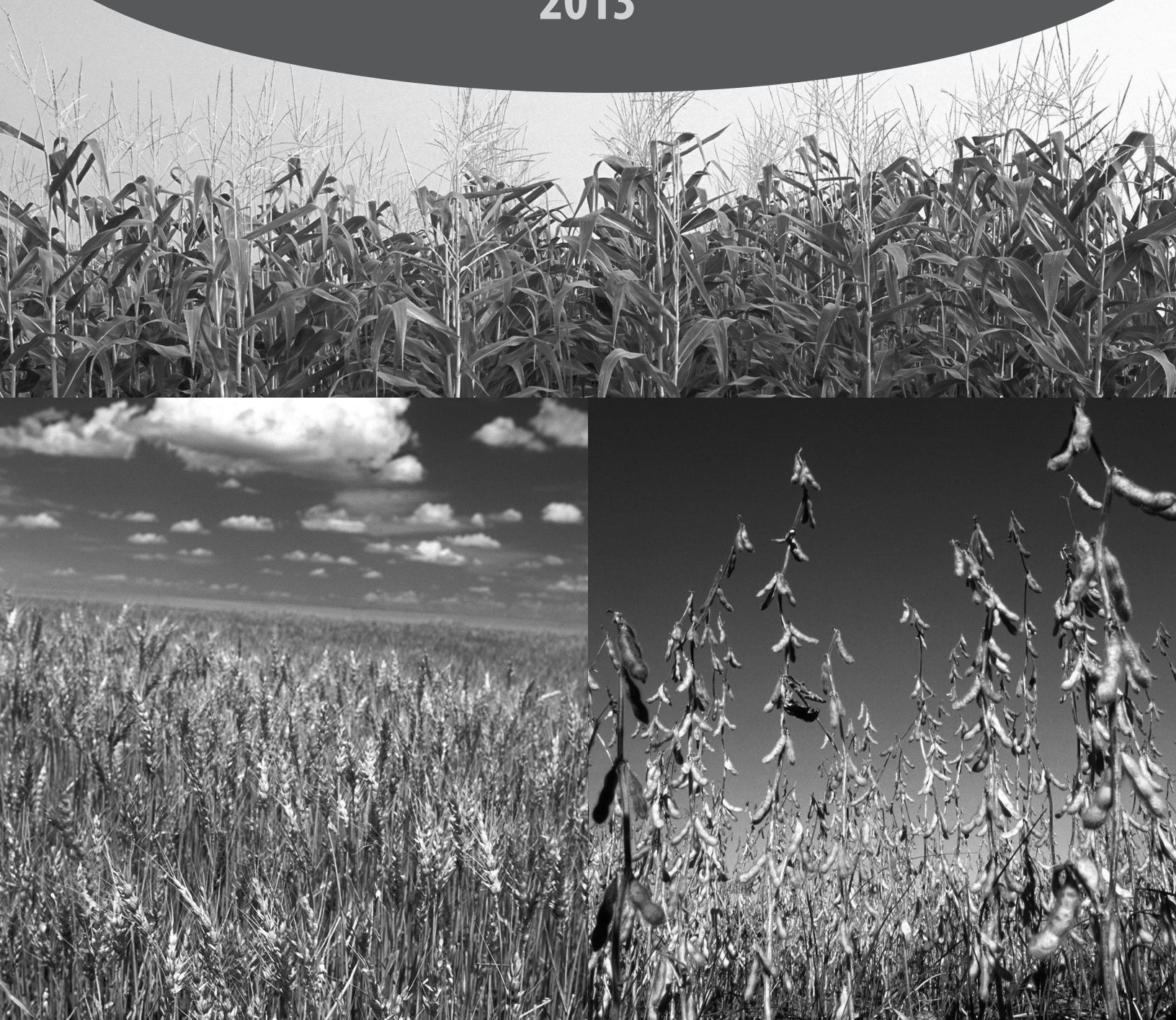


NC STATE UNIVERSITY

North Carolina Organic Grain Production Guide 2013



North Carolina Organic Grain Production Guide

2013

North Carolina Cooperative Extension Service
North Carolina State University
North Carolina Organic Grain Project
College of Agriculture and Life Sciences

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Recommendations for the use of agricultural chemicals are included in this publication as a convenience to the reader. The use of brand names and any mention or listing of commercial products or services in this publication does not imply endorsement by North Carolina State University nor discrimination against similar products or services not mentioned. Individuals who use agricultural chemicals are responsible for ensuring that the intended use complies with current regulations and conforms to the product label. Be sure to obtain current information about usage regulations and examine a current product label before applying any chemical. For assistance, contact your county Cooperative Extension Center.

A PRECAUTIONARY STATEMENT ON PESTICIDES

Pesticides must be used carefully to protect against human injury and harm to the environment. Diagnose your pest problem, and select the proper pesticide if one is needed. Follow label use directions, and obey all federal, state, and local pesticide laws and regulations

Chapter 1. Introduction

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The market for organic products is still growing at a rapid pace. In the United States, the organic food industry grew from \$1 billion in 1990 to over \$28.6 billion in 2010. The U.S. organic industry is growing at a rate of close to 8 percent annually (www.ota.com). By 2008, North Carolina was ranked fourth in the United States in production of certified organic eggs and broiler hens, producing over 258,000 eggs and 522,000 hens (USDA–ERS 2010). North Carolina also has six certified organic dairies, two organic wheat mills, two organic corn processors, and one organic soybean crusher.

To be certified as organic, livestock must be fed organic grains as required by the U.S. Department of Agriculture (USDA) National Organic Plan (NOP) Rules. This requirement leads to more opportunities for organic grain production. In North Carolina, organic grain producers have expanding opportunities to market their products to manufacturers that create foods for human consumption as well as for livestock feed markets.

This guide provides farmers, Extension personnel, and other agricultural educators with information about organic production, certification, and marketing of grain crops as well as references to further information (see the “Resources” section, pp. 65 – 67). More resources and information on organic grain production in North Carolina can be found online at www.organicgrains.ncsu.edu. This guide

does not cover all aspects of grain production, but focuses on specific techniques relevant to organic systems. Comprehensive guides to grain production can be found in the latest editions of these Extension publications:

Small Grain Production Guide:

www.smallgrains.ncsu.edu/production-guide.html

Corn Production Guide:

www.ces.ncsu.edu/plymouth/cropsci/cornguide/

Additional information is available from the NC State University Department of Crop Science: www.cropsci.ncsu.edu

The Organic Materials Review Institute (OMRI) publishes a list of commercially available products that can be used in certified organic operations for pest control and fertility (www.OMRI.org). However, some NOP acceptable materials are not listed in the OMRI list. The farmer is responsible for determining if any input is allowed for use on their organic farm. Conditions for use of an approved pesticide must be documented in the organic system plan, as described by the 2000 NOP.

We have made every effort to accurately cite NOP regulations, production information, and marketing information. Always consult your certification agency when you have questions about certification requirements specific to your farm.

Chapter 2. Organic Crop Production Systems

Ron Heiniger, Crop Science Extension Specialist, NC State University
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 Molly Hamilton, Crop Science Extension Assistant, NC State University

Organic production systems are based on management practices that promote and enhance farm biodiversity, biological cycles, and soil biological activity. Organic agriculture strives to minimize use of off-farm inputs and relies on management practices that restore, maintain, and enhance soil ecology and the farm landscape. Growers considering organic grain crops need to recognize that success will depend on developing a diversified crop management system, including an appropriate rotation plan. Recommendations in this guide were developed to help growers tailor soil health and pest management strategies to their specific conditions.

Components of Organic Production Systems

Table 2-1 lists the key components of an organic production system. The choices made for each component will affect the choices for other components as well as soil fertility and pest management.

Table 2-1. Components of cropping systems	
Components	Category
Crop sequence	Rotations Cover crops
Crop management	Variety/hybrid selection Planting depth Planting date Plant population Row width Harvest and storage
Soil management	Tillage practices Fertility
Pest management	Weed management Insect management Disease management

Crop Sequence

An organic production system begins with selection of the best rotation sequence of production crops

and cover crops based on the specific characteristics of the field. This is particularly important in the first few years of an organic production system because the transition period will set the conditions for success. Rotation sequences should be designed to:

- reduce weed pressure by minimizing the amount of weed seed produced and reducing perennial weeds;
- increase the amount of mineralizable nitrogen in the soil;
- reduce the incidence of insect and disease pests by eliminating hosts and interrupting pest life cycles.

This usually requires combinations or rotations of crops that attract or harbor different insects and diseases, fix nitrogen, inhibit weed growth, and enhance the soil. The following crop sequences are recommended for organic grain crop production in North Carolina.

Wheat–Red clover (or other forage legume)–Corn

Wheat and the legume provide continuous ground cover, help break up pest cycles, reduce warm-season weeds through the mowing of clover, and increase available nitrogen. Tilling the clover into the soil makes nitrogen available for the succeeding corn crop. Growing the legume for two seasons will result in more nitrogen returned to the soil and a longer period between corn crops to break pest insect and disease cycles. In systems without livestock, however, the legume cover crop might have little economic value unless it can be cut and sold for hay as an organic forage crop.

Wheat–Soybean–Corn

This classic rotation is also used by organic farmers. Traditionally, both double-cropped and full-season

soybeans are used in the rotation in roughly equal proportion. Some organic farmers are emphasizing more double cropping for a variety of reasons from economic to agronomic. The main reason is that soybeans planted after wheat usually suffer less pigweed competition. The first flush of pigweed emergence is the largest and occurs in May. Double-cropped soybeans planted in June have to contend with fewer emerging pigweeds. To successfully double crop more often, consider alternatives to wheat as a winter crop. Disease build-up can occur in wheat when grown on a field too frequently. Both barley and canola have proven to be profitable winter crops. Barley is a preferred feed grain for dairies, often commanding almost the same price as corn. Canola contracts have been offered by AgStrong (see “Buyers,” p. 58) for the last several years.

Wheat–Corn–High-value crop

The acreage of organic tobacco, sweet potatoes, and other wholesale vegetable crops has continued to

increase. Wheat and corn have provided valuable rotations, both economically and for managing pests. Soybeans are sometimes included in this rotation, but concerns over inadequate weed management in soybeans, which increases the weed seed bank, have limited enthusiasm in some regions.

Transitioning to Organic Cropping Systems

A switch to organic production from conventional agriculture requires a 36-month transition period. That is to say, 36 months must elapse between the last application of a prohibited substance and organic certification. Experienced grain farmers can use their skills, knowledge, and experience with conventional grains as a base to build new proficiency with crop rotation, cover crops, mechanical weed control, recordkeeping for certification, and marketing of organic crops. Most North Carolina farmers can go organic with little capital investment; however, mechanical weed equipment, separate storage facilities, or both may be needed.

Farm Profile: Burch Farms, Inc.

Burch Farms, in Faison, NC, produces about 1,000 acres of certified organic wheat, butternut squash, and sweet potatoes on Norfolk and Goldsboro soils. Burch Farms plants cover crops—sometimes before and after each cash crop—to improve soil quality and add nitrogen to the soil with legumes. The rotation can be flexible, but generally, butternut squash and sweet potatoes follow Austrian winter pea cover crops. Wheat follows sweet potatoes. Crimson clover–vetch or Austrian winter peas–oats cover crops are planted in the fall to overwinter between the butternut squash and sweet potatoes. These mixtures provide nitrogen, increase soil organic matter and improve soil structure, while preventing erosion. Once the wheat and butternut squash are harvested, a cover crop of sorghum–Sudan grass (or buckwheat) is planted to improve the soil for the remainder of the summer. Buckwheat, a very competitive warm-season annual, grows quickly and has a fairly short lifespan (fully flowering at 35 to 45 days). It fits well in

a rotation after a summer crop and before the first frost, where it can quickly provide cover in a field, preventing late warm-season annual weeds from germinating. Currently, along with fertility provided by the overwintered cover crops, Burch Farms is applying 0.5 to 3.5 tons of farm-produced compost per acre, depending on the most recent soil and tissue samples, before each vegetable and grain crop.

This rotation works well in an organic production system because it is fairly long (at least three years), is very diverse, and includes cover crops that are used to build soil health and fertility.

Having grain crops in the rotation also benefits the farm in terms of labor and marketing. Organic corn and wheat are low-return crops compared to organic sweet potatoes and other vegetables. They are, however, relatively easy to grow, require little labor, and have lower production costs. With the price premiums for organic corn and wheat, these crops are very profitable and the farmer is glad to have them in the rotation.

It is advisable to begin transitioning to organic with a relatively small acreage and carefully chosen fields. Fields with low weed, insect, and disease pressures and with relatively good soils give the best chance of success when starting with organic production. Fields with more intense pest problems or soil requirements may take more experience with organic production to be successful.

Although crops produced during the transition to organic might be marketed for a premium over conventional crops, return will be less than for certified organic crops. Some grain buyers in North Carolina

and the Midwest are looking for nontransgenic (non-GMO) corn and soybeans, which must be used in transitional production. Some livestock producers in North and South Carolina are also looking for nontransgenic grains for feed and are willing to pay a small premium. These markets may be harder to identify than traditional organic markets, but they can provide economic incentives during the transition years required to change from conventional to organic farming. Some of these buyers register with this NC State University website: www.organic-grains.ncsu.edu/marketing/buyers.htm

Chapter 3. Crop Production Management—Corn

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Production Management

Key management practices for organic corn production:

- Choose organically grown (when possible), non-GMO hybrids with high vigor, high standability rates, disease and pest resistances, stress tolerance, high yield, and a maturity date of 112 days or less.
- Plant on time, at the proper depth, in a well-prepared seedbed, on narrow rows.
- Rotate crops.
- Achieve proper soil pH and good fertility.
- Choose the correct plant population.

Hybrid Selection

For organic growers seeking to identify appropriate corn hybrids, yield is not the primary consideration. Producers should consider these key hybrid characteristics for organic corn production:

- rapid early growth and vigor
- standability
- pest and disease resistance
- stress tolerance
- yield

Rapid early growth and vigor

Rapid early growth is essential to minimize the effects of seedling diseases and insects, increase root volume, and reduce weed infestation. Hybrid seed companies list seed vigor ratings. Few companies, however, list ratings covering early growth. In general, early growth is closely related to hybrid maturity. Early to medium maturing hybrids (102- to 114-day relative maturity) tend to exhibit better early growth than do late hybrids (> 115-day relative maturity). The best way to select hybrids with rapid early growth for North Carolina is to contact Cooperative Extension agents, seed company representatives, and

other growers who have had experience with different corn hybrids.

Standability

Standability is important because it is a measure of how well the crop will stand under difficult environmental conditions. Because pests and diseases can be problems, it is important that an organic hybrid has the ability to avoid lodging under stress. Most hybrid seed suppliers provide ratings for standability or stalk or root strength.

Pest and Disease Resistance

Resistance to common seedling, leaf, and stalk diseases is an important characteristic for hybrids in organic production systems. There are even some hybrids that tolerate insect pests such as European corn borer and southern cornstalk borer. Unfortunately, most hybrids do not have resistance to a wide range of diseases or pests. Growers should select hybrids that combine good early growth characteristics with a good resistance package to diseases that are major problems in their area. In North Carolina the major diseases of corn are grey leaf spot and northern and southern leaf blights

Yield

Unfortunately, variety testing of corn under organic conditions is sparse. Past NC trials can be found at www.organicgrains.ncsu.edu/production. Given the rapid turnover of hybrids, test results can rapidly fall out of date. Growers should conduct their own hybrid comparisons by selecting four to six promising hybrids and evaluating them on their farms with their management practices. The best procedure for grower testing of hybrids is the strip test where each hybrid tested is grown adjacent to a common “tester” hybrid. The strip test, with tester hybrids, permits

any yield data collected to be adjusted for soil variability. If not using a tester, growers should place the hybrids they are considering beside the hybrid that has performed best for them in the past. Growers conducting their own hybrid evaluations must remember to select uniform test fields with minimal soil variability and restrict comparisons to hybrids of the same maturity.

Planting Date

Planting date is crucial to the success of an organic production system. Planting too early results in slow growth and increases weed competition, the incidence of seedling diseases, and the likelihood of damage from seedling insects. On the other hand, planting too late results in a greater risk of drought stress, increased insect damage from second and third generations of European corn borers, and reduced yield due to decreasing hours of daylight. The recommendations here attempt to balance these considerations. In the NC tidewater and coastal plain, plant organic corn between April 15 and May 15. In the NC piedmont, plant organic corn between April 20 and May 20. In all NC locations, plant following at least two days when average temperatures are above 65°F. Depending on the soil type, time soil preparation and planting date so that soils are moderately dry at planting to minimize the risk of seedling diseases.

Seedbed Preparation and Planting Depth

Seedbed preparation should begin with a major tillage operation performed at least a month before planting. If cover crops are used, they may need to be killed and/or incorporated into soils earlier than one month before planting to allow for residue decomposition and to avoid seed corn maggots. Heavy applications of compost or manure should also be incorporated earlier. Follow up with at least two light tillage operations to create a smooth, weed-free seedbed. The final tillage operation should be performed on the day of planting to ensure that all germinated weeds have been destroyed when the seed is placed in the ground. Seeding depth is very important in an organic production system. Seeds planted too deeply

will be slow to emerge, and seedlings will have immediate weed competition and a greater likelihood of damage caused by seedling diseases. A seeding depth of just 1 inch is sufficient on most soils and allows for rapid emergences.

Plant Population

Plant population is another important factor in organic corn production, especially when corn is grown on sandy soils. Plant populations should be related to the moisture-holding capacities of each individual field. In organic systems, corn plant populations per acre should be 10 percent higher than in conventional systems. The higher plant population will increase light interception and reduce weed competition and the effects of pest damage. On soils with good-to-excellent water-holding capacity, the goal is a stand of 30,000 to 33,000 plants per acre; on soils with average water-holding capacity, 25,000 to 28,000 plants per acre; and on soils with poor water-holding capacity, no more than 22,000 plants per acre.

Row Spacing

Narrow rows permit more uniform plant distribution and result in rapid closing of the canopy. In choosing a row width, balance the potential advantages that come from narrower rows against the additional machinery cost and management that a narrow row system demands. Because cultivation is the primary weed control measure in organic production, make rows wide enough to permit the use of a tractor-mounted cultivator. Row spaces as narrow as 20 inches have been successful under organic conditions with alterations in cultivators and guided steering systems (see the farm profile in Chapter 7, p. 36).

Soil Fertility

Corn generally requires from 120 to 160 lb of nitrogen per acre, 30 to 50 lb of phosphorus per acre, 80 to 100 lb of potassium per acre, and smaller amounts of sulfur and micronutrients to obtain optimum yield. Organic corn growers should design their systems so that the amount of nutrients added to the system offsets the amount removed in the grain

or forage. The local offices of the USDA Natural Resources Conservation Service, Cooperative Extension, or the Soil and Water Conservation District can provide guidelines for a nutrient management plan. Chapter 6 (pp. 25 – 31) also has more information on organic soil management.

Weed Management

Grassy weeds and warm-season broadleaf weeds, such as cocklebur and morning-glory, will be among the most difficult to control. Although tillage prior to planting can help reduce early-season weeds, many of the summer annuals will continue to germinate and grow. It is very important to start with a clean seedbed and to till the soil just before planting so the crop begins with a head start on new weed seedlings. This will make it much easier to use cultivation to control grass and broadleaf weeds that are smaller than the corn.

It is also important to take advantage of the corn canopy's ability to shade the soil. Shade reduces the number of weeds germinating and slows their growth. Use of increased plant populations, narrower rows, row directions perpendicular to the path of the sun, and tall-growing hybrids all increase canopy density and lead to quick canopy closure.

Remember that weed competition during the first four to six weeks after planting will cause the most damage in terms of yield reductions. Weeds that emerge after canopy closure will have little effect on yield, although they can make harvest more difficult. Chapter 7 (pp. 32 – 37) has more information on managing weeds in organic production.

Insect Pest Management

Cultural practices are very important for establishing a vigorous, full corn stand. Stand establishment can greatly influence pest populations as well as crop competitiveness and tolerance to pest feeding. In fields where pests are historically abundant, do not plant organic corn if suitable, effective, and economical pest management options are not available.

Crop rotation

Crop rotation is one of the most powerful tools for

insect management and is also often the lowest-cost method of control. Rotations of at least two years and use of a nongrass crop will reduce the levels of many pests through starvation, interference with insect reproduction, or both. Rotation also gives the option of isolating corn crops from one year to the next. This may or may not be effective for wireworm. Depending on the species, a single generation of wireworm can take one to five years to complete. As a result, a multiyear rotation out of corn may be needed to avoid this pest. Rotation in large units with a minimum of 800 to 1,000 feet between current and previous corn is the most effective way to manage moderately mobile pests such as billbugs.

Cover crops

Cover crops may reduce the abundance of some pests, although little research has been done in corn. Alternatively, the density of certain pests, such as cutworms and probably wireworms, can be increased by cover crop use.

Tillage

Insect pests that feed on seed and small seedlings are typically found in the soil or at the soil surface. Populations of wireworms, cutworms, grubs, seed corn beetles, and other pests can be reduced with winter or early spring disking and the accompanying bird feeding and exposure. The combined action of these factors can give meaningful protection to planted seed and small seedlings. No-till organic corn using cover crop mulches is being tested around the state, but this system is not as well understood as no-till soybeans (see Chapter 6, pp. 25 – 31).

Rapid germination and seedling grow-off

Rapid germination and seedling grow-off reduces the time corn seed and seedlings spend in the most vulnerable stage between germination and the six-leaf stage and helps the crop gain a size advantage over weeds. Losses to seedling insects and other pests can be reduced by promoting early germination through row-bedding, seeding at the recommended depth, hybrid selection for performance under cool conditions, and adequate soil fertility.

Crop maturity

In corn, timely maturity of the crop almost always reduces insect damage. Certain pest insects and pathogens (for example, late-season corn borers and fall army worms) reach high densities in late July and August and may severely infest late-maturing corn. Timely planting and avoidance of late-maturing hybrids (over 120 days) will reduce the level of pests attracted to the crop in late season and prevent yield loss. When planted early, hybrids that mature in 112 days or less will usually avoid late-season caterpillar attack.

Hybrid selection

Rapid germination, early vigor, strong ear shanks, tight husks, resistance to stalk rots and other pests, strong stalks, and uniform performance over a wide population range are factors influenced by genetics that may reduce losses to insects.

Major Corn Insect Pests and Management

Corn billbugs

Billbugs can be serious pests of corn seedlings. No insecticide approved for organic use has activity against billbugs. Combining cultural tactics—rotation and isolation from previous corn crops—along with rapid seedling emergence and grow-off should help prevent concentrations of adult billbugs and promote rapid accumulation of tolerance. Three additional billbug management tactics are (1) avoiding areas with abundant nutsedge, which is an alternative host for billbug; (2) avoiding no-till production for organic corn because no-till soils warm more slowly and delay germination and grow-off; and (3) planting at the earliest possible date to allow seedling growth prior to billbug adult emergence.

Wireworm and black cutworm

In organic systems, the major tactics for reducing populations of these insects will be disk cultivation and avoidance of no-till situations. Cultural methods that promote rapid seedling growth and seeding at adequately high populations to allow some seedling loss can also be important.

European corn borer (ECB) and southern corn-stalk borer

Borers likely occur at some level in all NC cornfields. Their populations fluctuate greatly between years and sometimes within a single growing season. The organic farmer can influence the abundance of these borers through rotation, site selection (away from first-generation ECB nursery areas in potato and wheat fields), early planting, and use of short-season corn hybrids. Taking these actions to manage both space and time will help avoid high populations and promote tolerance for those borers that are present. Organically approved spinosad insecticides are labeled for ECB on corn, but they are expensive and are not likely to be effective when sprayed on tall corn. For ECB scouting procedures and thresholds, consult your county Extension center or the following website: www.ces.ncsu.edu/plymouth/ent/Entomology

Western corn rootworm

Western corn rootworm is a pest only in nonrotated corn. It can be successfully managed in an organic system by rotating corn with other crops.

Key Diseases and Management

Six key diseases—Grey leaf spot, Northern and Southern corn blights, seed rots and seedling blights, stalk rots, and charcoal rot, which are usually controlled in conventional systems either by fungicides or management practices—can have significant impacts on organically grown corn. Growers should be aware of these diseases and select hybrids and management practices that reduce the risk they pose. Grey leaf spot and Northern and Southern corn blights are best managed in organic systems by choosing resistant hybrids. While there are many other diseases that can attack corn, they rarely cause economic loss. Pictures of these field corn diseases can be found at this website: www.btny.purdue.edu/extension/pathology/cropdiseases/corn/corn1.html

Seed rots and seedling blights

Seed rots and seedling blights caused by species of *Fusarium*, *Stenocarpella*, *Pythium*, and other fungi

are often associated with the term “damping-off.” Plants die at emergence or within a few days of emergence. These diseases are more prevalent in poorly drained, excessively compacted, or cold, wet soils. Planting old or poor quality seed with mechanical injury will increase seed rot and seedling blight, as will planting seed too deep in wet, heavy soils. Seed vigor ratings are often used to select hybrids with genetic resistance to seed rots and seedling blight.

Stalk rots

Stalk rots (caused principally by the fungi *Stenocarpella zeae* and species of *Fusarium* as well as *Colletotrichum graminicola*) are present each year and may cause considerable damage, particularly if abundant rainfall occurs during the latter part of the growing season. Stalks previously injured by cold, leaf diseases, or insects are especially susceptible to attack by these fungi. Diseased stalks ripen prematurely and are subject to excessive stalk breaking. Stalk rots not only add to the cost of harvesting but also bring the ears in contact with the ground, increasing their chance of rotting. Adequate fertility (particularly adequate potassium) is the key to controlling stalk rot.

Charcoal rot

Charcoal rot (caused by the fungus *Macrophomina phaseolina*) becomes most evident with the onset of hot dry weather. It may cause stalk rot, stunting, and death of the corn plant. This disease is often considered to be stress-related. Typically, when this disease occurs in North Carolina, soil fertility and pH are at very low levels. Although the fungus survives in the soil, rotation is not generally helpful because most crops are susceptible to this disease. Supplying adequate nutrition and water is the principal means of control. Hybrid resistance in corn has not been documented.

Harvesting

Early harvesting usually avoids crop damage from pests or hurricanes and prevents field losses resulting from ear drop and fungal pathogens. Probably the most important reason for timely harvest is the

potential for yield reductions resulting from ear loss and ear rots due to stalk lodging, ear drops, and reductions in kernel weight. Fungal diseases that infect the corn kernel also cause more problems as harvest is delayed. Mycotoxins, such as aflatoxin and fumonisin, which are produced by fungal pathogens, also increase as harvest is delayed and may result in corn that is unsuitable for human or livestock consumption. Ideally, corn harvest should begin as soon as the grain reaches moisture levels of 25 percent or less. Under favorable conditions, corn should be ready to harvest in 10 days or less following the black layer formation at the base of the kernels.

Plant Reproduction and Propagation

Hybrids

Crops that are propagated by using the pollen from selected (usually inbred) male plants to fertilize selected (usually inbred) female plants are called hybrids. Neither the female or male plants may exhibit robust growth and/or vigor. Yet, when these plants are crossed, they may exhibit vigor, resistance to disease or drought, or other desirable characteristics. Probably the most common hybrid crop plant today is corn. Hybrid corn seed is produced by allowing male plants to have tassels to produce pollen. Tassels are removed from the female plants and pollination takes place by the male plants. The resulting seeds contain a mixture of genes from both parents at each point on the chromosome. Because the two parents are inbreds that carry the same genes at each point on their chromosomes (homozygous) the resulting hybrid exhibits the same characteristics (such as height, color, ear placement) across the seed lot. This gives the crop its uniformity and makes it easier to handle and harvest.

Open-pollinated crops

This is the term used to describe crops that are not hybrids and that produce seed by the crop pollinating itself. For simplicity these crops are often referred to as OP crops. Some of the most common OP crops are soybeans and wheat. In the corn industry, most of the crop seeds produced 75 to 100 years ago were

Managing Genetic Contamination in Corn

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Genetic contamination of organic corn with genetically modified (GM) genes is a growing concern for organic producers. Although corn pollen does not travel far in comparison to many other grass species, if temperature, humidity, and wind are favorable, corn pollen can travel thousands of feet. Research has indicated that cross-pollination between cornfields could be limited to 1 percent or less on a whole-field basis by a separation distance of 660 ft, and limited to 0.5 percent or less on a whole-field basis by a separation distance of 984 ft. However, cross-pollination could not be limited to 0.1 percent consistently even with isolation distances of 1,640 ft.

Organic certifying agencies and organic grain buyers will need to know how organic corn farmers avoided genetic contamination from neighboring GM corn crops. Some buyers (and all who ship products to Europe) will utilize a serological test that can detect a GM protein in the corn and will reject loads that are above a certain percentage. Contamination tolerance levels must be 0.9 percent or less for corn to qualify as organic in the European Union. The United States does not have a set threshold of contamination tolerance for organic certification, but many buyers are establishing their own product thresholds.

To reduce genetic contamination, farmers must plan ahead to spatially or temporally distance organic corn from conventionally-grown corn. Organic corn should be planted at least 660 ft from any neighboring GM corn (or conventionally-grown corn), if possible. This may mean planning a rotation around what your neighbors are doing. If distance separation is not possible, another strategy is to plant later or earlier than your neighbors so that your corn is pollinating at a different time. A typical corn plant will shed pollen for five to six days. A whole field will usually complete pollen shed in 10 to 14 days. If a neighbor producing GM corn is planting a 110-day corn hybrid, the organic

corn producer could plant a later maturity hybrid (say 118-day corn) 10 days after his neighbor has planted. This would create a maturity separation of 18 days, leaving plenty of time for the neighbor's GM corn to complete pollination. However, the organic producer must be careful not to confuse this temporal separation. If the neighbor is planting a later maturity variety (118-day), then the organic producer wanting temporal separation would also need to choose a later maturity variety (118-day or later) and plant at least two weeks later (pollination times could match if the organic producer chose an earlier maturing hybrid and planted later). Temporal separation strategies also must take into account that rarely could the organic corn producer plant earlier than the GM corn because organic corn seed is untreated and susceptible to early-season diseases. To significantly reduce any genetic contamination that may have occurred despite these measures, many farmers harvest the outside rows of their organic corn separately and sell it on the conventional market. The number of buffer rows needed depends on how susceptible the field was to cross-pollination contamination.

Blue River Hybrids has been marketing Pura Maize hybrids that will use what is known as the Ga1-s isolating mechanism. This is a naturally occurring gene in corn that stops pollen originating from a plant that does not have the Ga1-s gene from being able to pollinate a plant that does have the Ga1-s gene. This crossing barrier is utilized extensively in commercial popcorn hybrids because popcorn hybrids are grown in the Midwest, as is dent or field corn. If a popcorn ear is pollinated by dent corn pollen, then the resulting popcorn kernel does not behave as a true popcorn—which would irritate a lot of movie goers. Thus, popcorn hybrids that have the Ga1-s gene do not accept pollen from the surrounding GM field corn hybrids that do not have this Ga1-s gene. Dr. Major Goodman, NC State corn breeder, has also incorporated new crossing barrier genes into several breeding lines that will be released to the public in 2013. We hope that hybrids with these genes will become commercially available soon.

OP types. Today there is a thriving niche seed business in “old” or “antique” varieties. Nearly all old or antique varieties are OP materials. Because a crop is from open-pollinated seed stock does not mean the crop has not undergone serious plant breeding efforts through isolation, inbreeding, crossbreeding, and other means of genetic manipulation.

Unlike open-pollinated soybeans and wheat, which are largely self-pollinating, open-pollinated corn exhibits a large amount of cross-pollination (pollen from one plant fertilizing another plant). This means that most open-pollinated corn varieties are not homozygous with similar genes at each point on the chromosome. Instead open-pollinated corn exhibits mixtures of genes (heterozygous) at each chromosome similar to a hybrid. However, unlike a hybrid where each parent is identical and imparts identical mixtures of genes to the offspring, open-pollinated corn parents differ in their genetic makeup with the result that the offspring exhibits a wide range of characteristics—such as wide variations in height, maturity, ear placement, and kernel color. This variation is often undesirable because it makes the crop more difficult to manage and harvest.

The Problem with Saving Hybrid Seed

As stated earlier, hybrid seed has a mixture of genes from each parent at each of its chromosomes (alleles). The only saving grace is that because the parents were homozygous, each seed has the same mixture. When hybrid seed is saved, however, it is no longer possible to control which plant contributes the male genes and which contributes the female genes. Therefore, saved hybrid seeds are genetically different from each other. When these seeds are planted again, these different genes start to express characteristics (such as height and kernel color) that differ from each other. A fourth of the seeds will produce plants that look more like the female parent, a fourth will look more like the male parent, and the remaining half will have a combination of characteristics from the two parents. This segregation of genes means that seed saved from hybrids will start to produce plants that have the same problematic variation as open-pollinated varieties—such as a range of maturity, height, and color—which makes the crop difficult to harvest and manage.

Chapter 4. Crop Production Management—Organic Wheat and Small Grains

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Production Management

Key management practices for organic wheat and small grain production:

- Implement crop rotation.
- Bury crop residues with tillage, if possible.
- Choose varieties with resistance to disease and insect pests.
- Plant on time (not too early, not too late) in a well-prepared seedbed.
- Use correct seeding rates, drill calibration and drill operation.
- Avoid excessively high nitrogen levels (but work towards good soil fertility).
- Harvest on time. Don't let mature grain stand in the field.

Variety Selection

The best source of unbiased wheat variety performance information for NC is the *Wheat Variety Performance and Recommendations SmartGrains Newsletter* (www.smallgrains.ncsu.edu/variety-selection.html), which is released every July at NC State University and prepared by Randy Weisz (in the Crop Science Department) and Christina Cowger (USDA–Agricultural Research Service, Plant Pathology Department). This newsletter is based on the Official Variety Test Report (www.ncovt.com) and additional Cooperative Extension variety testing projects around North Carolina. As a general rule, only wheat varieties that are reported in this newsletter should be considered for production.

It is nearly impossible to pick a single best variety. Consequently, producers should plant at least two varieties every season to reduce their risks and maximize the potential for a high-yielding crop. The following are general guidelines for selecting varieties for organic wheat production:

- Check the *Wheat Variety Performance and Recommendations SmartGrains Newsletter* for a list of varieties tested for at least two years.
- The two disease and pest problems with the greatest potential to completely devastate a small-grain crop in any part of North Carolina are *Fusarium* sp. head blight (scab) and Hessian fly. Choose only varieties that are rated as moderately resistant (MR) to scab. Avoid varieties rated “poor” for Hessian fly biotype-L, especially if planting will be early or even on time.
- To avoid spring freeze injury, avoid early-heading varieties in favor of medium- and late-heading varieties.
- If you are in the NC piedmont, choose varieties with resistance to barley yellow dwarf virus (BYDV).
- If you are in the NC coastal plain, ideal varieties will have resistance to powdery mildew, leaf rust, and soilborne mosaic virus.
- If you are in the NC tidewater, choose varieties with resistance to leaf rust and soilborne mosaic virus.
- If wheat is being produced for the baking industry, it is a good idea to check variety selection with the end user.

Planting Date

Not too early and not too late! Planting too early puts the crop at severe risk for powdery mildew, Hessian fly, aphids, and BYDV. Planting too late will reduce yields, increase the risk of having a winter annual weed problem, and result in thin stands that will attract cereal leaf beetles. For the optimum planting times for your region, see “Small Grain Planting Dates” in the *Small Grain Production Guide* (www.smallgrains.ncsu.edu/production-guide.html).

Rotation and Field Selection

Planting wheat into old wheat stubble is always a bad idea. Several major small-grain diseases (*Stagonospora nodorum* blotch, tan spot, and scab) are transmitted by old wheat stubble. Short small grain rotations also put the crop at high risk to soil-borne diseases such as take-all. Clearly, wheat two years in a row is a bad idea.

Hessian fly pupae summer over in wheat residues, so planting into or even near old wheat stubble is a good way to get a Hessian fly infestation in a new wheat crop. The best way to avoid a Hessian fly problem is to plant at least one field (or ¼-mile) away from last year's wheat stubble and avoid planting near an early-planted wheat cover crop.

Fields with a history of Italian ryegrass or wild garlic should be avoided because there are no good organic methods for controlling these weeds.

Finally, fields in which infections by soilborne mosaic virus or wheat spindle-streak mosaic virus have ever been identified require special consideration. These two viruses are vectored by a soil dwelling microorganism. Of the two viruses, soilborne mosaic virus is the more damaging to yield. Once the virus and microorganism are present in a field, there are no practical ways to eliminate them. There are excellent wheat varieties that have resistance to one or both of these diseases, and a field known to have one or both viruses should be either planted with an appropriately resistant variety (see the *Wheat Variety Performance and Recommendations SmartGrains Newsletter*) or removed from small-grain production.

Seeding Rate, Drill Calibration and Operation

A good stand of wheat is the best defense against weeds and cereal leaf beetle and is the best indicator of a high yield potential. When planting on time with high quality seed into conventionally tilled seedbeds, the target seeding rate is 30 to 35 seeds per square foot. Increase this target rate if seed germination is below 90 percent or if planting is more than two weeks after the dates shown in Figure 1 in the *Wheat Variety Performance and Recommendations SmartGrains Newsletter*. A complete guide to seeding rate, drill calibration, planting

depth, and other planting considerations can be found in "Small Grain Seeding Rates for North Carolina" in the *Small Grain Production Guide*: www.smallgrains.ncsu.edu/production-guide.html

Special Considerations for Broadcast Seeding

Broadcast seeding often results in uneven seed placement in the soil, which results in uneven emergence and stands. Seeds may be placed as deep as 3 to 4 inches, where many seeds will germinate but will not emerge through the soil surface. Other seeds may be placed very shallow or on the soil surface. These seeds often do not survive due to dry soil or winter damage. The uneven stands from broadcasting often result in lower yields compared with drilling. Uneven seed depth and reduced yields are especially problematic when incorporation is done with a disk. Most growers who have been successful with broadcast seeding use a special implement (like a Dyna-Drive) that allows tillage to a specified depth. Because plant establishment potential is reduced and seed placement is not uniform, seeding rates should be increased for broadcast seeding. Increase broadcast seeding rates by 30 percent to 35 percent over drilled seeding rates.

Soil Fertility

Soil pH is very important for a high yielding wheat crop. Low soil pH can result in poor growth and development. High soil pH, especially on coarse-textured soils, can result in manganese deficiencies. Wheat that yields 65 bushels per acre takes up about 45 lb of phosphate per acre (most of which is removed with the grain) and about 135 lb of potash per acre (of which about 100 lb is in the straw). Wheat is a moderately heavy feeder, but not as heavy as corn. For best yield results, an organically approved nitrogen source (such as manure, compost, or a tilled-in legume) should be added at or before planting and again in the spring. A wheat crop yielding 65 bushels per acre will take up about 70 lb of nitrogen per acre. See Chapter 6 of this guide (pp. 25 – 31) for more information on soil fertility in organic production. Some organic farms are demonstrating large N carryover and may not need any spring nitrogen.

Unfortunately, no soil test exists that will predict how much nitrogen carryover to expect. In early spring, it is possible to tissue test a wheat crop and determine how much additional nitrogen, if any, is needed to produce optimal yield. Information about how to use this tissue test can be found in “Nitrogen Management for Small Grains” in the *Small Grain Production Guide*: www.smallgrains.ncsu.edu/production-guide.html

The application window for spring N is very narrow, and the source of fertility affects whether the nitrogen will be released in time to maximize yield. For manure sources, only the ammonium fraction should be considered available in time. This fraction is labeled “Ammonium NH₄⁺-N” on the waste analysis reports from the NC Department of Agriculture. Some of the slower releasing forms of nitrogen in the manure may be available during grain fill when protein content is set.

Weed Management

Essentially all weed control in organic wheat must be achieved in seedbed preparation before planting. Little to no cultivation is used in wheat after planting to kill emerging weeds, but a rotary hoe or tine weeder can be used before the crop emerges and again at the one-to-three-leaf stage. However, weeds usually cause fewer problems in wheat than in corn or soybeans because wheat is a strong competitor against weeds and is drilled in narrow rows that quickly shade the soil. This is especially true of wheat that is planted near the dates shown in Figure 1 in the *Wheat Variety Performance and Recommendations SmartGrains Newsletter*. Most wheat drills are set to plant rows that are 6 to 8 inches apart. Organic producers may want to take advantage of row spacing as narrow as 4 inches to help the wheat outcompete winter annual weeds. Avoid planting organic wheat in fields with Italian ryegrass or wild garlic problems as these weeds can lead to quality problems in the harvested grain. Also, use caution with hairy vetch as a cover crop in fields where wheat will be planted because hairy vetch that reseeds can contaminate wheat grain with seeds that are similar in size and weight and that are difficult to separate. See Chapter 7 (pp.

32 – 37) for more information on weed management in organic production systems.

Insect Pest Management

Many kinds of insects can be found in wheat fields, but only a few are likely to become yield threatening. A detailed description of small grain insect pests and their management can be found in “Insect Pest Management for Small Grains” (www.smallgrains.ncsu.edu/_Pubs/PG/Insects.pdf) in the *Small Grain Production Guide* (www.smallgrains.ncsu.edu/production-guide.html). Organic producers should take note of the following potential insect pests.

Aphids

Aphids are small sucking insects that colonize small grains early in the season and may build up in the spring or fall. They injure the plants by sucking sap or by transmitting BYDV. Aphid populations are usually kept in check by weather conditions (such as freezing temperatures in late fall) and biological control agents, such as lady beetles, parasitic wasps, syrphid fly maggots, and fungal pathogens, which are often abundant in small grains. Consequently, direct yield reductions due only to aphid feeding are rare. On the other hand, BYDV can be a serious problem, especially when it is transmitted to wheat plants in the fall. Because cold temperatures kill aphids, planting near or after the first freeze (see Figure 1, *Wheat Variety Performance and Recommendations SmartGrains Newsletter*) is a good way to avoid early aphid feeding and BYDV infections. If BYDV has been a problem in the past, selecting wheat varieties that are resistant to it may also be valuable (see the *Wheat Variety Performance and Recommendations SmartGrains Newsletter*).

Armyworm

Armyworm infests small grains, usually wheat, from late April to mid-May. They can cause serious defoliation, injury to the flag leaf, and head drop. Few cultural management options are available for armyworm. Organic growers have the choice of accepting the feeding of armyworms or using an insecticide

approved for organic production (such as a spinosad or pyrethrin) in emergency situations.

Cereal leaf beetle

The cereal leaf beetle has one generation each year, and both the adult and larval stages eat leaf tissue on wheat and oats. They also feed on barley, triticale, or rye. Leaf feeding by larvae during April and May can reduce yields. Cereal leaf beetle adults are attracted to poorly-tillered wheat fields. Management practices that lead to densely-tillered stands by mid-February can help to reduce the risk of having a cereal leaf beetle infestation. These practices include planting on-time, using high quality seed planted at recommended seeding rates, making sure that preplant fertility is adequate for rapid fall growth, and applying a split nitrogen application in February and March if additional tillering is needed in the spring. Insecticides approved for organic production (such as a spinosad or pyrethrin) and labeled for cereal leaf beetle may be applied in emergency situations. Although spinosad will provide adequate control of light infestations, it will not provide adequate control when cereal leaf beetle populations are high.

Hessian fly

In recent years, numerous NC fields have suffered extensive losses because of Hessian fly infestations. Historically a wheat pest in the Midwest, changes in field-crop production, including early-planted cover crop wheat, increased adoption of no-tillage double-cropped soybeans, and the use of wheat as a cover crop for strip-tillage cotton and peanut production, have permitted the Hessian fly to reach major pest status in North Carolina. Organic farmers should use several methods to minimize Hessian fly problems.

Because the Hessian fly life cycle depends largely upon the presence of wheat stubble, using rotations that do not plant new wheat into or near a previous wheat crop's stubble will be the most effective way to prevent infestations. Additionally, because the Hessian fly is a weak flier, putting at least one field (or about ¼-mile) between new wheat plantings and the previous season's wheat fields can be a successful method of preventing new infestations.

Disking wheat stubble after harvest effectively kills Hessian fly. Burning is not as effective as disking. Although burning wheat straw will reduce populations, many pupae will survive below the soil surface.

Serious Hessian fly infestations have occurred in areas where wheat for grain was planted near early-planted wheat for cover or early-planted wheat for dove hunting purposes. In organic systems using cover crops, selecting a small grain other than wheat will reduce Hessian fly populations. Oats, rye, and triticale are not favorable for Hessian fly reproduction and do not serve as a nursery.

In many wheat producing regions, a “fly free date” has been established to guide growers in planting after the first freeze has killed the Hessian fly adults. This approach has not worked in North Carolina because our first freeze is highly unpredictable and may not even happen until it is too late to plant. Instead it is a good idea to plant wheat on or after the dates in Figure 1, *Wheat Variety Performance and Recommendations SmartGrains Newsletter*.

If Hessian fly pressure is anticipated, selection of wheat varieties resistant to Hessian fly biotype-L is a good idea (see the *Wheat Variety Performance and Recommendations SmartGrains Newsletter*).

Disease Management

The best disease management tactic for organic producers is to avoid diseases in the first place by selecting wheat varieties with good resistance packages. Excellent small grain disease information and assistance with disease identification can be found in “Small Grain Disease Management” (www.smallgrains.ncsu.edu/_Pubs/PG/Diseases.pdf) in the *Small Grain Production Guide* (www.smallgrains.ncsu.edu/production-guide.html). When planning for an organic small grain crop, variety selection and cultural practices should include consideration of the following diseases.

Barley yellow dwarf virus

Because cold temperatures kill the aphids that vector BYDV in the fall, planting near or after the first freeze (see Figure 1, *Wheat Variety Performance and Recommendations SmartGrains Newsletter*) is a

good way to avoid BYDV infections. If BYDV has been a problem in the past, selecting wheat varieties that are resistant to it may also be valuable (see the *Wheat Variety Performance and Recommendations SmartGrains Newsletter*). Avoid planting into unincorporated light-colored residues of corn or other crops, as these attract aphids.

Powdery mildew

One of the most yield-limiting factors in NC wheat production is powdery mildew. This is especially true in the NC coastal plain and southern piedmont and some NC tidewater areas. Conventional producers often do not consider powdery mildew in their planning because they can rely on foliar fungicides to control the disease if it occurs. Organic producers do not have that luxury.

The best protection against powdery mildew is to select wheat varieties that are resistant to it. Organic producers in the NC coastal plain who want high-yielding wheat must plant mildew-resistant varieties. A second defense against powdery mildew is to plant after the weather has turned cold. This decision involves a trade-off. Although powdery mildew does not grow in cold weather, neither does wheat. This means that late-planted wheat may avoid powdery mildew, but it is also likely to suffer from lower yields and attack by cereal leaf beetle. However, organic producers should also avoid planting before the recommended planting dates (Figure 1, *Wheat Variety Performance and Recommendations SmartGrains Newsletter*).

Leaf rust

Leaf rust is a foliar disease that attacks wheat late in the growing season. Although leaf rust can occur anywhere in North Carolina, it is most likely to be a problem in the NC coastal plain and tidewater. Conventional producers rely on foliar fungicides to protect the crop from this disease. Organic producers must select varieties with good resistance to leaf rust. Organic producers, especially those in the NC tidewater, should try to select varieties that have a combination of powdery mildew and leaf rust resis-

tance. Variety resistance to leaf rust also deteriorates from year to year, so organic producers should check the most recent variety ratings every year before ordering seed.

Loose smut

Loose smut symptoms occur between heading and maturity. Infected seeds appear normal. The fungus, which is found inside the embryo of the seed, will grow within the plant from germination until the seed heads emerge and smutted grains appear. Therefore, symptoms from an infection that occurs in one year will not be seen until plants from the infected seed mature in another year. Because loose smut is seedborne, control measures focus on the seed to be planted. Certified seed fields are inspected for loose smut, and strict standards are enforced. Seed from fields with loose smut are rejected. So using certified seed is a highly effective way to avoid loose smut. Organic producers who use farmer-saved seed should never plant seed from a crop infected with loose smut.

Stagonospora nodorum blotch

Stagonospora nodorum blotch (SNB) is caused by the fungus *Stagonospora nodorum* and can be a serious disease of wheat. It used to be known as septoria leaf blotch and glume blotch. Symptoms may occur at any time during the plant's growth and on any portion of the plant.

Because wheat residues harbor the fungus, unincorporated residues can produce a severe SNB epidemic if fungal spores are splashed up onto the new crop. This puts no-till planted wheat that follows directly behind double-cropped soybeans at higher risk of an SNB epidemic. Conversely, plowing under wheat stubble will eliminate residue as a source of infection.

Potash, copper, and magnesium should be kept at recommended levels.

When SNB gets onto the developing grain head, the grain may be infected. If this grain is planted, the seedlings may be infected with SNB. Consequently, SNB can be seedborne. Using certified seed should

help minimize SNB. Organic farmers should never save seed for planting if the wheat crop had a serious SNB epidemic.

Wheat variety resistance is also a good way to minimize this disease (see the *Wheat Variety Performance and Recommendations SmartGrains Newsletter*).

Scab or head blight

Head scab of small grains is caused by the fungus *Fusarium graminearum*, which also infects corn. Scab can occur in all small grains. Wheat and barley are the most susceptible to the disease, oats are a little less susceptible, and rye and triticale are the most resistant. Infection occurs at or soon after flowering, when fungal spores reach small-grain heads by wind or rain-splash. Once it's established in a spikelet, the fungus can spread to other spikelets, resulting in heads that are partly green and partly bleached. Superficial pink or orange spore masses can be seen on infected spikelets. Early infections can cause kernel abortions, and later infections can cause shriveled kernels (called tombstones) that have low test weight. Scab produces toxins in the harvested grain, the most common being DON (deoxynivalenol or vomitoxin). When DON reaches 2 parts per million (ppm), the grain is no longer fit for human consumption and cannot be sold to a flour mill. When DON reaches 5 ppm, the grain is no longer fit even for swine feed. Wet weather before, during, and soon after small-grain flowering is the main factor determining whether there is a severe head scab epidemic. Warm temperatures (59 to 86°F) before and during flowering also favor scab. Sadly, no single management practice will defeat scab. Wheat producers who take the following measures, however, will reduce the likelihood of a major scab problem:

Many wheat varieties have moderate scab resistance. The best source for wheat variety resistance to scab is the *Wheat Variety Performance and Recommendations SmartGrains Newsletter*. There are also a few barley varieties with some scab resistance (such as Thoroughbred from Virginia Tech).

Spring weather is often not warm and moist for more than a week or two. So scab risk can be reduced by planting at least two wheat varieties from different heading-date classes (for example, one medium variety and one late variety). In that way, head emergence and flowering will be staggered through the spring, reducing the chance that environmental conditions will be conducive to scab in all wheat fields. A second way to force wheat to flower at different times in the spring is to stagger planting dates.

Scout for scab before grain heads turn golden, when the contrast between the bleached and green parts of heads is still apparent. If scab is severe (more than 10 percent of heads have scab), adjust the combine so that the lightweight diseased grain is blown out the back along with the chaff. This will not remove all the infected grain but can help reduce mycotoxin levels in grain heading to market.

Diagnoses and Assistance from the Plant Disease and Insect Clinic

If you have a question about whether a small-grain problem is caused by a disease, an insect, or something else, send a sample to the NC State University Plant Disease & Insect Clinic (www.cals.ncsu.edu/plantpath/extension/clinic/) for diagnosis. Send whole affected plants with intact roots surrounded by moist soil. Place a plastic bag around the roots to ensure they remain moist. If the plants are tall, it's fine to bend them double. For instructions and a submission form, contact the NC State University Plant Disease & Insect Clinic via the Web or by phone or mail:

Plant Disease and Insect Clinic
 NC State University
 Campus Box 7211
 1227 Gardner Hall, 100 Derieux Place
 Raleigh, NC 27695-7211
 For disease problems: 919.515.3619
 For insect problems: 919.515.9530
 Email: plantclinic@ces.ncsu.edu

Chapter 5. Crop Production Management—Organic Soybeans

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Production Management

Key management practices for organic soybean production:

- Choose varieties that perform well in your area (selecting earlier or mid-season maturity groups, if possible).
- Plant on time (not too late).
- Adjust equipment for a high plant population.
- Rotate crops.

Variety Selection

Choosing a soybean variety also means choosing a maturity group. Extremely early-maturing soybean varieties, Groups III and IV, avoid pests such as corn earworm but make weed management more difficult. These maturity groups begin to lose leaves when summer weeds can still grow. Group V or later soybeans can also be left unharvested until a killing frost defoliates weeds if weed control has been an issue. In the NC coastal plain, a Group V or VI (or an earlier planting) will help avoid corn earworm (CEW) infestation during flowering. CEW is seldom a problem in the NC piedmont.

Variety selection is also an excellent way to deal with nematode problems. Selecting varieties that are resistant to the species and race of nematode present in the field can limit the yield loss caused by these pests. It is also a good idea to choose at least two different varieties in order to spread out the seasonal workload and risk. The Official Variety Test Report available at www.ovt.ncsu.edu or through your county Extension Center is a good source of information on varieties. Unfortunately, there are fewer and fewer conventional or nontransgenic varieties available on the market. Organic farmers must be aware that transgenic beans are not allowed in certified organic production and choose alternate varieties. Results

from variety trials on organic land can be found online: www.organicgrains.ncsu.edu/organicresearch/soybeanovt2012.htm

Planting Date

Planting date and variety (or maturity group) selection go hand-in-hand. The key is to match planting date and variety maturity to the soil so that the row middles are lapped with soybean plants about 3 feet tall by flowering time. Planting earlier or planting a later-maturing variety can improve the likelihood of achieving this. In an organic farming system, avoiding pest problems is an important management technique. Planting early (by the end of May) with an early to midseason variety can help the crop avoid insect and disease problems. Double-cropped soybeans, generally planted in mid-June, require the use of Group VI or VII to obtain sufficiently large plants by flowering.

Row Spacing

The average row width in organic soybeans in North Carolina is 30 inches, but can be up to 38 inches and as low as 20 inches. Narrow-row soybeans lap row middles sooner, reducing the need for weed control. Although narrow-row soybeans will compete more effectively with weeds, row spacing should not be so narrow as to prevent between-row cultivation.

Plant Population

Maximum soybean yield potential is achieved once a soybean canopy has lapped the row middles and reached a height of at least 3 feet before flowering. In conventional production, this can be consistently achieved with plant densities of 100,000 plants/acre. However, this population recommendation is for production where herbicides are used and where

there is minimal to no weed competition. In contrast to conventional soybean production, weed control is the largest challenge for organic soybean production, and higher soybean seeding rates is one tactic that can improve weed control. A higher soybean plant population produces a thicker soybean canopy early in the season when weed control is critical. A seeding rate as high as 225,000 seed/acre for organic soybeans result in better weed control, higher yield, and the highest economic return compared to seeding rates of 175,000, 125,000, and 75,000 seed/acre. Lodging can become a concern with rates higher than 200,000 seed/acre with some varieties. Furthermore, while soybean disease management is less of a concern than weed management, a thick plant stand will trap moisture in the canopy, which creates a favorable environment for many diseases. Higher populations in organic soybean production are also recommended when blind or broadcast cultivation—from implements such as the rotary hoe or flex-tine harrow—is in use. These secondary tillage implements pass over the crop rows, often reducing the plant stand by 10 to 20 percent.

Seeding rate will depend on the planter capability, seed germination, and soil condition. Proper calibration of the planter is important, as well as planting in ideal soil conditions (the soil should be warm and moist, but not wet). If planting in June, increase these seeding rates by 20 percent.

Soil Fertility

Soybeans yielding 50 bushels per acre will remove about 188 lb of nitrogen per acre, 41 lb of phosphate per acre, and 74 lb of potash per acre from the soil. However, manure and compost applications are usually unnecessary because soybeans are nitrogen-fixing legumes and the crop can make use of any nutrients applied to, but not removed by, previous crops. If soybeans were not grown in previous years, soybeans should be inoculated with species of *Bradyrhizobium* bacteria specific for soybeans. See Chapter 6 of this guide (pp. 25 – 31) for more information about organic soil management.

Weed Management

Organic weed management is more challenging in soybeans than in corn because the soybean foliage does not generally overlap and shade the row middles until later in the season. Generally, narrow rows, down to 20 inches, and increased plant population can help the crop compete more effectively against weeds. When managing weeds in soybeans, consider also that different planting times for soybeans result in the plants competing against different sets of weed species. Weeds that emerge during the first four to five weeks after planting will cause the most damage in terms of yield reductions. Weeds that emerge after this time will have little effect on yield, although they may make harvest more difficult and will set seed. The goal should be to keep the field clean through the first four to five weeks after planting. Clean cultivation is used on most organic soybean acreage in the state. A blind cultivator, such as a flex-tine harrow or rotary hoe, is used before soybean emergence and approximately every five days afterwards. Anywhere from two to five blind cultivations occur before between-row cultivation begins. A frequent problem is the missing of blind cultivations due to wet weather. Unfortunately, near-row weeds missed during this wet weather often remain until the end of the season. Taller crops, such as corn, can endure lots of soil throwing, and between-row cultivators can be set to bury young weeds. Soybeans, however, can tolerate only small amounts of burial because pods sit low on the stem. One tactic is to “plant to moisture” when the weather forecast is clear so that at least one or two blind cultivations can occur on schedule. See Chapter 7 of this guide (pp. 32 – 37) for more information on managing weeds in organic production.

Insect Pest Management

Differences caused by variety selection, planting date, cultural techniques, site, and season can cause great variations in soybean plant attractiveness to insect pests. If organic soybean farmers recognize these differences, they can manage the crop for reduced insect pest numbers or, when this is not possible, predict which fields are attractive and may need

more attention to prevent yield loss. The organic soybean grower can normally rely on three factors to limit insect damage: reducing soybean attractiveness to pests, beneficial insects that reduce pest numbers, and the plant's ability to compensate for insect damage (tolerance). Important tactics used to reduce insect damage include the following five strategies:

Crop Rotation

Rotation helps reduce levels of pests such as grape colaspis and often improves crop health. Avoiding pests through a rotation of at least two years allows soybeans to tolerate the feeding of pests that later move into the field.

Tillage

For pests associated with the seed or soil or for those that harbor in stubble or residue, tillage can be an effective management method. For example, stem borer (*Dectes sp.*) harbors in soybean crowns after harvest over the winter. Research has demonstrated that burying stubbles to a depth of 2 inches can decrease larval survival and adult emergence. Mortality is higher on poorly drained land or when conditions are relatively moist. Seed-corn maggots, which can consume germinating seeds, can be reduced using tillage

Soil fertility and pH maintenance

Thin plant stands often have more corn earworms, but good growth reduces attractiveness. Reducing plant stress from low pH, poor fertility, or inadequate moisture will enable plants to better tolerate insect feeding.

Variety selection and early planting

High caterpillar populations can often be avoided by early planting of an early-maturing variety (such as varieties from maturity group V and VI). These plantings will bloom and harden-off before the corn earworm moth flight from cornfields, and the plants will be unattractive to the moths. Also, early maturity can greatly reduce soybean looper, velvetbean caterpillar, and late stink bug infestations. Double

cropped soybeans that are planted to Group VI or VII are common on organic farms. Percent loss from insects is generally 5 to 25 percent, but can be as high as 50 percent. In rare situations, stink bugs can be trap-cropped by early-maturity fields, leading to greater damage. Early-planted fields are generally more susceptible to colonization by stem borer and bean leaf beetle. However, planting soybean at the recommended rate and avoiding thin stands can reduce stalk girth and reduce the incidence of stem borer. Finally, beneficial insects often will colonize and establish in early-planted soybeans, helping to reduce the abundance of pests that arrive later in the season.

Variety selection can be important to manage certain insect pests. For example, lesser cornstalk borer can be a pest on drought-prone and sandy soil. Research has demonstrated differences in injury due to this pest that ranged from 9 percent to 31 percent among varieties. Data will soon be available online: www.ces.ncsu.edu/plymouth/ent/Entomology.html

Narrow rows

A complete canopy allows a higher level of biological control by insect predators, parasites, and diseases. Also, narrow-row soybeans seem to be less attractive to egg-laying corn earworm moths.

Remedial management

Group V or later-maturing varieties that are planted after late May can become infested by corn earworm moths moving from corn. These moths produce pod-feeding corn earworm larvae, and a high infestation may reduce yield by as much as 50 percent. Also, populations of leaf-feeding caterpillars (green cloverworm, soybean looper, and velvetbean caterpillar) may occasionally damage soybeans. These worms are usually very-late-season pests. In instances where caterpillar pests are not avoidable, insecticides approved for organic production, such as spinosads or *Bacillus thuringiensis* (Bt), may be successfully used. Scouting and the use of thresholds will indicate which fields are at risk. For scouting procedures for corn earworm see this website: www.ces.ncsu.edu/plymouth/ent/Entomology.html

Major Soybean Insect Pests and Management

Corn earworm/tobacco budworm

Corn earworm and tobacco budworm are some of the most important insect pests of soybean, through pod-feeding and sometimes foliar and flower feeding. Their biology is very similar. In conventionally-managed soybeans, tobacco budworm is more tolerant of certain conventional insecticides than corn earworm. From the point of view of the organic soybean producer, however, the distinction is largely unimportant. These insects will often infest soybeans in late July or early August. Cultural management tactics are the most important. Soybeans will be less attractive to these pests if blooms are not present, if the canopy is closed, and if there is little young, newly grown, vegetation. Remedial management using a spinosyn or *Bt* can be highly effective.

Stink bugs

The stink bug complex has been growing in importance as a pest group in soybeans. These insects injure soybeans by feeding on developing seeds inside pods. Although, as mentioned previously, early-maturing fields can occasionally attract high densities of these pests, in general, earlier-maturing and earlier-planted soybeans are less susceptible to stink bug infestation than later-maturing and later-planted soybeans.

Soybean looper

The defoliating soybean looper is a year-round resident of more southern areas, but it migrates into North Carolina each year. Peak larval population densities occur in September and are most prevalent on late-planted or later-maturing soybeans. Soybeans can tolerate a relatively high amount of foliar feeding, compared to other crops. Remedial management using a spinosyn or *Bt* can be highly effective.

Bean leaf beetle

Bean leaf beetles overwinter as adults and emerge over a three-month window during the spring in North Carolina. Adult beetles can injure soybeans by

feeding on the foliage. The first full-season soybeans to sprout in an area will attract many of the strong-flying beetles. Soybeans can tolerate a relatively high amount of foliar feeding compared to other crops. There are two generations of bean leaf beetles per year in North Carolina.

Disease Management

Soybeans have very few disease problems. This makes disease management in organic soybeans relatively easy. Nematodes are the main soybean disease agent in North Carolina. However, Asian soybean rust is a possible problem and, if present, will require much more intensive management to make organic soybean production viable.

Nematodes

The best way to avoid nematode damage is to plant varieties that are resistant to the nematode (and race) present in the field. These varieties can be found on the website www.soybeans.ncsu.edu/soyvar or from county Extension agents. Conventional nematicides are prohibited in organic agriculture. Crop rotation of at least two years will probably help reduce soybean cyst nematode populations, but rotation is not as useful when dealing with root knot nematode because it has multiple host plants. If nematode damage is suspected, collect samples from the field (fall is the best time) and send them to the NC Department of Agriculture & Consumer Services (NCDA&CS) laboratory (1040 Mail Service Center, Raleigh, NC 27699-1040, 919-733-2655) for nematode assays. They will identify a nematode population and species, if it is present. The Agronomic Division of NCDA&CS also has nematode management and assay information on its website: www.ncagr.com/agronomi/nemhome.htm

Asian soybean rust

Asian soybean rust is a disease that has the potential for causing severe economic damage in NC soybean crops. It must be considered when managing for soybean disease. To manage soybean rust potential in organic soybeans in North Carolina, select early-maturity groups or plant early to get the plants out of

the fields in time to avoid the rust inoculums, or do both. Do not, however, create such an early-maturing soybean crop that yields are substantially reduced. If you are at risk of Asian soybean rust, there are a few sprays labeled for use in soybeans that can be found on the OMRI website (www.omri.org).

For more information on soybean rust, visit one of these websites:

- www.usda.gov/soybeanrust/
(USDA site on Asian soybean rust)
- www.ces.ncsu.edu/depts/pp/soybeanrust/
(Soybean Rust Forecast Center at NC State University)
- www.sbrusa.net
(USDA online soybean rust tracking site)
- www.attra.ncat.org/attra-pub/asian_soy_rust.html
(Appropriate Technology Transfer for Rural Areas document on possible organic treatments for Asian soybean rust)

Chapter 6. Soil Management

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Soil Management and the Organic Standards

The USDA rules for certified organic farming include specific objective criteria, such as allowable and prohibited practices and inputs, and more subjective criteria, such as minimization of erosion and maintenance or enhancement of soil quality. Producers should note that international guidelines can differ from USDA guidelines. Certain inputs are allowable, and some inputs will be required to sustain soil fertility, but these must be applied in a manner that avoids nutrient excesses and minimizes runoff. Management of weeds, insects, and diseases often depends on several cultural practices. Crop rotation and tillage practices must provide an appropriate seedbed and pest control while minimizing erosion. Soil management practices must be developed in consultation with the certifying agent who interprets subjective aspects of the guidelines, approves inputs, and specifies needed documentation.

Crop Rotation (Tilth, Fertility, and Pest Management)

Crop rotation is critical to the maintenance of soil tilth (physical condition), fertility, and organic matter, and as a preventive practice to minimize pest problems. No specific rotations are mandated, but suggested crops to include are sods, cover crops, green manures, and catch crops. The rotation adopted must resolve any relevant problems with soil organic matter content, deficient or excess plant nutrients, soil erosion, and pest management (for perennial crops). Defining a rotation is also a key component in designing soil sampling and tillage management schemes. For short rotations (two to three years), soil samples can be collected once per rotation. For longer rotations, soil samples may still need to be collected every two to three years, preferably prior to planting the most intensively managed crops. Conservation tillage reduces soil erosion and can improve soil tilth, and may be alternated with

more intense cultivation needed at other times during the rotation.

Soil Fertility Management

Although crop nutritional requirements are the same for organic and conventional farms, organic producers need to be more creative due to the limitations on allowable inputs. Soils throughout the Carolinas differ in texture, organic matter, and past erosion and management history. Additionally, fluctuations in weather patterns and crop yields result in unpredictable residual nutrient status. Periodic soil testing is the only way to understand the current fertility level and sustain the fertility status of each field while avoiding excess nutrient accumulation. Plant tissue analysis can also be used to verify the adequacy of soil fertility management, particularly for nutrients not easily measured in routine soil tests (nitrogen, sulfur, boron). With tissue testing, the appropriate plant part must be collected at the proper growth stage as specified by laboratory guidelines. See www.ncagr.gov/agronomi/pdffiles/pta flyer.pdf or contact your local county Extension center for more details.

North and South Carolina have numerous sources of plant and animal manures and by-products. This region also has a favorable climate for growing a diversity of rotational and green manure cover crops. Farmers should study their crops to fully understand production requirements, nutrient needs, and common production problems. Crops differ in their nutrient removal rates (Table 6-1), and nutrient sources differ in their nutrient contents (Table 6-2).

Certain inputs are allowable on organic production systems, if applied according to guidelines. These include many (not all) natural and certain synthetic materials. The National List of Allowed and Prohibited Substances under the NOP is available at www.ams.usda.gov/nop/NationalList/FinalRule.html. This list specifies synthetic substances allowed for use and nonsynthetic substances prohibited for

Table 6-1. Nutrient removal (in lb) by different crops. Approximate removal rates can be adjusted based on comparison with the crop yield level shown. Missing values indicate no data available.

Nutrient	Corn, grain 150 bu	Wheat 60 bu	Soybean 50 bu	Tobacco, flue-cured 3000 lb	Irish potato 15 tons	Sweet- potato 300 bu	Fescue 3.5 tons	Ryegrass 5 tons	Sorghum- sudan 8 tons
N	112	75	188	85	90	40	135	215	319
P ₂ O ₅	53	38	41	15	48	18	65	85	122
K ₂ O	40	22	74	155	158	96	185	240	467
S	10	4	23	12	7	6	20		46
Ca	2	2	10	75	5	4			60
Mg	8	9	10	15	7	4	13	40	47
B	0.1	0.05	0.06	0.05	0.08	0.05			
Cu	0.06	0.04	0.05	0.03	0.06	0.02			
Mn	0.08	0.14	0.06	0.55	0.14	0.06			
Zn	0.15	0.21	0.05	0.07	0.08	0.03			

Table 6-2. Nutrient content of selected natural sources. These are general values and may not accurately represent the content of any specific source. Laboratory analysis should be performed prior to utilizing these materials. Missing values indicate no data available. Use of any specific source should be approved by the certifying authority prior to application to an organic farm.

Source	Units	N^a	P₂O₅	K₂O	S	Ca	Mg	B	Cu	Mn	Zn
Swine lagoon liquid	lb/acre inch	102 64 ^b	37	93	10	26	83	0.2	0.3	0.34	1.5
Broiler, fresh manure	lb/ton	16	17	11	2	10	4	0.1	0.7	0.6	0.5
Broiler, stockpiled litter	lb/ton	22	80	34	12	54	8	0.04	0.3	0.6	0.6
Layer, fresh manure	lb/ton	73	42	40	12	124	9	0.05	0.2	0.7	0.9
Layer, composted manure	lb/ton	44	38	39	6	87	8	0.05	0.1	0.5	0.5
Turkey, fresh manure	lb/ton	16	25	12	10	27	2		0.6		0.6
Turkey, stockpiled litter	lb/ton	22	72	33	10	42	7	0.05	0.3	0.6	0.6
Feather meal	lb/ton	128	8	2	15	5	1		0.03	0.03	0.1
Blood, dried	lb/ton	240 to 300 (total N)	60			6					
Bone meal, raw	lb/ton	70 (total N)	440		4	440	12				
Mushroom compost	lb/ton	10	8	4	9	47	4		1	0.2	0.1
Shrimp process waste	lb/ton	58 (total N)	200								
Cotton motes	lb/ton	40 (total N)	10	60	12	80	14				
Peanut hull meal	lb/ton	24 (total N)	12	16							
Wood ash	lb/ton	0.0	40	120		400	20				

^a Values shown represent plant available N estimate for material incorporated into the soil unless specified otherwise.

^b Sprinkle-irrigated and not incorporated.

use in crop production. A list of commercially available sources of these materials, which have been reviewed by the OMRI and classified as either allowed (A) or regulated (R), is available at www.omri.org/OMRI_brand_name_list.html. Other materials should be considered prohibited until further notice. In all cases, input use should be included in the farm plan and confirmed by the certifying authority prior to application.

Critical aspects of soil fertility management include pH, major nutrients (N, P, K, S, Ca, Mg), and micronutrients (especially B, Cu, Mn, Zn; but also Fe, Mo, Cl). A summary of soil fertility parameters and organic management options is given in Table 6-3.

Soil pH is important because it influences nutrient solubility, microbial activity, and root growth. Low pH levels common in native Carolina soils can kill developing root tips and prevent root colonization of the soil. Low soil pH continues to be the most common limiting factor for plant development seen in samples submitted to the NCDA&CS Agronomic Division Laboratory. Correcting low soil pH should be based on soil test recommendations that consider both the soil pH and the soil residual acidity levels, as well as crop pH requirement, target pH based on soil class, and whether calcitic or dolomitic lime should be used. Because most agricultural lime is from naturally-occurring minerals of relatively low solubility, its use is generally allowed in organic production systems. Hydrated limes, burnt limes, lime-stabilized biosolids, and industrial wastes or slags are not allowed. In rare cases when soil pH is too high to permit optimum crop growth, elemental sulfur can be used to lower soil pH. An approximate rate can be based on the estimation that the amount of acidity generated by 640 lb sulfur is the same as that neutralized by 1 ton of lime.

Nitrogen (N) is the most frequently limiting nutrient for crop production. Organic farms need to supply N through sources such as legumes, animal wastes or by-products, plant processing by-products, or limited additions of mined mineral deposits. It is possible for a nitrogen-fixing legume or legume-grass mixture cover crop to provide adequate nitrogen for

certain cash crops. A seed inoculum is recommended for legumes unless adequate native inoculum is present, and adequate soil fertility is needed to insure no other factors limit legume growth. Inoculums, however, must not be mixed with any prohibited substances—such as pesticides or inorganic fertilizers.

Some promising legume cover crops for North Carolina are described in Table 6-4. Besides the species listed, there are numerous other clovers, lupines, grasses, mustards, and species mixtures that could be useful.

Many farmers in North Carolina use composted or uncomposted poultry litter to supply the nitrogen needs for their organic field crops. Poultry litter and poultry by-products are available in many parts of the state. Mined nitrates, such as sodium nitrate (NaNO_3 , often referred to as Chilean nitrate), may be used in certain places, but are limited to a maximum of 20 percent of the crop's total N requirement. Constantly relying upon NaNO_3 , a restricted substance in organic agriculture, will be questioned by a certification agency. Because many international certifiers, including those in the European Union, Japan, Australia, and even some U.S. certifiers, prohibit any use of Chilean nitrate, producers should verify its acceptability to their certifier and to their prospective markets.

Other nutrients: P, K, Ca, Mg, S, Cu, Mn, Zn can generally be supplied in adequate amounts through additions of lime (Ca, Mg), animal or plant by-products or wastes (P, K, S, micronutrients), or permissible mineral inputs. Naturally-occurring minerals of relatively low solubility are generally allowed (lime, gypsum, rock phosphate, rock dusts, mined humates).

In addition, the following naturally-occurring minerals of relatively high solubility may be applied if used in compliance with the National List:

- Magnesium sulfate (Epsom salt), with a documented soil deficiency.
- Sulfate of potash and potassium magnesium sulfate, if from an approved source and with a documented soil deficiency.
- Muriate of potash, if derived from a mined source and applied in a manner that minimizes

Table 6-3. Soil fertility parameters and management options

		Problem		
Parameter	Effect on Plants	Documentation	Supply Options ¹	Not Allowed
pH	Nutrient solubility, Root development, Microbial activity	Soil test	Standard calcitic or dolomitic agricultural ground lime-stone; pH can be lowered by adding elemental sulfur.	Hydrated or burnt lime [Ca(OH) ₂ , CaO], industrial wastes, slags
Major Nutrients				
Nitrogen (N)	Component of proteins, chlorophyll	Tissue analysis	Legumes, manures ³ , animal by-products (blood, fish), plant by-products (cotton, apple, fermentation wastes), mined sodium nitrate (NaNO ₃) ³	Synthetic fertilizers, sewage sludges, municipal waste composts
Phosphorus (P)	Component of nucleic acids	Soil test, tissue analysis	Manures ³ , rock phosphate, animal by-products (bone meal; fish, shrimp, & oyster scraps; leather)	Processed rock phosphates
Potassium (K)	Water, salt, & pH balance; enzyme activation; protein synthesis; photosynthesis	Soil test, tissue analysis	Manures ³ , plant by-products (ash, dried seaweed), green-sand, sulfate of potash (K ₂ SO ₄) ⁴ , possibly muriate of potash (KCl) ^{3,4}	KCl if excess chloride
Sulfur (S)	Component of proteins; volatile compounds of mustard, garlic, onion	Tissue analysis	Manures ³ , plant by-products (cotton motes, peanut meal), elemental sulfur ⁴ , gypsum (CaSO ₄), Epsom salt (MgSO ₄) ⁴ , sulfate of potash (K ₂ SO ₄) ⁴	Synthetic fertilizers
Calcium (Ca)	Cell wall & membrane stabilization, cell growth, osmoregulation	Soil test, tissue analysis	Standard calcitic or dolomitic agricultural ground lime-stone, gypsum (CaSO ₄), bone meal, ash	Ca(OH) ² , CaO, calcium nitrate [Ca(NO ₃) ₂]
Magnesium (Mg)	Component of chlorophyll, cell pH and cation balance, enzyme activation	Soil test, tissue analysis	Standard dolomitic agricultural ground limestone, Epsom salts (MgSO ₄) ⁴ , sulfate of potash magnesium, bone meal, plant by-products (cottonseed meal, wood ash)	Synthetic fertilizers
Micronutrients²				
Boron (B)	Cell wall & membrane stabilization, cell growth, carbohydrate & protein metabolism, pollen germination	Tissue analysis	Manures, animal and plant by-products, soluble boron fertilizers ⁴	
Copper (Cu)	Enzyme component, photosynthesis, respiration, cell wall lignification, pollen formation	Soil test, tissue analysis	Manures, animal and plant by-products, sulfates & oxides ⁴	Chlorides
Manganese (Mn)	Enzyme activation, protein component, photosynthesis, cell growth	Soil test, tissue analysis	Manures, animal and plant by-products, sulfates & oxides ⁴	Chlorides
Zinc (Zn)	Enzyme component and activation, protein synthesis	Soil test, tissue analysis	Manures, animal and plant by-products, sulfates & oxides ⁴	Chlorides
Co, Fe, Mo, Se		Tissue analysis ⁵	Manures, animal and plant by-products, sulfates, carbonates, oxides, or silicates ⁴	Chlorides, nitrates

¹ Inputs must be on the National Organic Program or the OMRI-approved source list and approved by the certifying agents.² Avoid over-application of micronutrients since toxicities can occur.³ See restrictions in text.⁴ Documentation of nutrient deficiency required.⁵ Deficiencies of Co, Mo, and Se are not common in North Carolina, and these elements are not included in routine tissue analysis performed by the NC Department of Agriculture and Consumer Services. Consult a Cooperative Agricultural Extension office for information regarding private agricultural laboratories.

Table 6-4. Management characteristics of selected cover crop species for North Carolina

Species	Type	NC Planting dates ^a	Seeding rates ^b lb/ac	Seeding depth in.	Comments
Crimson clover	winter annual legume	Mtns: 8/10 – 9/15 (10/15?) Piedmont: 8/25 – 10/1 (10/15?) Coastal Plain: 9/1 – 9/30 (10/30?)	15 – 20 d 20 – 25 bc	¼ to ½	50-150 lb N/ac or more possible. On very-poorly drained soils often <25 lb N/ac.
Hairy vetch	winter annual legume	Mtns: 8/10 – 9/15 (10/15?) Piedmont: 8/25 – 10/15 (10/30?) Coastal Plain: 9/1 – 9/30 (10/30?)	15 – 20 d 20 – 30 bc	½ to 1 ½	100-150 lb N/ac or more possible on most soils. Avoid weedy persistence by killing before seed set.
Austrian winter pea	winter annual legume	Mtns: 8/10 – 9/15 (10/15?) Piedmont: 8/25 – 10/1 (10/15?) Coastal Plain: 9/1 – 9/30 (10/30?)	20 – 25 d 25 – 35 bc	¼ to ½	50-100 lb N/ac possible. Reportedly susceptible to sclerotinia fungal disease.
Cahaba white vetch	winter annual legume	Coastal Plain: 9/1 – 9/30 (10/30?)	15 – 20 d 20 – 30 bc	½ to 1 ½	Not adapted to NC mountain or piedmont region.
Rye	winter annual grass	Mtns: 8/15 – 9/30 (10/30?) Piedmont: 9/15 – 10/15 (11/15?) Coastal Plain: 9/30 – 11/15 (12/15?)	90	½ to 1 ½	Most vigorous winter growth of annual grasses.
Wheat					Avoid wheat as a cover crop in areas with wheat grain production.
Triticale					
Oats	winter annual grass	Piedmont: 9/15 – 10/15 (11/15?) Coastal Plain: 9/30 – 11/15 (12/15?)	120	½ to 1 ½	Not adapted to Mountain region.
Sunn hemp	summer annual legume	May-August	30 – 50 d 40 – 60 bc	½ to 1	Up to 125 lb N/ac reported in southeast U.S. Nematode resistant.
Forage soybean	summer annual legume	mid-April to July	90 – 120	1 to 2	Up to 250 lb N/ac possible. For forage, higher plant populations result in thinner, more palatable stems.
Cowpea	summer annual legume	May to August	30 – 90 d 70 – 100 bc	1 to 2	Up to 130 lb N/ac reported in eastern U.S., relatively drought tolerant
Sorghum-sudan	summer annual grass	May to July	35 – 40 d 40 – 50 bc	1 to 2	High biomass, multiple hay cuttings possible, possible chemical weed & nematode suppression effect
Buckwheat	cool season annual	September	50	½ to 1	30-45 day growth period, not tolerant of flooding or hardpans
Forage radish	cool season annual	September	10	¼ to ½	Potential to break up hardpans
Mustard	cool season annual	September	10 to 15	½	Roots may break up hardpans, incorporated residues may suppress soil-borne diseases

^a Planting dates shown are preferred dates, with the possible latest planting date with a question mark in parentheses.^b Seeding rates are shown when planted with a drill (d), or when seed is broadcast (bc).

chloride accumulation in the soil. This may be acceptable for most crops in the Carolinas with a soil test to document the deficiency and recommend an application rate.

- Many micronutrient salts, with documented soil deficiency and if not in the form of nitrate or chloride salts. This includes various soluble boron products and sulfates, carbonates, oxides, or silicates of zinc, copper, iron, molybdenum, selenium, and cobalt.

Numerous animal and plant by-products are available to provide essential crop nutrients (Table 6-2). It is important to check with the certifying agency, and the prospective market if possible, before using any input.

Tillage Practices

Management of soil tilth, organic matter, and fertility is an important aspect of a successful organic production system. Organic farming systems traditionally relied on preplant tillage and cultivation after planting to control weeds and reduce the incidence of seedling diseases and insect pests. However, tillage destroys organic matter and increases soil erodibility, both critical aspects of soil fertility, water holding capacity, and general soil quality. Following annual grain crops with cover crops so that the soil surface is protected by a growing crop for most of the year makes it easier to maintain soil organic matter content. The use of roller-crimpers to kill cover crops and heavy residue cultivators for additional weed control also provides soil and water conservation benefits. Where tillage is used, it should occur when soil moisture is low enough to prevent compaction. Because primary tillage operations are often a month before a crop is planted, this requires careful planning and the ability to take advantage of periods of dry weather. This also means that fields with soils that are poorly drained or that have low spots may not be good choices for organic production. Recommendations on the type of primary and secondary tillage practices for specific soil types and field conditions can be found elsewhere in this guide (see Chapter 7, “Weed Management,” page 32).

Documenting Crop Nutrient Deficiencies and Soil Quality Maintenance

Because use of some soil amendments is limited to cases of nutrient deficiency, organic producers should maintain soil testing and plant tissue analysis records documenting specific nutrient deficiencies that need correction. Soil test records can also be useful in documenting soil quality maintenance as these records indicate changes in humic matter and nutrient levels over time. Of particular concern are avoiding topsoil erosion, which could result from excessive cultivation for weed control (declines in humic matter are indicative of erosion losses), and avoiding excess phosphorus and micronutrient accumulation following application of manures and composts.

Composts and Manures

Specific guidelines must be followed when applying composts and manures in organic production systems. Materials must be applied at agronomic rates that comply with any applicable nutrient management guidelines (<http://nutrients.soil.ncsu.edu/>) and that avoid excess nutrients. Raw animal manures must either be (1) composted according to specific criteria, (2) applied to land used for a crop not intended for human consumption, (3) incorporated into the soil at least 90 days prior to the harvest of an edible product not contacting soil or soil particles, or (4) incorporated into the soil at least 120 days prior to the harvest of an edible product that does contact soil or soil particles. The guidelines for compost production for organic agriculture state that the initial C:N ratio must be between 25:1 and 40:1, and a temperature between 131 and 170°F must be achieved. This temperature must be maintained for at least three days for in-vessel or static aerated pile systems, or for at least 15 days during which there are at least five turnings for windrow systems. Composts not meeting these criteria must be applied based on other raw manure criteria, which also apply to lagoon liquids, lagoon solids, and stockpiled poultry litter. Ashes of manures may not be used, but ashes from other untreated plant and animal materials may be applied if not combined with any prohibited substances.

Avoid over-reliance on animal manures, because this could lead to accumulation of excess P, Cu, and Zn in soils. For example, based on the general nutrient data shown in Tables 6-1 and 6-2, stockpiled turkey litter applied at a rate of 5 tons per acre would supply approximately the amount of N removed by a 150-bushel-per-acre corn crop. Note that the amount of phosphorus added (as P_2O_5 equivalent) would be 360 lb/acre, while crop removal would only be 53 lb/acre. Similarly, 2.8 lb/acre of zinc would be added, while crop removal would only be 0.15 lb/acre. Sporadic use of manures—in conjunction with more frequent use of legume cover crops, green manures,

or other N sources—is an excellent way to supply several plant nutrients in appropriate amounts.

Extension fact sheets are available online that describe specific types of manures (such as swine, poultry, and dairy): www.soil.ncsu.edu/publications/extension.htm. Because nutrient composition of animal manures and composts can vary widely, submit a sample to the Plant and Waste Analysis Laboratory of the NCDA&CS Agronomic Division before using a manure or compost. Sewage sludge and composted municipal wastes are not allowable on organic fields.

Farm Profile: Looking Back Farms

Looking Back Farms, located in northeastern North Carolina, is a 350-acre organic grain farm located mostly on Arapaho fine, sandy loam soil. This farm has been certified organic for nearly 15 years. Currently, the farm employs a two-year rotation of corn–wheat–soybeans, with wheat and soybeans double cropped.

Corn is planted in May and is seeded at a rate of 32,000 seeds/acre on 36-inch rows. This rate is about 10 percent higher than a conventional rate for the area. The higher plant population reduces weed competition and allows the population to compensate for any plants lost during cultivation. Soybeans are planted on the same row spacing, and wheat is broadcast seeded at a rate of about 120 to 150 lb per acre.

Fertility Management: Looking Back Farms applies chicken litter from a neighboring farm on corn and wheat. The litter is applied preplant at 3 to 4 tons/acre. Mushroom compost (2:2:4 analysis) is used when available before soybeans (applied on top of wheat stubble when double cropping) and is eventually applied to all fields over two years. The compost contains liming agents and helps raise the soil pH, which keeps soil life and nutrients in balance, which in turn allows maximum crop health and growth. Cover crops are also used on this farm as part of the fertility management plan. Rye, crimson clover, Austrian winter pea, and triticale have all been grown as cover crops after corn. The cover

crops increase soil organic matter, soil microbiology, water infiltration, and water holding capacity. The legume crops—Austrian winter pea and crimson clover—also fix nitrogen, adding it to the soil so it is available for subsequent crops. The cover crops are broadcast seeded in October after corn has been harvested and fields tilled. The cover crops are cut and tilled into the soil in March. This gives enough time for the cover crop residue to break down before soybeans or corn are planted.

The farmers try to avoid a build-up of phosphorous and heavy metals from poultry litter in their soil by rotating the compost and litter fertility amendments and by using cover crops. They see benefits of one application of a fertility amendment for up to three years after the application because the organic amendments take much longer than conventional fertilizers to decompose and release N and other nutrients. They often do not see the benefits of applying litter or compost in the spring to their wheat crop because of this. Nitrogen from the litter or compost becomes available slowly, as the amendment breaks down, and the plants cannot take advantage of a nitrogen boost because the nutrients are released more slowly than conventional fertilizers. However, their yields do not suffer. It is likely that the organic amendments applied at planting (and years before) provide enough fertility as they slowly break down for the crop. No lime has been applied in many years, and the pH of soils in all fields is 6.0 to 6.5.

Chapter 7. Weed Management

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Weed pest management must be an ongoing consideration for organic farmers to achieve acceptable yields and crop quality. A system of weed management that includes multiple tactics will help reduce losses in both the short and long term. Various weed management tactics fall into two major categories: cultural and mechanical. Cultural tactics are associated with enhancing crop growth or cover, while mechanical tactics are used to kill, injure, or bury weeds. During a cropping season, successful organic weed management will rely on the cultural tactics described below to achieve competitive crop plants and will use the mechanical tactics to reduce the weed population that emerges in the crop. When a cash crop is not in the field, plant a cover crop or use an occasional shallow tillage to kill germinating and emerging weeds.

Cultural Tactics

Crop rotation

It is beneficial to have a rotation system that includes crops with different life cycles, growth patterns, and management techniques. This will reduce the chance that weeds can proliferate over successive years. For example, a rotation could include a summer crop, winter crop, legume, grass, a cultivated crop (corn) and a noncultivated crop (wheat or hay).

Cultivar and cover crop selection

Competitive differences exist among crop cultivars. Tall cultivars and cultivars with rapid establishment and quick canopy closure are more competitive with weeds than short or dwarf cultivars or cultivars (or seedlots) that have low seed vigor, are slow growing, or are less bushy. Some weed species are suppressed by crop-produced allelochemicals (naturally pro-

duced compounds that can inhibit the growth of other plants) in standing crops or in residues of allelopathic crops (for example, a rye cover crop). Results of studies conducted with wheat and rye have demonstrated that the production of allelochemicals varies widely with cultivar and can change in concentration during crop development. Paul Murphy, NC State wheat breeder, is selecting for weed suppressive wheat lines, and his progress can be followed online: www.organicbreeding.ncsu.edu/wheat.html

Seed quality

Seed cleanliness, percent germination, and vigor are characteristics that can influence the competitive ability of the seedlings. Seed that has not been carefully screened (especially farmer-saved seed) is often of lower quality than certified seed and may contain unknown quantities of weed seed or disease. Planting this seed may result in the introduction of pests not previously observed on the farm. There is also a risk that weed density will increase and that weeds will be introduced to previously uninfested parts of the field. Germination rate and vigor are equally important to weed management because they collectively affect stand quality and time to canopy closure.

Planting—sowing date, seeding rate, row spacing, and population

Sowing date and seeding rate affect the final crop population, which must be optimum to compete with weeds. Carefully maintained and adjusted planting equipment will ensure that the crop seed is uniformly planted at the correct depth for optimum emergence. Narrower rows and increased plant populations will help the crop compete with weeds. When blind cultivation such as rotary hoeing will be used, seeding rates should be increased by 10 to

20 percent. If a particularly aggressive blind cultivation tactic such as springtooth harrowing will be utilized, seeding rates should be increased to at least 20 percent.

Cover crops

Cover crops can provide benefits of reduced soil erosion, increased soil nitrogen, and weed suppression through allelopathy, light interception, and the physical barrier of plant residues. Cover crops such as rye, triticale, soybean, cowpea, or clover can be tilled in as a green manure, allowed to winter kill, or be killed or suppressed by undercutting with cultivator sweeps, mowing, or rolling. Warm-season cover crops help to suppress weeds by establishing quickly and out-competing weeds for resources. It is important to manage cover crops carefully so that they do not set seed in the field and become weed problems themselves.

Fertility—compost and manures

Uncomposted or poorly composted materials and manures can be a major avenue for the introduction of weed seeds. Soil fertility that promotes early and sustained crop growth, however, helps to reduce the chance that weeds will establish a foothold. Areas of poor productivity leave the door open to diseases, insect pests, and weeds.

Sanitation and field selection

Weeds are often spread from field to field on tillage, cultivation, or mowing equipment. Cleaning equipment before moving from one field to another or even after going through a particularly weedy section can prevent weeds from spreading between fields or within fields. A short investment of time to clean equipment can pay large dividends if it prevents spread of problem weeds. When transitioning to organic systems, it is highly advisable to start with fields that are known to have low weed infestations. Fields with problem weeds, such as Italian ryegrass, wild garlic, Johnsongrass, or bermudagrass, should be avoided if possible, as these weed species will be difficult to manage.

Mechanical Tactics

A healthy, vigorous crop is one of the best means of suppressing weeds. Some physical tactics, however, are almost always needed to provide additional weed control. The methods described below can be used together with good cultural practices to kill or suppress weeds—leaving the advantage to the crop. The goals of mechanical weed control are to eliminate the bulk of the weed population before it competes with the crop and to reduce the weed seed bank in the field. Important factors to consider for mechanical weed control are weed species present and their size, soil condition, available equipment, crop species and size, and weather. Because it might not be necessary to use a tactic on the entire field, knowledge of weed distribution and severity can be valuable. Tillage, blind cultivation (shallow tillage of the entire field after planting), and between-row cultivation are important aspects of mechanical weed control.

Tillage

Proper field tillage is important to creating a good seedbed for uniform crop establishment, which is a critical part of a crop's ability to compete with weeds. Tillage should also kill weeds that have already emerged. In the spring when the soil is warm, weed seeds often germinate in a flush after tillage. A moldboard plow will bury the weed seeds on or near the surface (those that come out of dormancy as the soil warms) and bring up dormant weed seeds from deeper in the soil. These weed seeds will normally be slower to come out of dormancy than weed seeds previously near the surface. Chisel plowing or disking does not invert the soil and can result in an early flush of weeds that will compete with the crop. If there is enough time before planting, the stale seedbed technique can be used as an alternate approach. In this technique, soil is tilled early (a seedbed is prepared), which encourages weed flushes, and then shallow tillage, flaming, or an organically approved herbicide is used to kill the emerged or emerging weed seedlings. While this technique should not be used in erosion-prone soils, it can be used to eliminate the first flush or flushes of weeds that would compete with the crop.

Blind cultivation

Blind cultivation is the shallow tillage of the entire field after the crop has been seeded. Generally, it is used without regard for the row positions. It provides the best opportunity to destroy weeds that would otherwise be growing within the rows and that are not likely to be removed by subsequent mechanical tactics. Blind cultivation stirs soil above the level of seed placement (further emphasizing the need for accurate placement of the crop seed), causing the desiccation and death of tiny germinating weed seedlings. Crop seeds germinating below the level of cultivation should not be injured. Blind cultivation will only kill weeds in the “white thread” stage. If the weed can be seen from the tractor, then it is too large to be destroyed by blind cultivation. Thus, early and timely blind cultivation is critical. However, more than two blind cultivation passes may cause some damage to soybeans. This damage results in decreased yield potential, but blind cultivation is still necessary to avoid much higher yield losses from weed competition. The first blind cultivation pass is usually performed immediately before the crop emerges, and subsequent passes occur approximately every five days afterwards. Blind cultivation cannot be performed when soybeans are in the crookneck stage during emergence. In North Carolina, farmers often need to perform three to five blind cultiva-

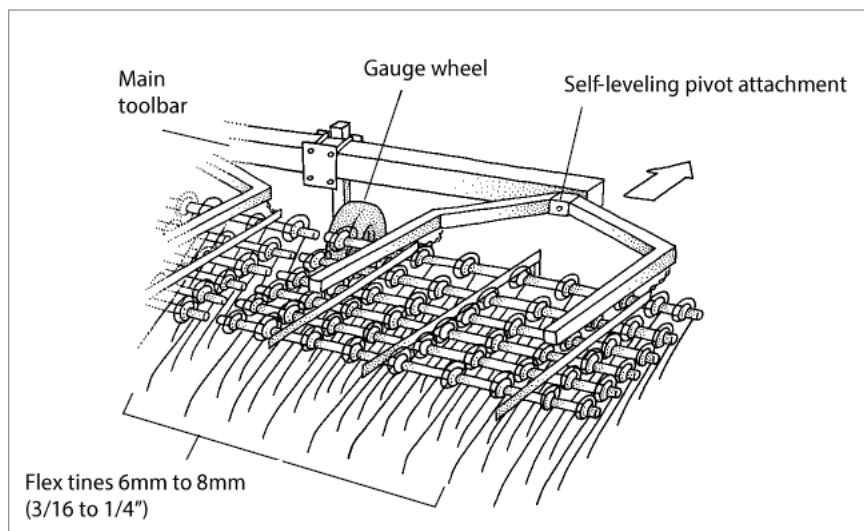


Figure 7-1. Flex-tine weeder. Illustration by John Gist (courtesy SARE).*

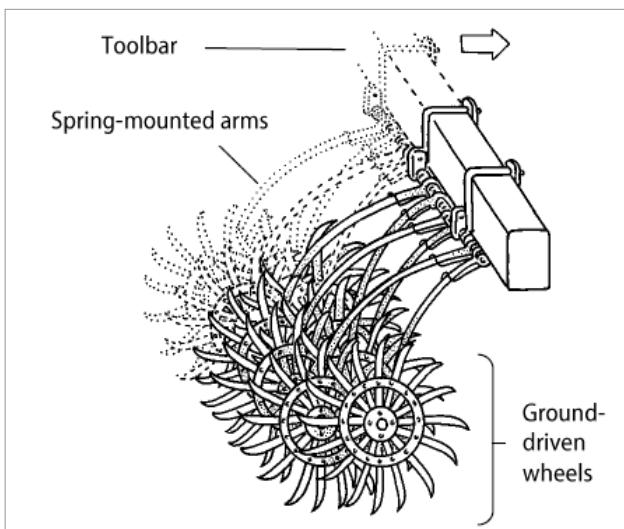


Figure 7-2. Standard rotary hoe. Illustration by John Gist (courtesy SARE).

tion passes, especially in a less competitive crop like soybeans. Blind cultivation is most effective when the soil is fairly dry and the weather is warm and sunny to allow for effective weed desiccation. Blind cultivation equipment includes rotary hoes (Figure 7-2), tine weeders (Figure 7-1), spike tooth harrows, springtooth harrows, and chain link harrows.

Between-row cultivation

Between-row cultivation should not be the primary mechanical weed control tactic but should be used as a follow-up tactic to control weeds that escaped

previous efforts. Between-row cultivation should be implemented when weeds are about 1-inch tall and the crop is large enough not to be covered by soil thrown up during the cultivation pass. Usually, more than one cultivation pass is needed. It may be useful to reverse the direction of the second cultivation pass in order to increase the possibility of removing weeds that were missed by the first cultivation. Planting corn in furrows can allow more soil to be moved on top of weeds and may be a useful practice on some farms. All cultivation

passes should be done before the canopy closes or shades the area between the rows. After this time, the need for cultivation should decrease, as shading from the crop canopy will reduce weed seed germination and equipment operations can severely damage crop plants. Cultivation works best when the ground is fairly dry and the soil is in good physical condition.

There are many types of cultivator teeth, shanks, and points. Choose the cultivating equipment that works best in your soils. Points for cultivator teeth vary in type and width. Half sweeps (next to the row) and full sweeps (between rows) are probably the most versatile and common, but each type of point works best under certain conditions and on certain weed species. Using fenders on cultivators

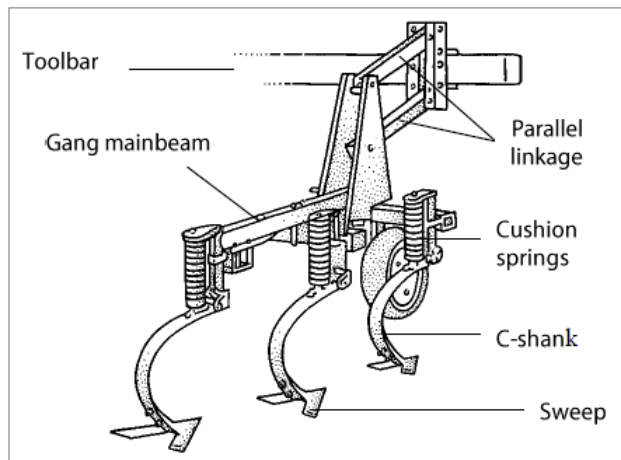


Figure 7-3. Low residue cultivator. Illustration by John Gist (courtesy SARE).

at the first pass can keep the soil from covering up the crop. Cultivator adjustments are very important and should be made to fit the field conditions. Tractor speed should also be modified through the field to compensate for variability in soil type and moisture.

The different types of between-row cultivators vary in how soil is moved, the size of the weeds that can be killed, and the precision of operation. Rolling cultivators (Figure 7-5) can be fine-tuned to throw precise amounts

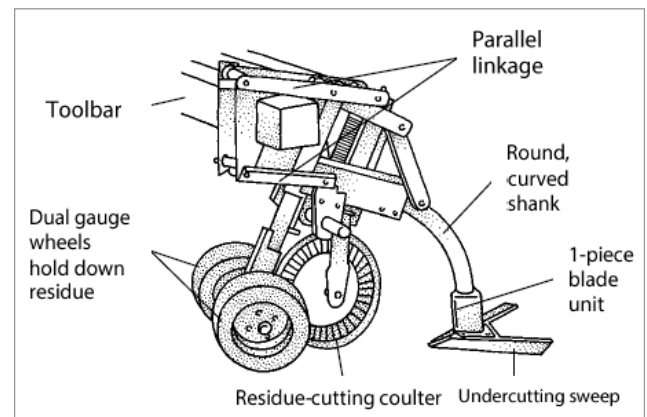


Figure 7-4. High-residue cultivator. Illustration by John Gist (courtesy SARE).

of soil towards the crop, peel soil away from the crop, or even do both during a single pass. This flexibility makes them a mainstay on most organic farms. S-tine cultivators are also frequently used in combination with rolling cultivators to remove larger weeds. In general, smaller weeds are easier to control than large weeds with one exception. Wide sweep cultivators (Figures 7-3 and 7-4) that are mounted on parallel linkages can run parallel to the soil surface. They are able to sever the roots of large weeds and kill them, but small weeds are able to reroot. Most wide sweep cultivators can be angled to control smaller weeds by changing the angle of the blade and can also throw soil when needed.

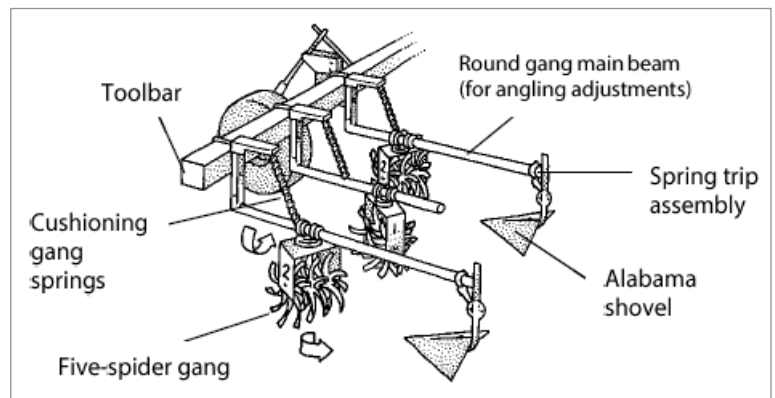


Figure 7-5. Rolling cultivator. Illustration by John Gist (courtesy SARE).

Farm Profile: Hubers Farm

Daren Hubers farms nearly 1,800 acres of conventional corn–beans production and 240 acres of organic grain production. His farm is located in the Blacklands (denoting soils high in organic matter) of eastern North Carolina. The farm consists of two main soil types: Ponzer muck and Newholland mucky loamy sand.

Overview: Corn (organic and conventional) is generally planted between March 25 and April 15 and is harvested starting the third or fourth week of August. Group III and IV soybeans are planted on conventional land, and Group V and VI beans are planted on organic land as a double crop after wheat. Daren plants organic corn and beans on 20-inch rows, with a target plant population of 34,000 corn plants per acre and 150,000 soybean plants per acre. Conventional beans are planted at 100,000 population.

Weed Management: Weed management is the biggest challenge to organic production on this farm. Daren feels that starting with a clean, well-prepared field is an important practice to keep ahead of the weeds. Weed control is difficult in their light, chaffy soils because tillage and cultivation often make the soil too “fluffy” and loose, causing sandblasting by soil that damages plants. Managing weeds in soybeans is especially difficult because soybeans are not as competitive with weeds as corn and require more tillage passes to achieve adequate weed control. In corn and soybeans on this farm, weed management starts with a 35-foot flex-tine weeder made by Kovar Manufacturing. Daren expanded the width of the

harrow by adding booms and teeth. Initially, the teeth had a 45-degree angle to them and were too aggressive in the soil (pulling plants out), so he cut off the ends (angled portion) of all the teeth and it performed well. Daren tries to go over fields every other day from the time of planting until crop emergence. After the crop emerges, Daren uses a rotary hoe once or twice, and then cultivates between rows alternating between a rolling cultivator and S-tine cultivator. Daren has also experimented with organic herbicides, specifically clove oil. He used a directed sprayer to target the bottom of soybean plants in the row. By employing this method, expensive herbicides were not broadcast and the most difficult weeds to eliminate were targeted by the spray. Daren was hoping to eliminate some cultivation passes by using an herbicide, and though partially effective, the herbicides were not economically efficient.

Cultivating large fields of 20-inch row organic corn and soybeans is tedious and slow. It is commonly said that the worst pest in a field of beans is the cultivator operator—when he drifts over rows. Daren helped eliminate this problem by investing in real time kinematic (RTK) satellite navigation. The RTK navigation system allows him to use a satellite GPS to locate his rows while he is planting. When he sets up his tractor and cultivator to the location of the planted rows, he can let the tractor drive itself, making good time, and not worrying about drift. The accuracy on the system is 1 to 2 cm. He also uses the system when blind cultivating with the harrow before the crop has emerged to ensure that tractor tires stay between the rows.

Flame weeding

Flame weeding provides fairly effective weed control on many newly emerged broadleaf species and can be used in tilled or no-till fields. Grasses may not be well controlled by flaming because their growing points are often below the soil surface. Flame weeding should be performed only when field moisture levels are high and when the crop is small.

Hand weeding and topping

Walking fields and hand weeding or topping (cutting off the weed tops) can vastly increase familiarity with the condition of the crop and distribution of weeds or other pests. Farmers who are familiar with problem locations can remove patches of prolific weeds before they produce viable seeds and reduce long-term problems caused by weeds that escaped management. Topping of flowering weeds can reduce seed set and the weed seed bank in the field.

Herbicides

Several herbicides have been approved for certified organic farming. These include acetic acid (distilled vinegar), clove oil, nondetergent soap-based pesticides, some corn gluten meal products, and boiling water. The cost of herbicides approved for organic farming may be prohibitively expensive for field crops. The OMRI publishes a list of commercially available products that can be used in certified organic operations for weed control (www.OMRI.org). Conditions for use of an approved herbicide must be documented in the organic system plan as specified in the 2000 NOP.

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Chapter 8. Rolled Cover Crop Mulches for Organic Corn and Soybean Production

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Interest in cover crop mulches has increased out of both economic and soil conservation concerns. The number of tractor passes required to produce corn and soybeans organically is expensive and logistically challenging. Farmers currently use blind cultivators, such as a rotary hoe or flex-tine harrow, two to five times, followed by two to four between-row cultivations (see “Weed Management,” Chapter 7, pp. 32 – 37). Repeated cultivations can be extremely effective but are highly sensitive to weather. During wet springs, cultivations are missed, leading to weedy fields. Soybeans are particularly troublesome when blind cultivations are missed. Soybean plants cannot have as much soil thrown up to their stems as corn, meaning in-row weeds missed by blind cultivation remain in the field until harvest time.

Killing Cover Crops Without Herbicides

Rolling cover crops has proven to be the most effective and inexpensive method for organic farmers to

kill cover crops. Multiple designs for roller-crimpers exist (Figure 8-1) to accommodate flat or bedded plantings. Free designs are available at the Rodale Institute’s website (rodaleinstitute.org/our-work/organic-no-till/). The design advocated by Rodale is manufactured and sold by I & J Manufacturing of Gap, PA (www.cropproller.com). Roller-crimper designs are engineered to maximize force on cover crop stems and to minimize vibrations on the tractor frame. Even so, farmers have reported occasional success using preexisting equipment such as cultipackers and smooth rollers. A combination of the right cover crop growth stage and hot weather can result in a good kill without having the optimal equipment.

Cover crops must be at least flowering or in the early stage of seed set before they can be killed with a roller. Each species has its set of characteristics to look for in determining when it can be roll-killed. Typical times and the growth stage characteristics

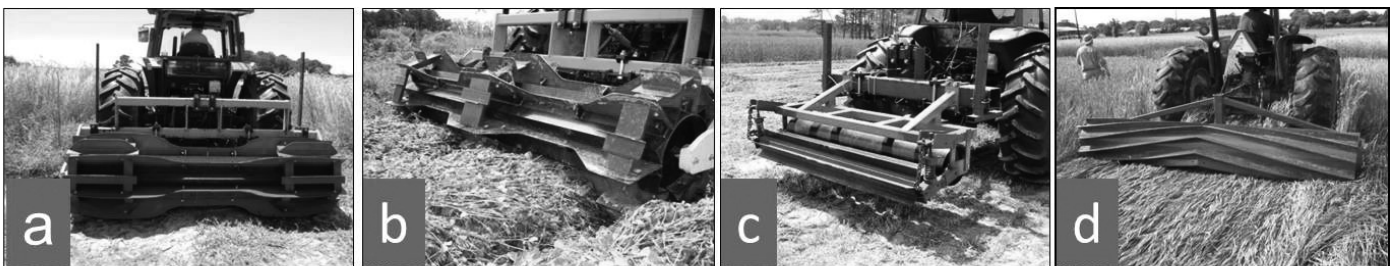


Figure 8-1. Roller crimper designs: (a) Roller crimper for elevated beds: one row and two furrows; (b) roller for elevated beds: two rows and three furrows; (c) two-stage roller/crimper designed to operate with smaller tractors (40 HP power source); (d) typical roller for flat planted crops. (Images provided by the NC Organic Grain Project.)

Table 8-1. Roll times for legume cover crops.

Adapted from Parr et al., 2011.

TIME*	GROWTH STAGE	SPECIES	CULTIVAR
Late April/ Early May	100% flower	Crimson clover	AU Robin Dixie AU Sunrise Tibbee
	Early pod set	Hairy vetch	AU Early Cover
Late May	Early pod set	Hairy vetch	AU Merit Steve Groff
Late May	Early pod set	Winter pea	variety unstated from NC Whistler
Early June	Early pod set	Common vetch	variety unstated from NC
	100% flower	Berseem clover	Bigbee

*Timing can vary in unusual years.

Table 8-2. Roll times for rye (*Secale cereale* L.) cover crops. Rye should be rolled during the early milk to soft dough growth stages.

TIME*	CULTIVAR
Late April	Wrens Abruzzi
	Wrens 96
	MatonII
Early May	Aroostook
Mid to late May	Rymin
	Wheeler

*Timing can vary in unusual years.

are listed in Tables 8-1 and 8-2. Same day rolling and planting has been advocated by some institutions. The roller can be mounted on the front of the tractor with the planter in the rear. While reducing trips, the soils are significantly drier at planting with the same-day approach. Researchers in Alabama, Georgia, and Maryland recommend rolling and waiting for rainfall to replenish soil moisture before planting. In North Carolina, only same-day planting has been tested so far, with good germination in soybean in seven out of nine trials, one of which had to be replanted to prevent total loss. Rolling and planting on different days presents a problem for farmers without GPS guidance. Rolling and planting must occur in the same direction, making the issue of what pattern to use when rolling and how to mark the passes with the planter a significant one.

Cover Crop Bloom Chart for North Carolina

These tables estimate the time of full bloom or ideal time for rolling the crop to fully kill the cover crop so that corn or soybeans can be planted into the rolled mulch.

Planters

Several features of a no-till planter are essential for such a high residue environment:

- Straight edged no-till coulters. Fluted edges lead to hair-pinning of the cover crop into the seed trench. Straight edges with bubbles or flutes are ok and help to loosen the germination zone on some soils.
- Heavy duty down-force springs or a pneumatic down-force system is often needed.
- Some planters may need extra weight mounted on the frame. If fertilizer or insecticide boxes are unused, they can be filled with sandbags.
- The best type of closing wheel for this system is still being debated.

Even with the heaviest of closers, sealing the trench can be difficult at times.

Weed Control

To get consistent weed control and good soybean yields, more than 8,000 lb of rye dry matter is needed (Figure 8-2). Early planting and adequate fertility are required to obtain this level of production. Even then, overly wet winters inhibit rye growth. Walking fields in March is recommended to assess whether the stand is sufficient for good rye production. A poor or spotty stand should be disked in and a clean tillage system used. If rye becomes too large before disking, it can be difficult to prepare a clean seedbed and to cultivate.

Less is known about the performance of legume-corn systems here in terms of weed control. Mixtures

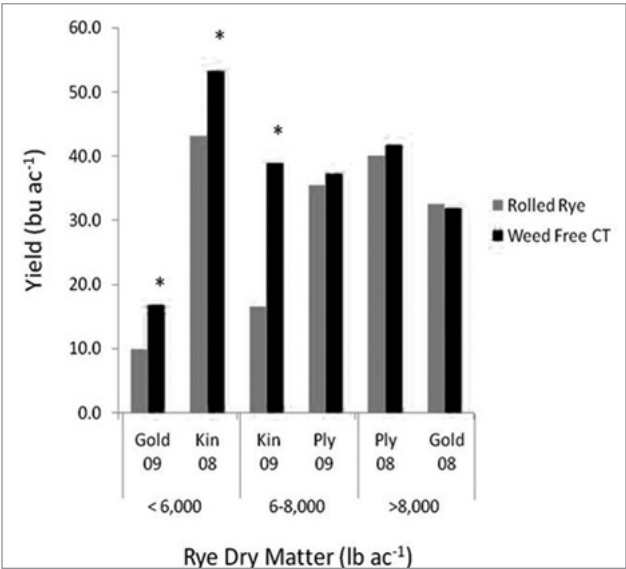


Figure 8-2. Soybean yield in roll-crimped rye mulches at Goldsboro, Kinston and Plymouth, NC in 2008 and 2009. Treatments consisted of rolled rye mulch with no additional weed control measures versus a weed free check that consisted of conventional tillage with S-metolachlor PRE and imazethpyr POST. Adapted from Smith et al., 2011.

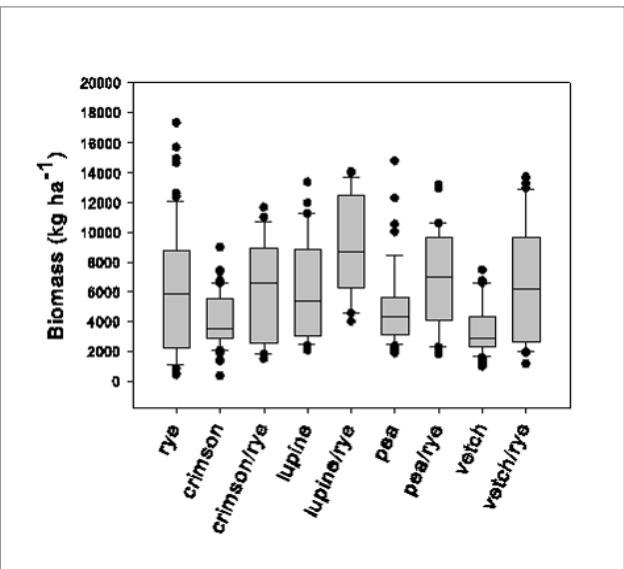


Figure 8-3. Productivity of legumes and legume-cereal mixes in the Southeast from 2008 to 2010. Figures come from a pooled analysis of trials in Georgia (GA) and North Carolina (NC). Box plots were created from nine site-years for all cover crops except lupine and lupine-rye, with four to six replicates per site-year. Lupine data is from GA only (five site-years) due to extremely low productivity in NC. Crimson clover varieties: *Trifolium incarnatum* L. AU Sunrise in NC; Dixie in GA. Vetch varieties: *Vicia villosa* Roth AU Early Cover in NC; *Vicia sativa* L. Cahaba White in GA. Winter pea varieties: *Pisum sativum* L. subsp. *sativum* var. *arvense* (L.) Poir variety unstated in NC and GA. Narrow-leaf lupine varieties: *Lupinus angustifolius* L. TifBlue 78 in NC and GA. NC data adapted from Parr et al. 20115. Rye, (*Secale cereale* L.) at both locations was Wrens abruzzi grown without added N fertility.

of legumes and rye are capable of producing more than 8,000 lb of dry matter (Figure 8-3). Whether this 8,000 lb cutoff applies to legume–corn systems is still unknown.

N Fertility in the Legume–Corn System

Legumes can be grown in monoculture or as a mixture with a small grain. Legumes are capable of providing a substantial proportion of the N demand for corn. While N production varies significantly from year to year, a good rule of thumb is that the legume can provide two-thirds of the needed nitrogen. Pelleted organic fertilizer can be applied at planting in only limited amounts with normal granular fertilizer boxes. For instance, John Deere granular boxes, with the high rate auger installed, can deliver approx-

imately 700 lb of conventional fertilizer at the highest setting. Pelleted feather meal, as an example, is less dense and only 500 lb can be delivered. At 12 to 13 percent N, the total N that can be applied is 65 lb. Assuming adequate legume cover crop growth, this may be sufficient. Other organic fertilizers are less rich in N, such as pelleted chicken litter, and therefore even less N can be applied. Clampco (<http://clampcoapplicators.com>) sells organic fertilizer boxes capable of putting down higher rates of granular and pelleted material than conventional fertilizer boxes. Another option is to broadcast chicken litter over the top at or soon after planting. While this practice would be allowed for feed crops, manures must be soil incorporated at least 90 days before harvest for all food-grade grains.

Chapter 9. Organic Certification

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To sell, label, or represent their products as “organic,” growers and processors who sell organic products valued at \$5,000 or more a year must be certified by a certifying agent accredited by the USDA. The National Organic Program Final Rule (NOPFR) spells out requirements for organic crop and livestock production, handling, certification, and recordkeeping. (The NOPFR and other related documents are available online at www.ams.usda.gov/nop/.)

Organic Certification Process

Because all certifiers must follow USDA requirements, the organic certification process is similar across certifiers. The farmer-applicant, the certifying agent, and the inspector must complete specific steps.

The farmer

A farmer seeking certification must do the following:

1. Comply with the federal standards for organic production (Table 9-1).
2. Choose a certifier.
3. Complete an Organic Farm (or System) Plan, which is also considered the application for certification. The Organic Farm Plan must describe all relevant aspects of the operation, include farm maps, and document a three-year field history for crops planted and inputs applied. (See Recordkeeping Requirements for more details.)
4. Submit the completed Organic Farm Plan as the application with certification fees and other required documents to the certification agency.

The certifying agent

1. Reviews the Organic Farm Plan and accompanying documentation to ensure completeness and determine whether the applicant appears to comply or has the ability to comply.

2. Verifies information regarding any previous certifications, notification of noncompliance, or denials of certification.
3. Arranges an on-site inspection of the farm, the next step toward certification. The certifying agent assigns an organic inspector who calls the applicant to set up an appointment. The inspection may take 3 to 6 hours, depending on the complexity of the operation.

The inspector

1. Verifies information from the Organic Farm Plan. To accomplish this, he or she inspects fields, farm buildings, and equipment; assesses contamination risks; fills out an onsite inspection report; and gathers as much information as needed for the certifying agent to determine if the operation complies with federal standards.
2. Evaluates crop health and growth, soil tilth, the fertility management program, pest and weed management strategies, seed sources, adjoining land uses, and the applicant's understanding of and commitment to compliance.
3. Reviews records to ensure monitoring and compliance. The inspector may be authorized to take soil, tissue, or product samples for analysis. The inspector reviews any noncompliance issues at the time of the inspection.
4. Conducts an exit interview to confirm the accuracy and completeness of the observations and information gathered, to address the need for additional information, and to discuss issues of concern.
5. Completes a report based on the information gathered. The inspector does not make the certification decision, but identifies noncompliance issues with regard to organic standards.
6. Sends the inspection report and all associated paperwork to the certifying agent.

What happens next?

After the inspection, the certifying agent assigns a certification committee, staff members, or review committee to review the Organic Farm Plan, the inspection report, and all associated documentation. If the certifying agent determines compliance in all procedures and activities, the applicant is granted certification and is issued a certificate of organic operation that must be updated each year. If the certifying agent determines any minor noncompliance issues, the applicant has the opportunity to correct these noncompliances as a condition of certification.

Maintaining organic certification

To maintain organic certification each year, the certified farmer must pay annual certification fees, submit an updated Organic Farm Plan detailing changes from the previous year, and submit an update on correction of any minor noncompliance issues previously identified by the certifying agent. Other records or information may be needed if deemed necessary. Each farm must be inspected at least once annually to maintain certification. The updated Organic Farm Plan and inspection report must also be completely reviewed by the certifying agent before the farm receives an updated certificate for the organic operation. (See Table 9-1.)

Denial of Certification

If certification is to be denied, the certifying agent must provide an applicant with written notification of noncompliance, giving the date by which the correction must be accomplished, and specifying any documentation necessary to support correction. The applicant may rebut in writing any noncompliances identified by the certifying agent. When a correction is not possible, a notification of noncompliance and notification of denial of certification is provided to the applicant. This notification is also provided to the USDA National Organic Program Administrator.

Re-applying The applicant can re-apply for certification when any noncompliances are corrected or request mediation with the certifying agent. When applying to a different certification agency, the farmer must submit a copy of the previous denial of

certification with the application paperwork to the new certifier.

Filing an appeal. An applicant can file an appeal of the denial of certification with the USDA National Organic Program administrator. If the certifying agent has reason to believe that the applicant made false statements or otherwise misrepresented compliance, the agent can simultaneously deny certification and issue a notification of noncompliance.

Recordkeeping: A Critical Requirement

Recordkeeping is critical to organic certification. A certified operation must maintain records that document the production, harvest, and handling of agricultural products intended to be sold, labeled, or represented as organic. Records must be adapted to the particular commodity that the certified operation is producing. For example, an organic grain farmer must keep records pertaining to the processes and facilities involved in the production, handling, and marketing of the organic grain crops, such as storage, cleanout, and transportation records. Records must also fully disclose all activities and transactions of the certified operation in sufficient detail as to be readily understood and audited.

All records must be maintained for at least five years beyond their creation and be sufficient to demonstrate compliance with the National Organic Program rules and regulations. Split operations (organic and conventional production on the same farm) must also maintain records on the conventional processes and facilities to ensure that no commingling occurs. The certified operation must make all relevant records available for inspection and copying during normal business hours by authorized representatives of the Secretary of Agriculture, the applicable state program's governing official, and the certifying agent.

One of the primary recordkeeping requirements of organic certification is maintaining an audit trail—the records that show the commodity was produced using only approved inputs, processes, and facilities. This can be challenging. Many new applicants are unsure of what documents are needed, and they do not know what an inspector needs to review during

Table 9-1. Federal standards for organic certification

To become a certified organic production operation, the farm and farm practices must comply with the Organic Foods Production Act of 1990 and the USDA National Organic Program rules and regulations (Federal Register, Vol. 65, No. 246, pgs. 80367-80663).

In simplified terms, National Organic Standards for crop farms require

- Proof that no prohibited materials have been applied to the crop for three years (36 months) prior to harvest. (A list of prohibited materials is provided below.)
- Distinct, defined boundaries for the organic operation.
- Implementation of an Organic System Plan, with proactive fertility systems; conservation measures; and environmentally sound manure, weed, disease, and pest management practices.
- Monitoring of the operation's management practices.
- Use of natural inputs and/or approved synthetic substances on the National List, provided that proactive management practices are implemented prior to use of approved inputs.
- Management of compost production and use. If compost is used for fertility, it may be applied at anytime but must be managed according to very specific parameters under the National Organic Standard requirements for compost production.
- Management of raw animal manure. If raw animal manure is used for fertility, it must be managed according to the crop being produced:

Feed crops (crops not intended for human consumption): It may be applied at anytime before harvest.

Crops for human consumption: It must be incorporated at least 90 days prior to harvesting a crop where the edible portion of the plant does not have contact with soil or soil particles, or 120 days prior to harvest of crops where edible portions do have contact with soil or could be splashed with soil particles.

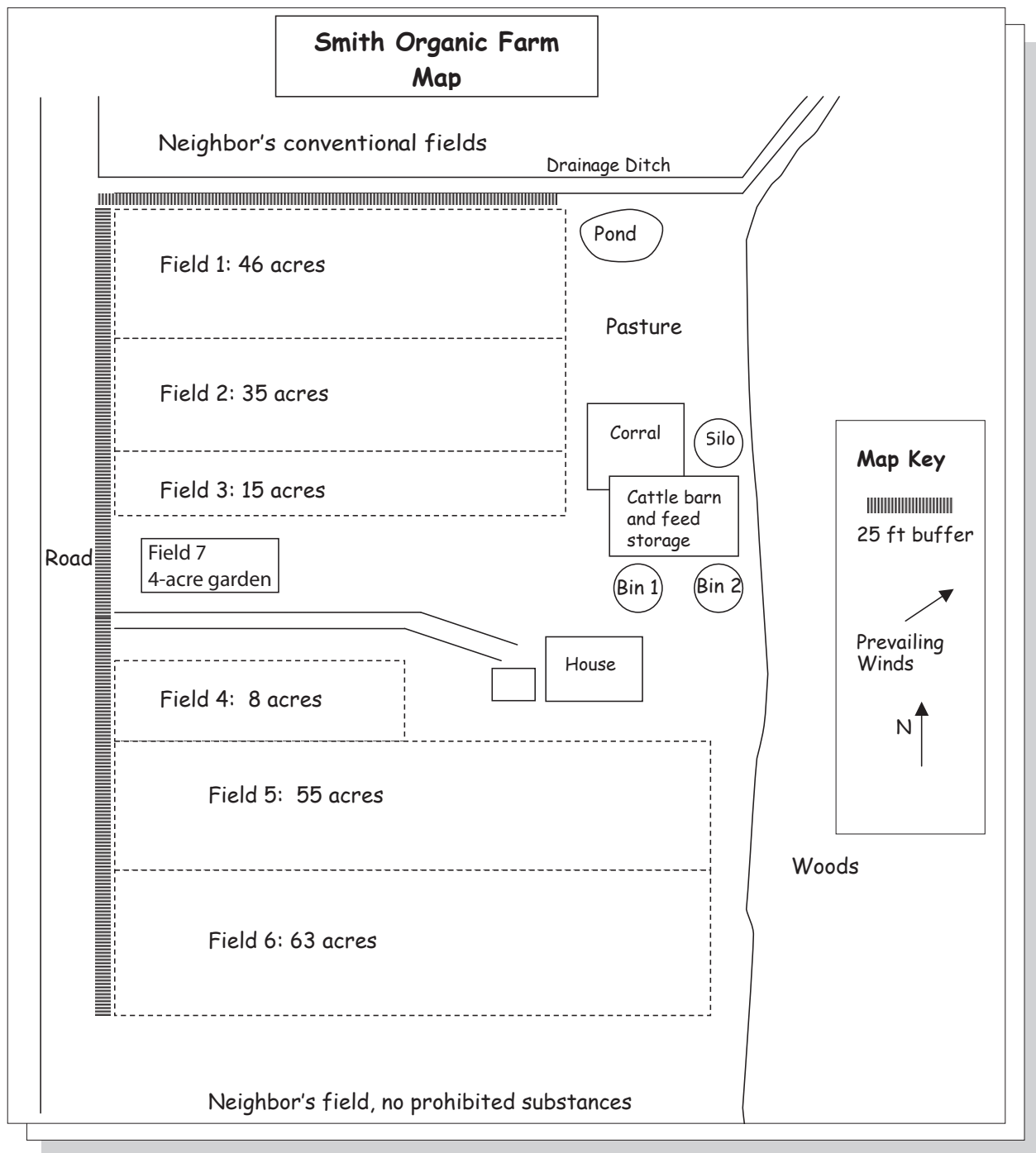
- Use of organic seeds, when commercially available (and no use of seeds treated with prohibited synthetic materials, such as fungicides, as noted below).
- Use of organic seedlings for annual crops when commercially available.

National Organic Standards prohibit

- Use of genetically engineered organisms, (GMOs) defined in the rule as "excluded methods."
- Residues of prohibited substances exceeding 5 percent of the EPA tolerance. A certifier may require residue analysis if there is reason to believe that a crop has come in contact with prohibited substances or was produced using GMOs.
- Use of sewage sludge.
- Irradiation.
- Use of any synthetic substance not on the National List.
- Use of any other prohibited substances on the National List.
- Field burning to dispose of crop residues. (Burning may be used only to suppress disease or to stimulate seed germination. Flame weeding is allowed.)

In addition, organic producers must

- Maintain or improve the physical, chemical, and biological condition of the soil, minimize soil erosion, and implement soil-building crop rotations.
- Use fertility management systems that do not contaminate crops, soil, or water with plant nutrients, pathogens, heavy metals, or prohibited substances.
- Maintain buffer zones, depending on risk of contamination.
- Prevent commingling on split operations. (The entire farm does not have to be converted to organic production, provided that sufficient measures are in place to segregate organic from nonorganic crops and production inputs).
- Maintain records for at least five years.

Figure 9-1. Sample farm map

inspection. The documents needed by the inspector depend on the production operation, but some basic documents are required for nearly every farm:

Farm maps

A farm map must clearly show the layout of the farm

and the land use in areas surrounding the farm or the organic fields (Figure 9-1). Maps must depict the following:

- Outlines of the fields. Indicate the field number and acreage of each field.
- Adjoining land uses. Indicate if adjoining land

Figure 9-3.
Sample field
activity log

YEARLY FIELD ACTIVITY LOG					
Field Number	<u>6</u>		Producer	<u>John Smith</u>	
			Crop Year	<u>2013</u>	
Acres	<u>63</u>		Previous Crop	<u>soybeans</u>	
			Crop Planted	<u>corn</u>	
Variety	<u>BF231</u>		Expected Yield	<u>95 bu/ac</u>	
			Crop Status	<u>organic</u>	
PLANTING INFORMATION					
Date Planted	<u>5/4/13</u>		Seeding Rate	<u>30,000 seeds/ac</u>	
			Final Stand		
TILLAGE INFORMATION					
Preplant	<u>disc (4/17/13); field cultivate (5/4/13)</u>				
Post Harvest	<u>disc (10/3/13); field cultivate (10/14/13)</u>				
INPUT APPLICATION INFORMATION					
Date	Type/Analysis	Rate Applied		Method of Application	
<u>4/16</u>	<u>chicken litter (4:2:2)</u>	<u>3 T/ac</u>		<u>broadcast</u>	
WEED CONTROL METHODS					
Date	Method	Comments			
<u>5/7</u>	<u>rotary hoe</u>	<u>field conditions fine</u>			
<u>5/10</u>	<u>rotary hoe</u>	<u>soil slightly damp</u>			
<u>5/25</u>	<u>cultivate-shovels</u>	<u>field conditions fine</u>			
PEST/DISEASE CONTROL INFORMATION					
Date	Product	Pest/Disease	Rate	Comments	
COVER CROPS					
Date Planted	Crop/Variety			Date Incorporated	
	<u>Plan to plant rye and vetch</u>				
HARVEST INFORMATION					
Date	Yield	% Moisture	Test Weight	Storage ID	Comments
<u>9/23</u>	<u>103 bu/ac</u>	<u>19%</u>		<u>ORG 2</u>	
<i>Use of this form is optional. Another form accomplishing the same purpose may be used if appropriate to your operation.</i>					

Field activity logs

These are probably the most important but least understood components of the audit trail. This is where the majority of the information regarding actual farming activity is kept. The field activity log, or field

record, should show all field prep work, planting information, postplanting fieldwork (such as cultivation, fertilization, and pest management), dates and rates of any and all inputs, and harvest dates for each field in the organic operation (Figure 9-3). A field log

can be kept in a number of ways. Carrying a pocket calendar and simply jotting down daily activities is a very simple and clear way to keep a field record. But one disadvantage of this system is that only one year's information is recorded at a time. Another approach is to keep a notebook that is regularly updated for each field. This helps track what happens in each field over a time span of several years. If keeping track of many fields is too difficult, a three-ring binder with a yearly record sheet for each field may be easier for long-term tracking. Computer software, such as simple spreadsheets, can also be used to maintain field activity records. Select a method that ensures documentation of all the required information in a way that works well for your operation.

Storage logs

These logs are needed only if crops are stored on the farm prior to sale. Usually grain farms will need some storage records (Figure 9-4). The following information is required: crop, amount, and date added to a bin or storage unit and what field it came from; crop, amount, and date removed from a bin; and the lot number for the sale (also see "sales documentation" below). If the storage bin was previously used for nonorganic crop storage, the storage log must indicate how and when the bin was cleaned prior to storing organic crops.

Sales documentation. This refers to all the information attached to a sale of organic products. It should include scale tickets, bills of lading, clean transport documentation, and invoices for sales. Also included in sales documentation should be the word "organic" and the lot number for the product sold. A lot number is an identification number used to track any crop sold as organic back to the originating field (Figure 9-5). This number is unique to each sale, but it should be based on a formula that is easy to remember because it needs to be consistently used.

Example

If Smith Organic Farm makes an organic sale for a soybean crop stored on the farm, the farmer would use a lot number such as "SOF-SB13-01-03." This number would signify:

Smith Organic Farm	SOF-
soybeans harvested in 2013 and	SB13-
stored in bin number 01	01-
third load sold from that bin.	03

Split production records

Keep in mind that if an organic farm grows the same crop organically and conventionally, the inspector will need to see all harvest, storage, and sales records for both the organic and conventional crops. This is necessary to verify that no commingling occurs between organic and nonorganic crops. Additionally, the records must show that all equipment was cleaned between uses in organic and nonorganic fields (Figure 9-6). This kind of affidavit is required for any equipment shared between organic and non-organic production, any rented equipment, or any field work completed by an outside contractor on a custom basis. The cleaning of transportation vehicles also must be documented. The cleanout date, previous product transported, organic product transported, cleaning activity, and name(s) of the driver(s) are generally needed for the documentation (Figure 9-7). Consult the certifier about specific cleanout procedures. Storage bins or containers and areas used for organic crops should be thoroughly cleaned before use and clearly labeled "organic."

This chapter includes several samples of the kinds of documents needed to create an organic audit trail (Figures 9-1 through 9-9). These specific documents are not required, but they can be used as templates that you can modify to match your production needs. Contact your certifier if you have specific questions regarding the requirements for audit trail documentation. Additional recordkeeping templates can be downloaded from www.carolinafarmstewards.org or www.attra.org.

Certification Agencies

A list of all USDA-accredited organic certifying agencies can be found on the Web at www.ams.usda.gov/nop/ or by request through the NOP office at 1400 Independence Avenue, SW, Room 2510 South Building, Washington, DC, 20250.

Choosing a Certifier

When choosing an organic certifier, an applicant should consider several factors. First, it may be helpful to choose a certifier that the end-user of your product recommends. For example, you could choose the certifier used by the organic mill who buys your organic grain.

Location and fees

Consider the location of inspectors that the certifier uses. Most certifiers require the applicant to pay all expenses associated with the on-site inspection,

including travel. Because the USDA requires that certifiers fully disclose all fees, an applicant can also compare certifiers based on expense or fees.

Turn-around time and experience

Also consider the turn-around time required by certifiers to process an application, and the experience the certifier has in certifying a particular type of operation. Some applicants choose a certifying agent based on the agency's level of involvement in organic certification policy and advocacy at state and national levels.

Figure 9-6.
Sample cleanout
affadavit for
equipment

COMBINE CLEANOUT AFFIDAVIT													
Please complete a clean-out affidavit before harvest and for each different crop harvested. Note field numbers and date clean-out procedures were performed.													
Producer <u>John Smith</u>	Clean-out Date <u>9/20/13</u>												
Crop <u>Corn</u>	Field Number <u>6</u>												
Custom Operator Name <u>John Smith</u>													
Address <u>12 Farmtown Road, Fairview, NC 27654</u>													
Type of Machine _____													
<div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p>Clean-out Procedure: (S) Sweeping; (C) Compressed air; (W) Washing Please mark each part of the combine that was cleaned and the procedure used.</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; padding: 2px 5px;"><u>C</u> Header</td> <td style="width: 50%; padding: 2px 5px;"><u>C</u> Sieves and Chaffers</td> </tr> <tr> <td style="padding: 2px 5px;"><u>C</u> Feederhouse</td> <td style="padding: 2px 5px;"><u>C</u> Cylinder and/or Rotor</td> </tr> <tr> <td style="padding: 2px 5px;"><u>S</u> Grain Tank</td> <td style="padding: 2px 5px;"><u>C</u> Shoe Supply Augers</td> </tr> <tr> <td style="padding: 2px 5px;"><u>C</u> Straw Walkers</td> <td style="padding: 2px 5px;"><u>C</u> Unloading Auger</td> </tr> <tr> <td style="padding: 2px 5px;"><u>S</u> Ledges, Frame Rails</td> <td style="padding: 2px 5px;"><u>C</u> Rock Trap</td> </tr> <tr> <td style="padding: 2px 5px;"><u>C</u> Clean and Return Elevators and Cross Augers</td> <td></td> </tr> </table> </div>		<u>C</u> Header	<u>C</u> Sieves and Chaffers	<u>C</u> Feederhouse	<u>C</u> Cylinder and/or Rotor	<u>S</u> Grain Tank	<u>C</u> Shoe Supply Augers	<u>C</u> Straw Walkers	<u>C</u> Unloading Auger	<u>S</u> Ledges, Frame Rails	<u>C</u> Rock Trap	<u>C</u> Clean and Return Elevators and Cross Augers	
<u>C</u> Header	<u>C</u> Sieves and Chaffers												
<u>C</u> Feederhouse	<u>C</u> Cylinder and/or Rotor												
<u>S</u> Grain Tank	<u>C</u> Shoe Supply Augers												
<u>C</u> Straw Walkers	<u>C</u> Unloading Auger												
<u>S</u> Ledges, Frame Rails	<u>C</u> Rock Trap												
<u>C</u> Clean and Return Elevators and Cross Augers													
I hereby attest that the above practices and procedures have been completed in accordance with Organic Certification Standards.													
Operator _____	Producer _____												
Date _____	Date _____												
(Attach a copy of the invoice for contracted services.)													
Use of this form is optional. Another form accomplishing the same purpose may be used if appropriate to your operation.													

Figure 9-7. Sample cleaning affidavit for transportation

Off-Farm Transportation Cleaning Affidavit	
This semi-trailer/container, license number _____ was swept/air blown/ flushed/washed (circle all that apply) prior to loading of organic product.	
Landowner/Shipper:	_____
Field/Lot Number:	_____
Destination:	_____
Trucking/Shipping Firm:	_____
Date Loaded:	_____
Date Delivered:	_____
Crop/Product:	_____
I hereby certify that the above equipment was cleaned thoroughly using the method indicated to keep the integrity of the organically grown/processed product intact.	
Date:	_____
Signed:	_____
Title:	_____
	(Owner, Truck Driver, etc.)
This form must accompany Bill of Lading to: _____	

	(Unloading or Delivery Point)

Organic Compliance in Grain Production

Organic grain production involves some specific requirements that may not apply to other farms because of the way grain is produced, stored, and sold.

Isolation buffers

The size requirements vary for isolation buffers between organic land and adjacent nonorganic land, depending on land uses, prevailing winds, runoff directions, ditches, and other barriers. An isola-

tion buffer is usually between 20 and 50 feet wide. However, cross-pollinated or wind-pollinated organic crops (such as corn) should be isolated from GMO crops of the same type by a larger buffer to maintain seed purity. Part of a field buffer can consist of the outside rows of a crop field, harvested and sold as conventional (Figure 9-8). Confirm buffer distances with your certification agency. If an applicant can provide a written statement from his or her neighbors that no prohibited materials are being used on

adjoining land, the organic operation may not need a buffer at all.

Organic seed

Organic seed must be used when commercially available. In many cases, however, the crop or variety desired is not commercially available as organic seed. This is particularly true for organic grain production. Generally, the applicant must contact at least three seed companies or sources that carry organic seeds and try to obtain organic seed of the crop or variety desired. The three seed sources contacted must produce or supply seed of the crop desired. The applicant must document the contact, including the date; whether the contact involved a telephone, fax, letter, or email message; the crop and variety; and the most comparable variety with organic seed source and price (Figure 9-9). The certifying agent may

require a copy of this documentation if nonorganic seed is used. Contact the following organizations for more information about organic seed availability for crop production:

NC State University, Organic Grain Web site
www.organicgrains.ncsu.edu/cropproduction/seedsuppliers.htm

National Sustainable Agriculture Information Service

1-800-346-9140

P.O. Box 3657, Fayetteville, AR 72702

http://attra.ncat.org/attra-pub/organic_seed/

Organic Materials Review Institute

541-343-7600

Box 11558, Eugene, OR 97440

www.omri.org/seeds

Figure 9-8. Sample buffer crop record

BUFFER CROP USAGE			
Producer Name <u>John Smith</u>		Crop Production Year <u>2013</u>	
Field Number <u>6</u> Crop Harvested <u>Corn</u> Quantity harvested <u>50 bushels</u> Stored in bin number <u>06</u>			
Used for (check): <input type="checkbox"/> seed <input type="checkbox"/> On farm non-organic livestock feed <input checked="" type="checkbox"/> Sold <input type="checkbox"/> Other _____			
Sold to: (invoice attached) <u>Milling, Inc.</u>			
Field Number _____ Crop Harvested _____ Quantity harvested _____ Stored in bin number _____			
Used for (check): <input type="checkbox"/> seed <input type="checkbox"/> On farm non-organic livestock feed <input type="checkbox"/> Sold <input type="checkbox"/> Other _____			
Sold to: (invoice attached) _____			
Field Number _____ Crop Harvested _____ Quantity harvested _____ Stored in bin number _____			
Used for (check): <input type="checkbox"/> seed <input type="checkbox"/> On farm non-organic livestock feed <input type="checkbox"/> Sold <input type="checkbox"/> Other _____			
Sold to: (invoice attached) _____			
Field Number _____ Crop Harvested _____ Quantity harvested _____ Stored in bin number _____			
Used for (check): <input type="checkbox"/> seed <input type="checkbox"/> On farm non-organic livestock feed <input type="checkbox"/> Sold <input type="checkbox"/> Other _____			
Sold to: (invoice attached) _____			

Use of this form is optional. Another form accomplishing the same purpose may be used if appropriate to your operation.

Figure 9-9. Sample seed record

SEED VERIFICATION FORM					
Please list all varieties, lot numbers, and treatments (insecticides, fungicides, or inoculants) used, for seeds planted or to be planted on your farm. Indicate if the seeds are certified organic, untreated non-organic, or treated non-organic. If organic seed is not purchased, you must show proof of your attempts to source organic seeds. Give information on non-GMO verification analysis, if possible.					
Producer Name: <u>John Smith</u>			Crop production year: <u>2013</u>		
<u>Seed Information</u>			Lot #	Is seed organic (O), untreated non-organic (U), or treated non-organic (T)?	Type and Brand of Treatment
Crop	Variety	Supplier			
corn	BF231	Organic Seed, Inc.	46	O	none
soybeans	T385	Seed, Inc.	102	U	none

Pesticides

A number of pesticides—mainly nonsynthetic compounds and biocontrols—are approved for use in certified organic production systems. Insecticides include neem, *Bacillus thuringiensis*, *Beauveria spp.*, diatomaceous earth, pyrethrum, spinosads, horticultural oils, and species of *Trichoderma*. Fungicides include hydrogen peroxide, potassium and sodium bicarbonate, copper products, sulfur, species of *Pseudomonas*, and pesticidal soaps. While these products have potential for controlling insect or disease pests, or both, no research has been conducted with them in grain crops in North Carolina, and we cannot make recommendations for their use in this state. The cost of pesticides approved

for organic production may also be prohibitively expensive for field crops. Conditions for use of an approved pesticide must be documented in the organic system plan as required by the 2000 NOP before a pesticides is used.

The OMRI publishes a list of commercially available products that can be used in certified organic operations for pest control: **www.OMRI.org**. Some approved products may not be listed by OMRI, but always check with your certifier before using any product. Some certifiers charge a fee for reviewing any pesticide that will be used on a crop. Always contact your certifier prior to using any pesticide to document use or to gain approval for use.

Accidental contamination

Accidental contamination of a farm by prohibited substances can occur because of spraying by the Department of Transportation (DOT), electrical companies, or neighbors. It is important to communicate very clearly about your organic operation and display signs that indicate organic land. Inform the DOT and electrical companies about the location of organic land and specifically ask them to avoid spraying the area.

This chapter, including figures and tables, is derived from NC Cooperative Extension publication AG-681, *Organic Certification of Field Crops: A Guide* (Hamilton et al., 2007).

Chapter 10. Marketing Organic Grain Crops

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Marketing organic grains is very different from marketing conventional grains. Organic grain is usually sold to a specific buyer, while a farmer using conventional methods can deposit an entire harvest at the local grain elevator. For NC farmers, the organic grain buyers are almost always farther away from farms than conventional markets, meaning freight costs are an additional consideration. The NOPFR requires that organic grain be handled, processed, and stored in facilities separate from conventionally grown and handled grain. This means that in a split operation (with both conventional and organic grain production), harvesting, transportation, and storage equipment for organic grain needs to be separate in time or space from equipment used in handling conventional grain. However, organically produced crops can bring higher prices than conventional crops, so the extra trouble in getting the crop to market may be financially beneficial.

The Marketplace

Nearly all organic grains are marketed as either livestock feed or as food for human consumption. Organic grain for human consumption, referred to here as “food-grade grain,” generally earns a higher premium than organic grain for livestock feed. However, growing for the livestock feed market lowers the risk of going organic for those who are new to organic farming. Growing organic grain for the food-grade market requires a lot of attention to detail and experience with organic grain production and marketing. Quality and cleanliness specifications are more stringent than for livestock-feed grain, and markets are usually harder to identify. Often a specific variety is required by a buyer of a food-grade grain. For most NC farmers, the livestock feed market is more easily accessible than the food-grade grain market. There are markets in North Carolina, however, for food-grade organic wheat, rye, and corn.

Marketing Plan

It is always a good idea to have a marketing plan, especially when marketing organic grains. Research is a key component of successfully marketing organic grains. Begin researching the market before the crop is planted. Talk to organic grain buyers, organic certifiers, suppliers, and other organic grain farmers to gather information on how best to market your crop. The Internet can be a good resource for current information. As a first step, see “Marketing Resources” on this website: www.organicgrains.ncsu.edu/marketing/marketing.htm

It is important to know your customers and know what they want, whether they are brokers, processors, retailers, or end-users. Find out if buyers are looking for a certain variety of grain or a certain quantity and whether they have quality specifications for the grain. Most buyers want to buy organic grain on a clean, delivered basis. If other arrangements are desired, the farmer may need to negotiate with the buyer. It is also important to know what price buyers are willing to pay for grain, and when and how they will pay. Transportation is another critical consideration in a marketing plan. How will the product get to the buyer and when? What are the costs? Good recordkeeping is also a key part of a marketing plan and organic certification and will keep a farmer knowledgeable about how profitable the operation is and where improvements can be made.

Storage

Storage may be critical for marketing organic grains, especially wheat. Buyers often do not have sufficient storage capacity, cash-flow, or both to accept an entire crop at one time. A crop may need to be stored for several weeks or months. Some farmers store grain for up to 11 months to meet market demand. Often, a better price for the grain is offered a few months after harvest, so storage may also be an eco-

nomic advantage. To maintain grain quality during storage, insects must be kept out and the grain must be stored at proper temperature and moisture conditions. Split operations will need separate storage bins, or storage bins will need to be thoroughly cleaned (swept, vacuumed, blown out with pressurized air, or all of these) to prevent commingling of organic and conventional products. Storage bins should be labeled as organic, and records of their contents must be maintained.

The best way to manage insect pests in stored organic grains is to avoid them. It is important to prevent problems in stored grain by keeping bins, ducts, and augers clean and by storing grain at a temperature lower than 60°F and at low humidity. Another suggested and often used method to prevent insect pest problems in stored organic wheat and corn is to add food-grade diatomaceous earth (DE) to the grain as it is being loaded into the storage bins (at a rate of up to 50 lb per 22,000 lb of grain). Diatomaceous earth can be sprinkled on top of the grain while it is moving in the auger to the bin, and then on top of the grain after it is loaded. The surface of each particle of DE is very sharp on a microscopic level, and these sharp edges cut into worms as they feed or move over the grain, causing them to desiccate. Be sure to talk to your grain buyer and certifier before using DE as a storage additive. To identify insect pests of stored grain, see the *Small Grain Production Guide* storage sections. This publication is available through county Extension centers or online: www.smallgrains.ncsu.edu/production-guide.html

Handling Stored Grain

Stored-grain management is a long-term approach to maintaining postharvest grain quality, minimizing inputs, and preserving the integrity of the grain storage system. To implement an effective management program, you must understand the ecology of the storage system. Storage management must focus on the following factors:

- Grain temperature
- Grain moisture
- Air relative humidity
- Storage time

An excellent preventive postharvest grain management approach is the SLAM system (Sanitize/Seal, Load, Aerate, Monitor).

Sanitize and Seal

- Housekeeping—clean bin, aeration ducts, and auger trenches where insects thrive on dust and foreign material
- Cleanup—clean up around the bin, removing weeds, trash, and moldy grain.
- Seal bin—seal all openings to provide barrier protection against insect entry at all locations below the roof eaves.

Load

- Load clean, dry grain—High levels of grain moisture increase the potential for high populations of stored-grain insects and molds. In North Carolina, corn that will be stored for more than 6 months should be dried to 13.5 percent moisture.
- Core the grain—This involves operating the unload auger to pull the peak down and remove the center core of the bin that contains the most fines and small foreign matter.
- Spread or level grain—A level grain surface is easier to manage and less likely to change temperature during storage.

Aerate

- Maintain grain temperature—Grain temperature should be below 60°F to control insects and mold. Grain temperatures should be reduced to the optimum storage level as early as possible following harvest, and grain temperature should be managed by aeration of grain in the fall, winter, and early spring. The aeration time necessary to achieve 60°F will vary due to the airflow rates of the equipment used and ambient temperatures. Aeration can also reduce grain moisture content from $\frac{1}{4}$ to $\frac{1}{2}$ of 1 percent during one aeration cycle.
- Use aeration to prevent moisture migration—In most grain bins, moisture migration occurs due to significant temperature differences that de-

velop within the grain mass. These temperature differences are caused by changes in outside temperatures and humidity throughout the year and result in changes in the equilibrium moisture of the grain. Operators must constantly monitor grain condition, particularly during periods of temperature change (fall or spring), to determine how temperature differences are effecting moisture migration in the bin. Aeration can be used to equalize grain temperature and moisture throughout the bin.

Monitor

- Use a grain thermometer to track grain temperature.
- Schedule regular grain sampling and monitoring.
- Aerate and turn hot spots when detected.

Genetic Contamination

Organic integrity must be maintained throughout the growing, harvesting, storage, and transportation processes. Because organic standards prohibit the use of genetically modified organisms, proper harvesting and storage procedures are essential parts of organic grain marketing. A positive test result (a GMO percentage above a certain level) can cause a buyer to reject an entire load. If the farm is a split operation, thorough cleaning of harvest equipment (including hauling equipment and all augers) between operations for conventional and organic crops is very important. Grain-receiving pits, augers or conveyors, elevator legs, dryers, and storage bins are all sources of contamination and should be cleaned to minimize mixing. Running some organic grain at maximum capacity through the system to clean out any residual transgenic grain can also help reduce contamination risks.

Transportation

Organic grain buyers generally need the grain delivered to their facilities, and buyers pay on a delivered basis. This means that the grower is often responsible for transportation. Trucks that transport grain from the farm to buyers should be cleaned thor-

oughly before loading organic grain. It is important to remember to clean the hopper bottoms and any covering (such as canvas) on the truck as well as the bed. Document the cleaning, as this will be needed by the buyer and the certifier. Documentation can be a written statement or affidavit that says when and how the cleaning was done. It shows that the producer is taking responsibility for the cleanliness of the transportation vehicle.

Grain Quality

Grain quality is very important to food-grade grain as well as livestock-feed grain. The quality of the grain determines its value. High-quality grain must be clean and free of weed seed, undamaged, uncontaminated, and identifiable. Controlling weeds, pests, and volunteer crops in the field can help keep quality high. Also, proper combine settings will help keep grain dirt-free and undamaged.

Contracts

Organic grain buyers will sometimes contract with producers to supply a grain crop within a specified time period at a specified price. Contracts are legal agreements between the farmer and the buyer and are more common to large grain producers in the western states than grain producers in the eastern states. Some organic grain buyers in North Carolina, however, are starting to contract for organic grain based on acreage. The buyer will sign a contract with a farmer to buy all the grain coming off of an agreed upon number of acres. This reduces the risk to the farmer if there is a poor yield, as the farmer is only obliged to sell the yield from the contracted acres. Some specialty organic grain crops, such as canola, spelt, or sunflowers, may require contracts.

Getting Paid

To ensure that you are paid once your crop is harvested and delivered, start by finding out information about the buyer. How soon after the crop is delivered will the buyer pay? What experiences have other farmers had with the buyer? Check with the buyer's organic certification agency or your certification agency and ask if other organic growers had prob-

lems with the buyer. When dealing with a new buyer, it may be prudent to sell the minimum quantity at first to avoid major losses.

Completed paperwork may be needed to get paid. Organic grain marketing depends on documentation. When delivering grain to a buyer, be sure to have all required paperwork, such as a bill of lading, clean-truck affidavit or truck-cleaning document, weigh slip, and a copy of the organic certificate under which the product is certified. Proof of certification is critical. Lot numbers assigned to field, harvested crop, and trucking help to track the crop. Check with the buyer to see if any other documentation will be required.

Finding Organic Grain Buyers

To find a buyer for your organic grain, contact organic grain mills, brokers, and processors directly. Networking with other farmers, buyers, or state agencies may also be very helpful in finding buyers. You can see the list of buyers interested in North Carolina produced organic grains on the NC State University website for organic grain: www.organic-grains.ncsu.edu/marketing/buyers.htm. This list is not comprehensive, and there may be other companies that will buy NC organic grain. One way to find new buyers for organic grain is to explore the Internet.

Alternative Marketing Techniques

Direct marketing to the end user is another way of selling an organic grain crop. This may work best for livestock feed grains. There are a number of producers in North and South Carolina who are very interested in producing organic livestock. To be able to certify livestock as organic, the animals must be fed organic feed from organically grown crops. A relationship with one or more livestock producers would give the grain or forage farmer and the livestock producer an advantage in pricing. The livestock producer can get a better price for the organic grain for feed, and the grain producer can get a price for

the crop without the “middleman” costs. This arrangement can work for livestock producers who are able to store and mix their own feed. When in this situation, organic grain farmers may have to store grain for a longer time than usual and deliver the grain on multiple occasions. Or the grain farmer can grind and mix feed to be delivered to or picked up by livestock producers as they need it. Organic forage crops can also be sold in this way. Grain farmers can find livestock producers who may need organic feed through organic certification agencies or organizations such as the Carolina Farm Stewardship Association (CFSA), Rural Advancement Foundation International (RAFI-USA), the American Livestock Breeds Conservancy (ALBC) or through this website: www.organicgrains.ncsu.edu

Adding value to the initial organic grain crop product through some type of processing is another way to market organic grains. Processing can be as simple as cleaning and bagging the grain or as complex as milling the grain and producing baked goods from the milled grain. You may need additional equipment to do any on-farm processing, certification for the process and equipment, and, possibly, liability insurance. However, it may be very worthwhile to investigate the options. One organic grain farmer in North Carolina had a small corn mill that he used to process his own corn into meal, grits, and cracked corn for chicken feed. He then sold these value-added products, packaged, to retailers or marketed them directly to consumers.

Cooperative marketing may work for organic grain producers who do not have the labor, time, or equipment to deal with the quality and delivery specifications or cleaning and storage operations. These marketing costs can reduce the price premiums of organic grains, especially for smaller producers. Transportation, storage, and cleaning costs may be reduced by cooperative or collaborative marketing. Finding and working with other organic grain producers may also be a way to sell smaller quantities of organic grains or alternative grain crops.

Crop Budgets

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These budgets are an estimate of the full economic costs and returns for organic grain production in North Carolina. The budgets are based on but one set of many possible cultural and management practices that could be used in the production of organic grain. The most common cultural and management practices in North Carolina were used as the basis for the costs and returns shown in the budgets. Specific farm conditions will vary considerably, which affects both cost of production and yields. Organic production may have more variation in yields and price than conventional production systems. These budgets are only intended to be used a guide to developing costs and returns estimates for your farm specific situation. Individual farmers are encouraged to develop their own cost and return for their organic grain crops.

Each individual budget includes estimates of gross receipts, variable operating costs, and fixed costs for that crop. Budgets are a guide to what particular costs and returns are expected to be, on average, for a representative farm over time and at similar locations. They provide estimates of costs and returns for one year for one crop. An enterprise budget for a specific crop cannot take into account the effects of various crop rotations, which could greatly affect the production practices, costs and returns. Note also that the fixed costs include the costs associated with the transition from conventional farming to certified organic status. Farm overhead costs are not considered, including any cost or charge for land. The measure of profit is returns to land, management and risk.

Gross Receipts and Yields

Gross receipts are estimated from expected prices and normal yields. Yields were estimated to be twenty-five percent lower than for conventional production methods of the same crop. This reduction in yields was based on personal conservations with

producers and industry sources. Over time experienced growers should expected to see yields improve to near conventional yields under good growing conditions. Price discovery is more difficult for organic production due to the smaller number of buyers.

Variable Costs

Variable costs are those costs that will change based on the level of production. For example, increased production will require higher levels of soil fertility. Since most organic grain is not sold at harvest, drying, and storage costs for three months are included in budget. The machinery costs are based on new equipment prices for the year in which the budget was developed. Used equipment has lower ownership costs (depreciation, interest on investment, tax, insurance) but has higher annual repair and maintenance costs. Labor costs depend on the farm situation. Some activities may require extra hired labor with the associated additional expense, while on another farm the activity might be performed by the owner. A labor charge is included in the budget to reflect either the cost of hiring someone to perform the work or the minimum return the owner wants for his or her time.

Fixed Costs

The fixed costs include machinery and equipment ownership costs and amortized transition costs. The ownership costs of machinery and equipment are depreciation, interest on investment, taxes and insurance.

Transition Cost

The transition cost reflects the fact that, during the transition period, cultural practices must be altered to come into compliance with the organic rules, type of crops grown and crop mix may need to be changed to meet soil fertility and weed management constraints. It is expected that costs increase and revenue decreases because yields are reduced and crop products cannot be sold as organic. The transition cost is estimated by the difference in organic and conventional revenue and costs during the three-year

transition period. This transition cost can be thought of as an investment in certified organic production and, as such, it should be amortized over the farmer's

planning horizon. In these budgets, the estimated transition cost was amortized at 8% over 10 years and listed as a fixed cost of production.

NC State University—Corn Organic Production
Estimated Costs and Returns per Acre, 75 Bushel Yield, 2012

	Unit	Quantity	Price or Cost per Unit	Total per Acre	Your Farm
1. GROSS RECEIPTS					
Corn	BU	75.00	\$10.00	\$750.00	
TOTAL RECEIPTS				\$750.00	
2. VARIABLE COSTS					
Seed	THOU	28.00	\$2.13	\$59.64	
Lime (prorated)	TON	0.33	\$50.00	\$16.50	
Chicken litter	TON	3.50	\$36.00	\$126.00	
Tractor/machinery	ACRE	1.00	\$46.94	\$46.94	
Drying	BU	0.00	\$0.12	\$0.00	
Cover crop	BU	2.00	\$48.00	\$96.00	
Hauling	BU	75.00	\$0.35	\$26.25	
Storage	BU	75.00	\$0.20	\$15.00	
Labor	HR	4.41	\$9.30	\$41.01	
Interest on op. cap.	\$	53.29	45.00%	\$23.98	
TOTAL VARIABLE COSTS:				\$451.32	
3. INCOME ABOVE VARIABLE COSTS				\$298.68	
4. FIXED COSTS					
Tractor/machinery	ACRE	1.00	\$47.21	\$47.21	
**Transition costs	ACRE	1.00	\$35.62	\$35.62	
**Organic certification	ACRE	1.00	\$11.00	\$11.00	
TOTAL FIXED COSTS:				\$93.83	
5. TOTAL COSTS:				\$545.15	
6. NET RETURNS TO LAND, RISK AND MANAGEMENT:				\$204.85	

BREAK-EVEN YIELD			BREAK-EVEN PRICE	
VARIABLE COSTS	45	BU	VARIABLE COSTS	\$6.02
TOTAL COSTS	55	BU	TOTAL COSTS	\$7.27

* PLEASE NOTE: This budget is for planning purposes only.

**Transition cost is three-year period of conversion from conventional production to organic amortized at 5% for 10 years. Chicken litter price includes cost of transportation and \$6/acre spreading.

NC State University—Corn Organic Production
Per Acre Machinery and Labor Requirements for 75 Bushels Corn

MONTH	OPERATION	TIMES OVER	LABOR HOURS	MACHINE COSTS	VARIABLE COSTS	FIXED COSTS
3	Heavy disk 16'	2.00	0.26	0.24	\$9.04	\$7.68
4, 5	Cultivator 6R30	2.00	0.31	0.28	\$7.40	\$4.44
5	Planter 6R30	1.00	0.13	0.12	\$3.51	\$3.05
5, 6	Spring tooth	3.00	0.36	0.33	\$3.57	\$2.43
10	Combine w/ header	1.00	0.33	0.30	\$13.85	\$20.29
10	Heavy disk 16'	1.00	0.13	0.12	\$4.52	\$3.84
10	Truck 1.5 Ton	1.00	0.25	0.23	\$1.44	\$2.00
10	Grain drill 16'	1.00	0.14	0.13	\$3.61	\$3.48
PER ACRE TOTALS FOR SELECTED OPERATIONS			1.91	1.75	46.94	47.21
UNALLOCATED LABOR (HR/AC)			2.50			

INCOME ABOVE VARIABLE COSTS AT DIFFERING YIELDS AND PRICES

YIELD	PRICE (\$/BU)				
(BU)	\$9.00	\$9.50	\$10.00	\$10.50	\$11.00
68	\$156.18	\$189.93	\$223.68	\$257.43	\$291.18
71	\$189.93	\$225.56	\$261.18	\$296.81	\$332.43
75	\$223.68	\$261.18	\$298.68	\$336.18	\$373.68
79	\$257.43	\$296.81	\$336.18	\$375.56	\$414.93
83	\$291.18	\$332.43	\$373.68	\$414.93	\$456.18

NC State University—Wheat Organic Production
Estimated Costs and Returns per Acre, 37 Bushel Yield, 2012

	Unit	Quantity	Price or Cost per Unit	Total per Acre	Your Farm
1. GROSS RECEIPTS					
Wheat	BU	37.00	\$9.50	\$351.50	
TOTAL RECEIPTS:				\$351.50	
2. VARIABLE COSTS					
Seed	BU	2.50	\$22.00	\$55.00	
Fertilizer					
Lime (prorated)	TON	0.33	\$50.00	\$16.50	
Chicken litter	TON	1.50	\$36.00	\$54.00	
Tractor/machinery	ACRE	1.00	\$29.96	\$29.96	
Drying	BU	0.00	\$0.12	\$0.00	
Cover crop	ACRE	0.00	\$48.00	\$0.00	
Hauling	BU	37.00	\$0.35	\$12.95	
Storage	BU	37.00	\$0.20	\$7.40	
Labor	HR	3.10	\$9.30	\$28.83	
Interest on op. cap.	\$	42.48	5.00%	\$2.12	
TOTAL VARIABLE COSTS:				\$206.76	
3. INCOME ABOVE VARIABLE COSTS				\$144.74	
4. FIXED COSTS					
Tractor/machinery	ACRE	1.00	\$35.58	\$35.58	
**Transition costs	ACRE	1.00	\$17.75	\$17.75	
**Organic certification	ACRE	1.00	\$11.00	\$11.00	
TOTAL FIXED COSTS:				\$64.33	
5. TOTAL COSTS:				\$271.09	
6. NET RETURNS TO LAND, RISK AND MANAGEMENT:				\$80.41	

BREAK-EVEN YIELD			BREAK-EVEN PRICE	
VARIABLE COSTS	22	BU	VARIABLE COSTS	\$5.59
TOTAL COSTS	29	BU	TOTAL COSTS	\$7.33

PLEASE NOTE: This budget is for planning purposes only.

*Transition cost is three-year period of conversion from conventional production to organic amortized at 5% for 10 years.

**Organic certification costs vary but estimated to be \$11/acre.

NC State University—Wheat Organic Production
Per Acre Machinery and Labor Requirements for 37 Bushels Wheat

MONTH	OPERATION	TIMES OVER	LABOR HOURS	MACHINE COSTS	VARIABLE COSTS	FIXED COSTS
9	Rotary mower 14'	1.00	0.12	0.11	\$2.02	\$2.13
10	Heavy disk 16'	2.00	0.26	0.24	\$9.04	\$7.68
11	Grain drill 16'	1.00	0.14	0.13	\$3.61	\$3.48
6	Combine w/ header	1.00	0.33	0.30	\$13.85	\$20.29
6	Truck 1.5 Ton	1.00	0.25	0.23	\$1.44	\$2.00
PER ACRE TOTALS FOR SELECTED OPERATIONS			1.10	1.01	29.96	35.58
UNALLOCATED LABOR (HR/AC)			2.00			

INCOME ABOVE VARIABLE COSTS AT DIFFERING YIELDS AND PRICES

YIELD	PRICE (\$/BU)				
(BU)	\$8.55	\$9.03	\$9.50	\$9.98	\$10.45
33	\$77.96	\$93.77	\$109.59	\$125.41	\$141.23
35	\$93.77	\$110.47	\$127.17	\$143.86	\$160.56
37	\$109.59	\$127.17	\$144.74	\$162.32	\$179.89
39	\$125.41	\$143.86	\$162.32	\$180.77	\$199.22
41	\$141.23	\$160.56	\$179.89	\$199.22	\$218.56

NC State University—Soybean Organic Production
Estimated Costs and Returns per Acre, 20 Bushel Yield, 2012

	Unit	Quantity	Price or Cost per Unit	Total per Acre	Your Farm
1. GROSS RECEIPTS					
Soybeans	BU	20.00	\$18.00	\$360.00	_____
TOTAL RECEIPTS:				\$360.00	_____
2. VARIABLE COSTS					
Seed	BU	1.50	\$21.50	\$32.25	_____
Fertilizer					
Lime (prorated)	TON	0.33	\$50.00	\$16.50	_____
Chicken litter	TON	0.00	\$36.00	\$0.00	_____
Tractor/machinery	ACRE	1.00	\$46.18	\$46.18	_____
Drying	BU	0.00	\$0.12	\$0.00	_____
Cover crop	ACRE	2.00	\$48.00	\$96.00	_____
Hauling	BU	20.00	\$0.35	\$7.00	_____
Storage	BU	20.00	\$0.20	\$4.00	_____
Labor	HR	4.26	\$9.30	\$39.62	_____
Interest on op. cap.	\$	39.22	5.00%	\$1.96	_____
TOTAL VARIABLE COSTS:				\$243.51	_____
3. INCOME ABOVE VARIABLE COSTS				\$116.49	_____
4. FIXED COSTS					
Tractor/machinery	ACRE	1.00	\$47.90	\$47.90	_____
**Transition cost	ACRE	1.00	\$32.50	\$32.50	_____
**Organic certification	ACRE	1.00	\$11.00	\$11.00	_____
TOTAL FIXED COSTS:				\$91.40	_____
5. TOTAL COSTS:				\$334.91	_____
6. NET RETURNS TO LAND, RISK AND MANAGEMENT:				\$25.09	_____

BREAK-EVEN YIELD			BREAK-EVEN PRICE	
VARIABLE COSTS	14	BU	VARIABLE COSTS	\$12.18
TOTAL COSTS	19	BU	TOTAL COSTS	\$16.75

PLEASE NOTE: This budget is for planning purposes only.

*Transition cost is three-year period of conversion from conventional production to organic amortized at 5% for 10 years.

**Organic certification costs vary but estimated to be \$11/acre.

NC State University—Soybean Organic Production
Per Acre Machinery and Labor Requirements for 20 Bushels Soybeans

MONTH	OPERATION	TIMES OVER	LABOR HOURS	MACHINE COSTS	VARIABLE COSTS	FIXED COSTS
5	Heavy disk 16'	2.00	0.26	0.24	\$9.04	\$7.68
5	Cultivator 6R30	2.00	0.31	0.28	\$7.40	\$4.44
6	Planter 8R30	1.00	0.10	0.09	\$3.94	\$4.55
6,7	Spring tooth	2.00	0.24	0.22	\$2.38	\$1.62
10	Combine w/ header	1.00	0.33	0.30	\$13.85	\$20.29
10	Truck 1.5 Ton	1.00	0.25	0.23	\$1.44	\$2.00
10	Heavy disk 16'	1.00	0.13	0.12	\$4.52	\$3.84
10	Grain drill 16'	1.00	0.14	0.13	\$3.61	\$3.48
PER ACRE TOTALS FOR SELECTED OPERATIONS			1.76	1.61	46.18	47.90
UNALLOCATED LABOR (HR/AC)			2.50			

INCOME ABOVE VARIABLE COSTS AT DIFFERING YIELDS AND PRICES

YIELD	PRICE (\$/BU)				
(BU)	\$16.20	\$17.10	\$18.00	\$18.90	\$19.80
18	\$48.09	\$64.29	\$80.49	\$96.69	\$112.89
19	\$64.29	\$81.39	\$98.49	\$115.59	\$132.69
20	\$80.49	\$98.49	\$116.49	\$134.49	\$152.49
21	\$96.69	\$115.59	\$134.49	\$153.39	\$172.29
22	\$112.89	\$132.69	\$152.49	\$172.29	\$192.09

Resources on Organic Grain Production

Organic Grain Production

Appropriate Technology Transfer for Rural Areas (ATTRA)—Organic Farming
P.O. Box 3657, Fayetteville, AR 72702. Telephone:
1-800-346-9140
attra.ncat.org/organic.htm

Michalak, P. (ed.) 2002. *Organic Grain: Cropping System and Marketing*. 80 pages.
The Rodale Institute. 611 Siegfriedale Road,
Kutztown, PA 19530-9320.
Telephone: 610-683-1400. Fax: 610-683-8548. Email:
info@rodaleinst.org
www.rodaleinstitute.org

NC Organic Field Crop Production and Marketing
website, Department of Crop Science, NC State
University, Raleigh, NC
www.organicgrains.ncsu.edu

Cover Crops

Bowman, G., C. Shirley, and C. Cramer. 1998.
*Managing Cover Crops Profitably. The Sustainable
Agriculture Network Handbook Series, Book 3*.
Available from Sustainable Agriculture Publications,
Hills Building, Room 10, University of Vermont,
Burlington, VT 05405-0082
[www.sare.org/Learning-Center/Books/
Managing-Cover-Crops-Profitably-3rd-Edition](http://www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition)

Creamer, N.G. and K.R. Baldwin. 1999. *Summer
Cover Crops*. Horticulture Information Leaflets (HIL-
37). NC Cooperative Extension, NC State University.
www.ces.ncsu.edu/depts/hort/hil/hil-37.html

Hoyt, G.D., Waggoner, M.G., and Crozier, C.R. (2004).
Soilfacts: Winter Annual Cover Crops. (AGW-439-
58). NC Cooperative Extension, NC State University.
[www.soil.ncsu.edu/publications/Soilfacts/AGW-
439-58/AGW_439_58.pdf](http://www.soil.ncsu.edu/publications/Soilfacts/AGW-439-58/AGW_439_58.pdf)

Organic Certification Information

National Organic Program. USDA Agricultural
Marketing Service

www.ams.usda.gov/AMSv1.0/nop

Includes: Production and handling regulatory text,
national list of accredited certifiers, and “National
List of Allowed and Prohibited Substances”

ATTRA (See the listing above under “Organic Grain
Production” for contact and website information.)

Future Harvest—Chesapeake Alliance for Sustainable
Agriculture (A network of farmers, professionals,
and landowners)
106 Market Court, Stevensville, MD 21666
Telephone: 410-604-2681
www.futureharvestcasa.org/

Growing Small Farms, Chatham County Center, NC
Cooperative Extension. Promoting awareness, un-
derstanding, and practice of sustainable agriculture.
P.O. Box 279, Pittsboro, NC 27312
Telephone: 919-542-8202
www.ces.ncsu.edu/chatham/ag/SustAg/index.html
Organic Certification Guide
[www.ces.ncsu.edu/chatham/ag/SustAg/orgcert-
guide.html](http://www.ces.ncsu.edu/chatham/ag/SustAg/orgcert-guide.html)

Organic Materials Review Institute (OMRI). OMRI is
a nonprofit organization whose primary mission is to
publish and disseminate generic and specific (brand
name) lists of materials allowed and prohibited for
use in the production, processing, and handling of
organic food and fiber. Brand name lists are available
online.

Box 11558, Eugene, OR 97440.
Telephone: 541-343-7600
www.omri.org

Insect Pest Management

NC Integrated Pest Management Information, NC Cooperative Extension
ipm.ncsu.edu

NC Pest Management Information Program
ipm.ncsu.edu/ncpmip/

Van Duyn, J.W. (2005). *Management of Soybean Insect Pests in North Carolina*. NC Cooperative Extension, NC State University.
www.ces.ncsu.edu/plymouth/pubs/ent/index3.html

Reisig, Dominic. (2011). NCSU Field Crop Entomology. NC Cooperative Extension, NC State University.
www.ces.ncsu.edu/plymouth/ent/Entomology

Nutrient Management

Natural Resource Conservation Service (NRCS), USDA
 P.O. Box 2890, Washington, DC 20013
www.nrcs.usda.gov

NRCS North Carolina office
 4405 Bland Rd., Suite 205, Raleigh, NC 27609
 Telephone: 919-873-2100
www.nc.nrcs.usda.gov

NC Division of Soil and Water Conservation
 1614 Mail Service Center, Raleigh, NC 27699-1614
 Telephone: 919-733-2302
portal.ncdenr.org/web/swc/

Weed Management

Bowman, G. 1997. *Steel in the Field. A Farmer's Guide to Weed Management Tools*. Sustainable Agriculture Network Handbook 2. Beltsville, ME: Sustainable Agriculture Network.
www.sare.org/Learning-Center/Books/Steel-in-the-Field/Text-Version

Martens, M. and Martens, K. 2002. Organic weed control: cultural and mechanical methods. *Acres*, 32(8). www.acresusa.com/toolbox/articles.htm

Marketing

NC Organic Field Crop Production and Marketing, Department of Crop Science, NC State University, Raleigh, NC
www.organicgrains.ncsu.edu/marketing/marketing.htm

ATTRA Organic Marketing Resources
attra.ncat.org/marketing.html

Organic Farming and Marketing, Economic Research Service, USDA
www.ers.usda.gov/Briefing/Organic/

Organic Trade Association, 74 28 Vernon St, Suite 413, Brattleboro VT 05301
 Telephone: 802-275-3800
www.ota.com

USDA Market News
Eastern Cornbelt Organic Pricing Report
www.ams.usda.gov/mnreports/gx_gr120.txt
Upper Midwest Organic Grain and Feedstuffs Report
www.ams.usda.gov/mnreports/nw_gr113.txt

NC Cooperative Extension Publications and websites, NC State University

Bowman, D.T. 1997-2011. *North Carolina Official Variety Trials*. www.ncovt.com/

Heiniger, R. (ed.) (2005). *The North Carolina Corn Production Guide*.
www.ces.ncsu.edu/plymouth/cropsci/cornguide/

Weisz, R. *North Carolina Small Grains Production website*.
www.smallgrains.ncsu.edu/

Other NC Cooperative Extension Online Publications, NC State University

Crozier, C. and D. H. Hardy. (2003). *Soilfacts: Soil Acidity and Liming for Agricultural Soils* (AGW-439-50).

www.soil.ncsu.edu/publications/Soilfacts/AGW-439-50/SoilAcidity_12-3.pdf

Osmond, D.L., C.R. Crozier, and D.H. Hardy. (1997). *Soilfacts: Careful Soil Sampling, the Key to Reliable Soil Test Information* (AG-439-30).

www.soil.ncsu.edu/publications/Soilfacts/AG-439-30/

Hoyt, G.D., M.G. Waggoner, and C.R. Crozier. (2004). *Soilfacts: Winter Annual Cover Crops* (AGW-439-58).

www.soil.ncsu.edu/publications/Soilfacts/AGW-439-58/AGW_439_58.pdf

Weisz, R.(ed.) (2011). *2011 – 2012 Small Grain Production Guide* (AG-580).

www.smallgrains.ncsu.edu/NCSmallGrains/ProductionGuide.html

Zublena, J.P., J.V. Baird, and J.P. Lilly. (1997).

Soilfacts: Nutrient Content of Fertilizer and Organic Materials (AG-439-18).

www.soil.ncsu.edu/publications/Soilfacts/AG-439-18/

Zublena, J.P. (1991). *Soilfacts: Nutrient Removal by Crops in North Carolina* (AG-439-16).

www.soil.ncsu.edu/about/publications.php

Additional facts sheets, including those describing specific manures (such as swine, poultry, and dairy) are available through the Department of Soil Science website.

www.soil.ncsu.edu/about/publications.php

NC Department of Agriculture and Consumer Services, Plant Tissue Analysis

www.ncagr.gov/agronomi/pwshome.htm

NC Cooperative Extension publications can be obtained through local county Extension centers and online.

www.ces.ncsu.edu

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