which means mid-scale growers may not have to add compost every year. This should reduce input costs. The following should be considered when choosing cover crops:

1. Match the window for cover crop growth with the time between cash crops;
2. Consider potential allelopathic effects;
3. Balance the need for nitrogen for heavy feeders with the need for high biomass for weed suppression and the need for carbon to maintain soil organic matter; and
4. Understand the equipment needed to manage the cover crop.

Cool-season vegetable production takes advantage of the fact that disease and pest pressures are low during fall through early spring. With any new endeavor it is recommended to start small. Plant test plots to see how the new crops fit your particular situation. There will also be a learning curve with any new undertaking. It may take three years or more before successful returns are realized.

Resources

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