North Carolina Organic Grain Production Guide

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

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Contents

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 Cooperative Extension 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 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 agent.

Chapter 1. Introduction

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The market for organic products is growing at a rapid pace. In the United States, the organic food industry grew between 17 and 21 percent each year from 1997 to 2003, and an average annual growth rate of 18 percent has been forecast through 2008 according to the Organic Trade Association (www.ota.com). In 2003, the market growth of organic bread and grains was over 20 percent, with growth of organic meat, poultry, and fish near 78 percent. These trends are expected to continue.

To be certified as organic, livestock must be fed organic grains as required by the U.S. Department of Agriculture (USDA) National Organic Plan Rules. This requirement leads to more opportunities for production of organic grains. In North Carolina, organic grain producers have expanding opportunities to market their products to manufacturers that create foods for human consumption as well as to livestock feed markets. Organic grain prices are usually 150 percent higher than prices for conventionally-produced grain. Other benefits of organic grain production include increased soil health, farm income diversification, and lower levels of exposure to common farm chemicals for both people and the environment. Farmers in North Carolina are in a unique position to take advantage of the early growth of organics by growing and selling organically produced grain. If they are to take advantage of the price premium for organic products, however, more research on organic grain and oilseed production in North Carolina is needed. In addition, a network of organic grain farmers should be developed, and marketing information and Extension education should be made available to help growers compete successfully in this rapidly expanding industry.

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, pages 46-48). It 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/Guide/cover.html
- *Corn Production Guide*: http://www.ces.ncsu.edu/plymouth/cropsci/cornguide/

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

This guide does not make recommendations about the use of pesticides in organic systems. No research has been published on the use of pesticides approved for organic production of grain crops in North Carolina, and we cannot make recommendations for their use here. The cost of pesticides approved for organic production may also be prohibitively expensive for field crops. The Organic Materials Review Institute (OMRI) publishes a list of commercially available products that can be used in certified organic operations for pest control (www.OMRI.org). Conditions for use of an approved pesticide must be documented in the organic system plan, as described by the 2000 National Organic Plan (NOP).

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

Chapter 2. Organic Crop Production Systems

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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 fit 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. However, in systems without livestock, the legume cover crop might have little economic value unless it can be cut and sold for hay as an organic forage crop. Cutting for hay will reduce the amount of biomass from residue and may reduce the amount of nitrogen available to subsequent crops.

Wheat – Soybean – Corn. This rotation has many of the same advantages as the above rotation, but the soybean crop can be harvested and marketed. One disadvantage of this rotation is longer soil exposure since soybean is planted after wheat and harvested before corn. Weeds emerging in the soybean crop may be difficult to control, and less nitrogen will be fixed by the soybean crop. However, a cover crop could be incorporated into this rotation to provide ground cover when needed, to expand the rotation beyond two years, or both. A short, two-year rotation will need to be approved by a certification agency.

Farmers who have long-established organic fields usually use a longer rotation of four or five years. A longer crop rotation could rely on one of these sequences:

- Corn – rye cover crop – soybeans – rye or crimson clover cover crop – wheat – cowpea cover crop.
- Corn – wheat – (double cropped) soybeans – crimson clover cover crop – sunflowers or summer cover crop – small grain (oats, barley, triticale).

Legumes or other broadleaf crops should be grown at least two of every five years. A well-developed cropping sequence should result in minimal problems with insects and plant diseases. Weeds are usually the major issue for long-term organic systems, but even weed problems can be managed through suppression by particular cover crops and timely cultivation.

Transitioning to Organic Cropping Systems

A switch to organic production from conventional agriculture requires a 36-month transition period. 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, record-keeping for certification, and marketing of organic crops. Most North Carolina farmers already have rotations that include corn, wheat, and soybeans. Such farms can go organic with little capital investment; however, mechanical weed equipment, separate storage facilities, or both may be needed for organic harvests.

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 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 N.C. State University Web site: www.cropsci.ncsu.edu/organicgrains/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. The key hybrid characteristics for organic corn production are

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

Table 3-1 provides a list of organic and conventional untreated hybrids that have been evaluated and rated for these key characteristics.

Rapid early growth and vigor
Rapid early growth is essential in minimizing the effects of seedling diseases and insects, increasing root volume, and competing with weeds. In general, early growth is closely related to maturity date. Early- to medium-maturing hybrids (102 to 114 days) tend to exhibit better early growth than do late hybrids (longer than 115 days). The best way to select hybrids with rapid early growth for North Carolina is to contact Extension agents, seed company representatives, and other organic growers who have had experience with different corn hybrids.

Standability
Standability is an important measure of how well the crop will stand under difficult environmental conditions. Because pests affect stalk strength, an organic hybrid needs to be able to resist lodging under stress.

Pest and disease resistance
Resistance to common seedling, leaf, and stalk diseases is an important characteristic for hybrids in organic production systems. Some hybrids even tolerate insect pests such as European corn borer and southern cornstalk borer. Growers should select hybrids that combine good early growth characteristics with good resistance to diseases that are likely to be problems in their fields.

Stress tolerance
Stress tolerance is the ability to produce acceptable yield under drought or other environmental stresses. Hybrid seed suppliers often refer to this characteristic as "drought tolerance." This characteristic is important since limited available nitrogen, which is often a problem in the early years of an organic system, can lead to nutrient and drought stress. Hybrids that can tolerate this stress will produce higher yields and compete more successfully with weeds.

Yield
The only reliable indicators of yield potential in organic systems will come from tests conducted using organic practices. Most of the hybrid compari-

Table 3-1. Evaluations of organic and untreated corn hybrids for relative maturity, seed vigor, early growth rating, standability, disease ratings, and stress tolerance.*

Hybrid	Relative Maturity	Seed Vigor	Early Growth	Standability Rating	Southern Corn Leaf Blight	Gray Leaf Spot	Stress Tolerance
Organic Hybrids							
NC+ 69R36	115	8	6	7	6	5	7
NC+ 62N37	111	7	7	6	7	4	8
NC+ 68F32	112	7	6	6	7	4	7
NC+ 60N37	109	8	6	9	5	4	8
Doeblers N509	103	8	9	9	7	5	7
Doeblers N640	111	7	7	8	8	4	8
Untreated Conventional							
Pioneer 34K77	107	7	6	6	7	4	7
Pioneer 34B97	108	6	6	6	6	5	7
Pioneer 3394	110	8	8	6	5	2	7
Pioneer 33G26	112	7	8	7	5	5	7
Pioneer 33M54	114	5	5	6	7	6	7
Pioneer 32R25	114	6	5	4	4	3	8
Syngenta N65-M7	109	5	6	6	4	6	8
Syngenta N79-L3	115	7	7	7	4	4	6
Augusta A-4587	116	5	5	7	6	4	7

* Ratings are based on a scale of 1 to 10. A rating of 10 represents a plant with complete resistance or tolerance to disease or stress.

sons done in organic systems use hybrids best suited to the upper Midwest, and there is only a limited amount of organic-yield test information available in North Carolina. In these circumstances, growers may get the best information from local hybrid comparisons when drought or other types of stress were factors. For instance, official variety tests conducted in North Carolina during 2002 reflect results from drought conditions and might be indicators of hybrid performance in organic systems. Those hybrids with good compensating mechanisms may do well in situations of low nitrogen availability or high pest pressures. Growers should conduct their own hybrid comparisons by selecting four to six promising hybrids and evaluating them under their own management practices. The best procedure is the *strip test,* where each test hybrid is grown adjacent to a standard hybrid (see Figure 3-1). This pattern permits the yield data to be adjusted for soil variability. If a standard is not used, test hybrids can be alternated with the hybrid that has the best past performance. Growers conducting their own hybrid evaluations should remember to select uniform test fields to minimize soil variability and to restrict comparisons to hybrids of the same maturity class.

Figure 3-1. Sample planting pattern for a strip test.

New Hybrid 1	Standard Hybrid	New Hybrid 2	Standard Hybrid	New Hybrid 3	Standard Hybrid	New Hybrid 4	Standard Hybrid

Planting Date

Planting date is a crucial factor in the success of an organic production system. Planting too early results in slow growth and increases the amount of 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 from a decrease in intercepted sunlight due to decreasing hours of daylight. The recommendations here attempt to balance these considerations. In the **tidewater** and **coastal plain**, plant organic corn between April 15 and May 15. In the **piedmont**, plant organic corn between April 20 and May 20. In all locations, plant following at least two days when average temperatures are above 65ºF. 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. The seed should be placed exactly 1 inch deep, and the soil compressed to provide maximum seed-soil contact for rapid germination and growth. Seeding depth is a very important factor 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.

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 populations 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 row widths wide enough to permit the use of a tractor-mounted cultivator. Where weeds are not a major problem, use row spacing of 20 to 24 inches. Where weed control will require multiple passes of a cultivator, use row spacing of 30 to 36 inches.

Soil Fertility

Corn generally requires from 120 to 160 pounds of nitrogen per acre, 30 to 50 pounds of phosphorus per acre, 80 to 100 pounds 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, the Cooperative Extension Service, or the Soil and Water Conservation District can provide guidelines for a nutrient management plan. Chapter 6 in this manual also has more information on organic soil management.

Weed Management

Grassy weeds and warm-season broadleaf weeds, such as cocklebur and morningglory, will be among the most difficult to control. While 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 prior to planting so that 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 ability of the corn canopy 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 in this manual 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 at high levels, do not plant organic corn if suitable, effective, and economical pest management options are not available.

Crop rotation

Crop rotation is the most powerful tool 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. 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.

Control of insects with 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 beetle, 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. In organic corn production, no-till should be avoided or used with caution, especially in areas where southern corn billbug, wireworms, and cutworms are common.

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 levels 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. Some hybrids have European-corn-borer-resistance traits that will reduce susceptibility to this important pest.

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 disc 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 cornstalk borer

Borers occur in all North Carolina corn fields. 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 white potato and wheat fields), early planting, use of short-season corn hybrids, and selection of hybrids with ECB tolerance. 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 office or the following Web site: http://www.ces.ncsu.edu/plymouth/pubs/ent/index1.html.

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

Three key diseases—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. 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 Web site: http://www.btny.purdue.edu/Extension/Pathology/CropDiseases/Corn/.

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.

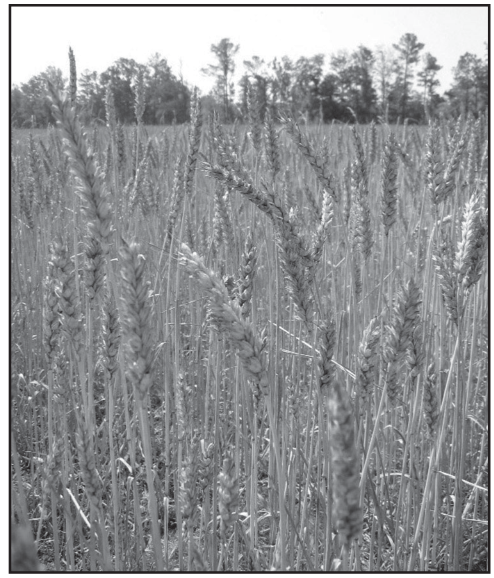
Charcoal rot

Charcoal rot (caused by the fungus *Macro-phomina 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 since 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.

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:

- Choose varieties with resistance to disease and insect pests.
- Plant on time (not too early, not too late) in a well-prepared seedbed.
- Implement crop rotation.
- Use correct drill calibration and operation.
- Avoid excessively high nitrogen levels (but work towards good soil fertility).
- Destroy crop residues with tillage, if possible.

Variety Selection

As a general rule, only small grain varieties that have been successfully grown in the North Carolina Small Grain Official Variety Test for two years should be considered for production. Official Variety Test reports are available online at http://www.smallgrains.ncsu.edu or from your county Extension center. It is nearly impossible to pick a single best variety. Consequently, producers should plant two or more varieties every season in order 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 *Official Variety Test Report* for a list of varieties tested for at least two years.
- To avoid spring freeze injury, eliminate early-heading varieties in favor of medium- and late-heading varieties.
- If powdery mildew is common in your area, select varieties that are rated as “good” for powdery mildew resistance.
- If you are a producer in the tidewater area, select varieties that have “good” or “fair” resistance to leaf rust.
- If possible, avoid varieties that are rated “poor” for Hessian fly biotype-L.
- 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 barley yellow dwarf virus. 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 the most recent edition of the *Small Grain Production Guide* or go online to http://www.smallgrains.ncsu.edu/Guide/Chapter7.html.

Rotation and Field Selection

Planting wheat into old wheat stubble is always a bad idea. Several major small grain diseases and Hessian fly are vectored on old wheat stubble. Short rotations put small grains at high risk to numerous soilborne diseases and should be avoided in organic production. Additionally, as described in more detail below, 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 to avoid planting near an early-planted wheat cover crop. Fields with a history of Italian ryegrass, wild garlic, wheat spindle streak, or wheat soilborne mosaic virus should be avoided.

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. A complete guide to seeding rate, drill calibration, planting depth, and other planting considerations can be found in the most recent edition of the *Small Grain Production Guide* or go online to http://www.smallgrains.ncsu.edu/Guide/Chapter6.html.

Soil Fertility

Wheat that yields 40 bushels per acre uses about 50 pounds of nitrogen per acre, 25 pounds of phosphate per acre, and 15 pounds of potash per acre. 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. See Chapter 6 of this guide for more information on soil fertility in organic production. In early spring, it is possible to test a wheat crop and determine how much additional nitrogen it needs to produce optimal yield. Organic growers may want to use tissue testing to determine whether the crop needs additional spring top-dress nitrogen.

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 if needed. 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. 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 for more information on weed management in organic production systems.

Insect Pest Management

Wheat fields are susceptible to many kinds of insects. Only a few species may become pests, and even when they do, they usually do not reach damaging above-threshold numbers. However, in some seasons or under certain circumstances, insect pests of wheat can be very damaging. The following insects may become abundant enough to cause significant injury to wheat crops in North Carolina: aphids (several species), cereal leaf beetle, Hessian fly, and armyworm (sometimes called true armyworm). Other plant-feeding insects, such as grasshoppers, chinch bugs, or fall armyworms, may occasionally damage wheat. Descriptions of all these insects may be found in the most recent edition of the *Small Grains Production Guide*, at county Extension centers, or at the following Web sites:
http://www.ces.ncsu.edu/plymouth/pubs/ent/index4.html
http://www.smallgrains.ncsu.edu/Insects/Insects.html

Wheat-feeding aphids

Three primary species of aphids occur in North Carolina wheat: the English grain aphid, the bird-oat cherry aphid, and the corn leaf aphid. Aphid feeding potentially reduces yield, but usually not dramatically. Aphids are also vectors of barley yellow dwarf virus (BYDV), and this disease can be a serious concern. A complex of biological control agents accompanies aphids, including parasites, predators, and pathogens (mainly fungi). These biological control agents ordinarily exert a powerful controlling influence on aphid populations, especially in the spring, although it usually requires some time before the aphid populations "crash" due to the combined influence of these agents.

Several cultural practices can help reduce the chance of aphid damage and BYDV infection in organic production:

Avoid early planting. Cool weather will slow aphid feeding and activity in the newly emerged crop. Planting after the end of warm weather not only reduces the chance of crop damage due to aphid feeding, but also makes it less likely that aphid-transmitted BYDV infections will occur. The aphid population may build up again in the spring, but these populations are less damaging because plants are larger, growing more rapidly, and are more tolerant to feeding and BYDV infection.

Avoid excessively high soil nitrogen levels. Aphids reproduce most rapidly on plants with high-nitrogen content. Maintaining nitrogen levels within the prescribed agronomic level (found in the most recent edition of the *Small Grain Production Guide*) helps to avoid high aphid populations.

Select wheat varieties with BYDV resistance. If BYDV is a regular problem on your farm or on neighboring farms, a highly effective strategy is to select wheat varieties that are resistant to this disease. A list of wheat varieties and their resistance to BYDV can be found at this Web site:

http://www.smallgrains.ncsu.edu/Varieties/Varieties.html

Armyworm

Armyworm moths are one of a few moths active in late winter and early spring. Armyworm caterpillars may cause serious defoliation and substantial head drop. They are most prevalent in the northeastern counties of North Carolina.

Management options. 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) in emergency situations. Accepting the feeding of armyworm is not likely to result in large yield losses unless plants were defoliated early (before or during the heading period). For scouting information on armyworm, check the most recent edition of the *Small Grain Production Guide* or go online to http://www.smallgrains.ncsu.edu/Guide/Chapter11.html.

Cereal leaf beetle

The cereal leaf beetle (CLB) has one generation each year, and both the adult and larval stages eat leaf tissue on wheat and oats. They do not feed on barley, triticale, or rye. Leaf feeding by larvae during April and May can reduce yields.

Cereal leaf beetle is an introduced pest, and few native biological control agents affect adult beetles, eggs, or larvae. A few generalist predators, such as lady beetles, appear to consume cereal leaf beetle eggs and, perhaps, young larvae in early spring. The North Carolina Department of Agriculture has released several species of exotic parasites throughout the state. These parasites develop within cereal leaf beetle eggs or larvae and have the potential to keep populations below an economic level. Parasite release programs have worked well in several other states, but so far have had limited success in North Carolina.

Cultural practices. Cereal leaf beetles prefer to attack a thin field full of little plants rather than a thick, lush field full of large, healthy wheat. To minimize the chances of beetle invasion, the organic producer needs to do everything possible to assure a thick, well tillered, healthy crop. This means good seed bed preparation, planting on time, using high quality seed, correct drill calibration, and getting good soil-seed contact at the proper seeding depth. These steps will also increase the crop's tolerance to CLB feeding.

Insecticides. Insecticides approved for organic production (such as a spinosad) and labeled for cereal leaf beetle may be applied in emergency situations. For scouting information for cereal leaf beetle, check the most recent edition of the *Small Grain Production Guide* or go online: http://www.smallgrains.ncsu.edu/Guide/Chapter11.html. In addition, a special publication on this pest can be found at http://www.ext.vt.edu/pubs/entomology/444-350/444-350.html.

Hessian fly

In recent years, Hessian fly infestations have caused extensive losses in many North Carolina fields. Organic farmers should use several methods to minimize Hessian fly problems.

Rotation. 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, since 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.

Tillage. 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.

Careful use of cover crops. 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.

Plant on time. Do not delay planting until after the first freeze (often called the fly-free date) because an early freeze in North Carolina is not a dependable event. Often a "killing freeze" does not occur until December in many areas of North Carolina, which is later than most growers need to have wheat planted for agronomic purposes. Organic producers throughout North Carolina should also avoid planting before the recommended planting dates.

Resistant varieties. Many wheat varieties are advertised as having Hessian fly resistance. To be effective in North Carolina, however, wheat varieties must be specifically resistant to Hessian fly biotype-L. A list of wheat varieties with biotype-L resistance can be found on the Internet at http://www.smallgrains.ncsu.edu/ or through county Extension offices. For more information on Hessian Fly, see *The Hessian Fly: A Pest of Wheat in North Carolina* (AG-368), which is available online: http://www.ces.ncsu.edu/depts/ent/notes/Grain/Hessian/HflyAG-368.html.

Disease Management

Disease identification

The first step in solving disease problems is to identify the disease. Excellent small grain disease information and assistance with disease identification can be found in the latest edition of the *Small Grains Production Guide* or on the Web at http://www.smallgrains.ncsu.edu/Diseases/Diseases.html. Varieties are rated for disease resistance at http://www.smallgrains.ncsu.edu/Varieties/Varieties.html.

Barley yellow dwarf virus

Barley yellow dwarf virus (BYDV) is the most important viral disease of wheat, oats, barley, and rye in this state. The virus is transmitted by aphids that spent the summer on nearby corn crops or host grasses. The best control measure in organic production is to plant varieties that are resistant to this disease.

Powdery mildew

One of the most yield-limiting factors in North Carolina wheat production is powdery mildew. This is especially true in the coastal plain, the southern piedmont, and some 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.

Select resistant varieties. The best protection against powdery mildew is to select wheat varieties that are resistant to it. Organic producers who want high-yielding wheat must plant powdery-mildew-resistant varieties. Wheat varieties grown in North Carolina are evaluated for disease resistance every year, and new disease-resistance ratings are published in the *Small Grains Official Variety Test Results* and posted on the Internet every July in time for growers to order the best varieties for the next year's production. Organic producers should check the Web site http://www.smallgrains.ncsu.edu/Varieties/Varieties.html every year (or contact the county Extension agent for the information) and use the list of the most resistant varieties as a starting point for ordering seed.

Adjust planting date. 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, especially those in the coastal plain, southern piedmont, and tidewater region, should also avoid planting before the recommended planting dates.

Leaf rust

Leaf rust is a foliar disease that attacks wheat late in the growing season. While leaf rust can occur anywhere in North Carolina, it is most likely to be a problem in the 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 tidewater, should try to select varieties that have a combination of powdery mildew and leaf rust resistance. 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 seed appears 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. Therefore, 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.

Septoria leaf and glume blotch

Septoria leaf and glume blotch may occur at any time during the growth of the plant and on any portion of the plant. Rotation away from small grains for at least three years can lessen the severity of septoria. Plowing under wheat stubble will prevent infection from the previous wheat crop. Potash, copper, and magnesium should be kept at recommended levels. In some cases, septoria can be seedborne, so certified seed can reduce introduction of the disease. Organic farmers should never save seed for planting if the wheat was infected with septoria.

Scab or head blight

Scab, a fungus that is seen as prematurely bleached heads or spikelets, can occur in all small grains. Of the small grains, wheat and barley are the most susceptible to this disease, and rye and triticale are the most resistant. Scab occurs and is spread to small grains in the spring. It also results in toxins (vomitoxin is most common) in the harvested grain.

The first line of defense against scab is to plant wheat varieties with resistance to the fungus. A complete list of wheat varieties and their resistance to head scab can be found at http://www.smallgrains.ncsu.edu or at county Extension centers. Wheat producers with a history of scab should seriously consider selecting varieties based on this information. Tillage practices that bury wheat or corn residues and rotations of at least three years are effective means of controlling scab in organic production. Planting several wheat varieties with different heading dates will stagger head emergence and flowering through the spring and reduce the chance that environmental conditions will be suitable to scab in all wheat fields.

If scab is present, the combine may be adjusted so that the lightweight diseased grain is removed along with the chaff. This will not remove all the infected grain, but can help reduce mycotoxin levels in the grain going to market. Organic producers should never use farmer-saved seed if head scab was present in the crop that produced the seed.

Other small grain diseases

Several other diseases can be problems for small grain in North Carolina. Growers in need of more detailed information should check online at http://www.smallgrains.ncsu.edu or with their county Extension agent.

Avoiding Spring Freeze Injury

Late spring freeze damage is a major factor in reducing yields of North Carolina wheat. "Heading date" is an important indication of how susceptible a variety will be to late spring freeze damage. Early-heading varieties are the most susceptible to freeze damage. Medium- and late-heading varieties are more likely to avoid spring freeze damage, and they generally produce higher yields than early- or medium-early heading varieties. Heading date also indicates the best planting date for a wheat variety. Medium- and late-heading wheat varieties tend to do best when planted at the start of the planting season, and should be the first varieties planted. Early and medium-early varieties tend to produce the highest yields when planted later in the fall. Wheat variety heading date information can be found online: http://www.smallgrains.ncsu.edu/Varieties/Varieties.html.

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.
- Plant in narrow rows.

Variety Selection

Choosing a soybean variety also means choosing a Maturity Group. In organic production, an earlier-maturing (Maturity Group V for most of North Carolina) or mid-season variety (Maturity Group VI) is preferred over late-maturing varieties (Group VII or later). Early-maturing beans can avoid hurricane winds and moisture and associated disease problems and yield losses. Because of soil type and more frequent rains, the blacklands of North Carolina can use an earlier-maturing bean (Group V or earlier) without yield loss. However, farther west and on sandier soils, a later-maturing variety (Group VI or later) may be needed to get adequate yields. In the coastal plain, a Group VI or late V (or an earlier planting) will help avoid corn earworm (CEW) infestation during flowering. CEW is seldom a problem in the 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 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. Table 5-1 lists top-yielding non-GMO, feed-grade varieties in North Carolina through 2004, as noted by J. Dunphy in *North Carolina Soybean Variety Information* (2005, Extension publication CS-SB-15).

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 mid-season variety can help the crop avoid insect and disease problems.

Row Spacing

Soybeans in row widths of 20-inches or less tend to have higher yields than soybeans in wider row widths. Narrow-row soybeans also lap the row middles sooner, making further weed control measures during the season unnecessary.

Plant Population

Weeds are the main pest that organic soybean producers are going to face, and a thick plant population

Table 5-1. Nontransgenic soybean varieties, relative yield over all locations, number of locations and years in variety trial.

Variety	Percent +/- Average*	No. of sites	First year	Last year
Maturity Group IV				
DP 4748 S	-13.0	2	2000	2000
Maturity Group V				
5002T	-2.9	6	2003	2004
5601T	-3.1	13	2001	2004
95B33	-5.1	14	2000	2001
AP 572STS	-8.9	8	2000	2000
Bolivar	-2.3	4	2004	2004
DP 5110 S	-6.3	22	2000	2004
DP 5989	-4.0	22	2000	2002
Fowler	-3.5	28	2000	2004
Freedom	-16.2	4	2004	2004
HBK C5894	-3.1	4	2004	2004
Hutcheson	-4.3	35	2000	2004
Ozark	-11.8	4	2004	2004
SS 5200-STS	-17.0	16	2001	2003
SS 597	2.4	15	2000	2001
Teejay	8.4	4	2004	2004
USG 550nSTS	-14.0	13	2002	2004
Maturity Group VI				
665	6.4	25	2000	2003
Boggs	-13.0	8	2004	2004
Dillon	2.5	29	2000	2004
HBK 6600	-8.0	8	2000	2000
NC-Roy	9.7	29	2000	2004
Satelite	-9.7	22	2000	2002
Soyola	-0.1	25	2000	2003
Maturity Groups VII and VIII				
Cook	3.8	15	2000	2004
N7001	0.6	18	2000	2004
N7102	-21.5	4	2002	2002
N7103	-8.7	8	2000	2002
NC-Raleigh	12.1	18	2000	2004

* Percent above (+) or below (-) average yield of all varieties of the same maturity group at the same locations in NC Official Variety Tests (OVT) in 2000 through 2004.

will compete with weeds more effectively. Thicker populations have denser, earlier-closing canopies that out-compete weeds and do not allow enough light to penetrate for weed seed germination. However, a thick plant stand also traps moisture in the canopy, which creates a good environment for disease. A good compromise is needed, but a closed canopy is preferred. Although it increases the risk of disease, it is also the best way to maximize yields. An ideal stand would have plants that are about 3 feet tall with row middles lapped by the time of flowering. Plant population in the field can vary widely and still achieve good yields. On 36-inch rows with a May planting date, an ideal plant population would be 6 to 8 plants per foot (about 100,000 plants per acre). In 20-inch rows, the recommended plant population is still 100,000 plants per acre, but the plant population per foot will be lower. If planting on 7-inch rows, 2 plants per foot (150,000 plants per acre) can achieve good yields. Seeding rate will depend on the planter calibration, 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 pounds of nitrogen per acre, 41 pounds of phosphate per acre, and 74 pounds 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. Inoculums must not be genetically engineered. See Chapter 6 of this guide for more information about organic soil management.

Weed Management

Organic weed management is more challenging in soybeans than in corn since the soybean foliage does not generally overlap and shade the row middles until later in the season. Generally, narrow rows 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. See Chapter 7 of this guide for more information on managing weeds in organic production.

Insect Pest Management

Differences caused by variety selection, planting date, cultural techniques, site, and season 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:

Rotation
Rotation helps reduce levels of pests like soybean colaspis and cyst nematode and often improves crop health. Avoiding pests through rotation of at least two years allows soybeans to tolerate the feeding of pests that later move into the field.

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 Groups III, IV, or V). These plantings will bloom and harden-off before the corn earworm moth flight from corn fields, and the plants will be unattractive to the moths. Also, early maturity can greatly reduce soybean looper, velvetbean caterpillar, and late stink bug infestations. In rare situations, stink bugs can be trap-cropped by early-maturity fields, leading to greater damage.

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 control
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 to above threshold levels. 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 Web site: http://www.ces.ncsu.edu/plymouth/pubs/ent/index3.html.

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 Web site 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 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 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 their Web site: 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 North Carolina 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 and/or plant early to get the plants out of the fields in time to avoid the rust inoculum. Do not, however, create such an early-maturing soybean crop that yields are reduced substantially.

For more information on soybean rust, go to one of these Web sites:

- 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

In an organic farming system, rotation and tillage practices must provide an appropriate seedbed and pest control while minimizing erosion. Soil fertility must be sustainable without application of prohibited substances. Soil management practices must be developed in consultation with the certifying agent who judges compliance with organic standards, 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, 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. 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.

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, past erosion, and residual nutrient contents. Periodic soil testing is the only way to understand the current fertility level and maintain the fertility status of each field. Plant tissue analysis can also be used to verify soil fertility status, 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.com/agronomi/ptaflyer.htm or contact your county Extension center).

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 that can provide needed nitrogen and other nutrients. 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 farming systems, if applied according to guidelines. These include mostly natural and a few synthetic materials. The National List of Allowed and Prohibited Substances under the National Organic Program is available online: http://www.ams.usda.gov/nop/NationalList/FinalRule.html. This list specifies synthetic substances allowed for use and nonsynthetic substances prohibited for use in crop production. The Organic Materials Review Institute (OMRI) was developed to review materials for approval in order to simplify the National List. OMRI classifies materials as either allowed (A) or regulated (R), and lists generic and brand names of materials. OMRI can be accessed via the Web at www.omri.org; or by mail or phone at Box 11558,

Table 6-1. Nutrient removal (in pounds) by different crops. Missing values indicate no data available.

Nutrient	Corn grain	Soybean	Fescue	Ryegrass	Sorghum-Sudan	Irish Potato	Tobacco (flue-cured)
N	112	188	135	215	319	90	85
P_2O_5	53	41	65	85	122	48	15
K_2O	40	74	185	240	467	158	155
S	10	23	20	-	-	7	12
Ca	2	10	-	-	-	5	75
Mg	8	10	13	40	47	7	15
B	0.03	-	-	-	-	-	-
Cu	0.06	0.05	-	-	-	-	0.03
Zn	0.15	0.05	-	-	-	0.08	0.07
Yield	150 bu	50 bu	3.5 tons	5 tons	8 tons	15 tons	3,000 lbs

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. Use of any specific source should be approved by the certifying authority prior to submitting an application for organic certification.

Source	Units	N [a]	P_2O_5	K_2O	S	Ca	Mg	B	Cu	Mn	Zn
Swine lagoon liquid	lb/acre in/acre	109[b] 68[c]	37.1[c]	93.1[c]	10	26	8.3	0.18	0.3	0.34	1.5
Broiler, fresh manure	lb/ton	15.6	17	11	2	10	4	-	-	-	-
Broiler, stockpiled litter	lb/ton	21.6	80	34	12	54	8	0.04	0.27	0.59	0.55
Turkey, fresh manure	lb/ton	16.2	25	12	-	27	2	-	-	-	-
Turkey, stockpiled litter	lb/ton	21.6	72	33	9.5	42	6.8	0.05	0.34	0.62	0.56
Blood, dried	lb/ton	240 to 300 (total N)	60	-	-	6	-	-	-	-	
Bone meal, raw	lb/ton	70 (total N)	440	-	4	440	12	-	-	-	-
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] Plant-available N unless otherwise stated.
[b] Plant-available N values shown represent estimate for material incorporated into the soil unless specified otherwise.
[c] Sprinkle-irrigated and not incorporated.

Eugene, OR 97440, (541) 343-7600. 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 submitting an application for certification as an organic farm.

Critical aspects of soil fertility management include pH, major nutrients (nitrogen, phosphorus, potassium), secondary nutrients (sulfur, calcium, magnesium), and micronutrients (especially boron, copper, manganese, and zinc; but also iron, molybdenum, chlorine, selenium, and cobalt). A summary of soil fertility

Table 6-3. Soil fertility management options.

		Effect on Plants	Problem Documentation	Supply Options[1]	Not Allowed
pH		Nutrient solubility, root development, microbial activity	Soil test	Lime (standard, ground calcitic or dolomitic carbonate source)	Hydrated or burnt lime [$Ca(OH)_2$, CaO]
Major Nutrients	Nitrogen (N)	Component of proteins, chlorophyll	Tissue analysis	N fixation by legumes, manures[3], animal by-products (blood, fish), plant by-products such as cotton (restricted due to pesticide use) or 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), greensand, sulfate of potash (K_2SO_4)[4], possibly muriate of potash (KCl)[3,4]	KCl if excess chloride
Secondary Nutrients	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_2SO_4)[4]	Synthetic fertilizers
	Calcium (Ca)	Cell wall & membrane stabilization, cell growth, osmoregulation	Soil test, tissue analysis	Lime (mined carbonates), 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	Dolomitic lime, Epsom salts ($MgSO_4$)[4], sulfate of potash magnesium, bone meal, plant by-products (cottonseed meal, wood ash)	Synthetic fertilizers
Micronutrients[2]	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 & activation, protein synthesis	Soil test, tissue analysis	Manures, animal and plant by-products, sulfates & oxides[4]	Chlorides
	Cobalt (Co), Iron (Fe), Molybdenum (Mo), Selenium (Se)		Tissue analysis[5]	Manures, animal and plant by-products, sulfates, carbonates, oxides, or silicates[4]	Chlorides, nitrates

[1] Inputs are limited to materials approved on the National Organic Program List or on the OMRI-approved source list after consultation with the certifying agent regarding need to document deficiency and application records.
[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 NCDA&CS. Consult a Cooperative Extension office for information regarding private agricultural laboratories.

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. The low pH levels common in native Carolina soils continue to be the most common limiting factor for plant development seen in samples submitted to the NCDA&CS Agronomic Division Laboratory. Since most agricultural lime is from naturally-occurring minerals of relatively low solubility, its use is generally allowed in organic farming systems. Hydrated limes and burnt limes are not allowed. Pelletizing agents should be evaluated to determine that they are not prohibited materials.

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-and-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 ensure no other factors limit legume growth. Inoculums, however, must not be genetically engineered. Nitrogen-fixing cover crops for summer in North Carolina include cowpeas and soybeans. Winter N-fixing cover crops include hairy vetch, Cahaba vetch, Austrian winter peas, and many clovers. 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 ($NaNO_3$, bulldog soda, or Chilean nitrate) may be used, 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.

Other nutrients. Phosphorus, potassium, calcium, magnesium, sulfur, copper, manganese, and zinc can generally be supplied in adequate amounts through additions of lime (calcium, magnesium), animal or plant by-products or wastes (phosphorus, potassium, sulfur, 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 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 before using any input.

Tillage Practices

Management of soil tilth, organic matter, and fertility is an important aspect of a successful organic farming system. Current organic systems usually require tillage prior to planting and cultivation after planting, especially for corn and soybean production, to control weeds and reduce the incidence of seedling diseases and insect pests. However, tillage destroys the organic matter that is critical in improving soil fertility and soil water-holding capacity. The use of rotations with cover crops where the soil surface is covered with a growing crop for most of the year is important in maintaining organic matter content during periods when corn is not grown. Tillage should be performed when soil moisture is low enough to prevent compaction. Since primary tillage operations are usually performed at least a month before a crop is planted, this requires careful planning and the ability to take advantage of periods of dry weather. No-till agriculture in organic systems is starting to be used in parts of the country. The Rodale Institute has experimented with no-till organic using cover crops and tractor-mounted rollers to kill the cover just before planting into it.

Documenting Crop Nutrient Deficiencies and Soil Quality Maintenance

Since use of some soil amendments is limited to cases of nutrient deficiency, organic producers should maintain records of soil test results and plant tissue analysis to document specific nutrient deficiencies that need correction. Soil test records can also be useful in documenting soil quality maintenance because they will show changes in humic matter and nutrient levels over time. It is important to avoid topsoil erosion from excessive cultivation for weed control (declines in humic matter indicate erosion losses) and to avoid accumulation of excess phosphorus and micronutrients following application of manures and composts.

Composts and Manures

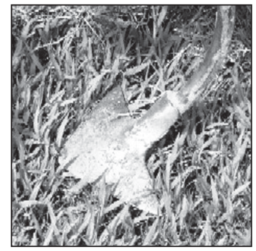
Specific guidelines must be followed when applying composts and manures in organic farming systems. Materials must be applied at agronomic rates in compliance with any applicable nutrient management guidelines and in ways that avoid excess nutrients (see http://www.soil.ncsu.edu/nmp/ncnmwg/ or contact your local Soil and Water Conservation District office). Raw animal manures must be

- composted according to specific criteria,
- applied to land used for a crop not intended for human consumption,
- incorporated into the soil at least 90 days prior to the harvest of an edible (human-consumed) product not contacting soil or soil particles, or
- 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 131º and 170ºF must be achieved. This temperature must be maintained for at least 3 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, since this could lead to accumulation of excess phosphorus, copper, and zinc in soils. For example, based on the general nutrient contents 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 pounds per acre, while crop removal would only be 53 pounds per acre. Similarly, 2.8 pounds per acre of zinc would be added, while crop removal would only be 0.15 pounds per 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 plant nutrients in appropriate amounts.

NC State University *Soilfacts* bulletins describe specific types of manures (such as swine, poultry, and dairy) at http://www.soil.ncsu.edu/about/publications/index.php). Since nutrient composition of animal manures and composts can vary widely, it is wise to submit a sample to the Plant and Waste Analysis Laboratory of the NCDA&CS Agronomic Division before use. Sewage sludge and composted municipal wastes are not allowed on organic fields.



Chapter 7. Weed Management

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Top. Row cultivator shovel.
Below. Flex-tine weeder.

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). Because some weeds are triggered to germinate by tillage, rotations of tilled and no-till crops (such as a forage or hay crop) may also be of benefit.

Cultivar and cover crop selection

Competitive differences exist among crop cultivars. Tall cultivars and cultivars with rapid establishment and quick canopy closure are reportedly 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 produced 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. Allelopathic characteristics of cultivars are being investigated in the small grains breeding programs at several universities.

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 a slightly increased plant population (up to 10 percent higher than usual) will also help the crop compete with weeds.

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. However, soil fertility that promotes early and sustained crop growth 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. However, some physical tactics are almost always needed to provide additional weed control. The methods discribed 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. Since 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. The first blind cultivation pass is usually performed immediately before the crop emerges, and a second pass is performed about a week later. This depends, of course, on weather, soil and crop conditions, and weed pressure. 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, tine weeders, 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 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.

Other methods of mechanical weed control may be effective and efficient depending on the available equipment, budget, and goals of the farm.

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 only be performed 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. While these products have potential for controlling weeds in organic farming systems, no research has been conducted with them in grain crops in North Carolina. Therefore, we cannot give recommendations for their use in this state. The cost of herbicides approved for organic farming may also be prohibitively expensive for field crops. The Organic Materials Review Institute (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 National Organic Plan.

No-till Organic Weed Control

Recent research on no-till organic agriculture shows some potential for organic systems to be much less reliant upon mechanical weed control. The basic premise for no-till organic weed control is to plant a cover crop with high residue, mow or roll that cover crop, and no-till plant into the residue. This system, however, takes a lot of planning to work well. For more information on organic no-till farming, contact the Rodale Institute by mail at 611 Siegfriedale Road, Kutztown, PA 19530-9320, by telephone at 610-683-1400, or on the Web: http://www.rodaleinstitute.org.

Weed Guides

Several weed identification guides are available for purchase through various publishers. NC State University offers *Identifying Seedling and Mature Weeds,* an excellent and inexpensive resource developed for the southeastern United States. It does not, however, include some weed species that are troublesome in North Carolina grain crop production. Another recommended guide is *Weeds of the Northeast*. A few guides are also available on the Web:

- http://www.ppws.vt.edu/weedindex.htm
- http://web.aces.uiuc.edu/weedid/
- http://www.weeds.iastate.edu/weednews/ncseed.htm

Ordering information

Identifying Seedling and Mature Weeds (AG-208). Stuckey, Monaco and Worsham. (1989). Communication Services, Box 7603, NC State University, Raleigh, NC 27695-7603. Telephone: 919-513-3045. $10.

Weeds of the Northeast. Uva, Neal and DiTomaso (1997). Cornell University Press, P. O. Box 6525, Ithaca, NY 14851-6525. Telephone: 607-277-2211

Chapter 8. Organic Certification

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In order to sell, label, or represent their products as "organic," growers who sell $5,000 (or more) a year of organic products must be certified by a USDA-accredited certifying agent. The National Organic Program Final Rule (NOPFR) spells out requirements for organic crop and livestock production, handling, certification, and record-keeping. The NOPFR, and other related documents, can be viewed on the Web at www.ams.usda.gov/nop/. (See Table 8.1.)

Who Must Be Certified?

If an operation earns $5,000 (or more) in a year from organic agricultural products, that operation must be certified. Operations selling less than $5,000 a year in organic agricultural products and direct marketing the products to the end-user are exempt from certification, but they must operate in compliance with the federal regulations and may not label products as certified organic.

Organic Certification Process

Because all certifiers must follow USDA requirements, the organic certification process is similar across certifiers. First, farms must comply with the federal standards for organic production (Table 8-1). The next steps involve choosing a certifier and completing an Organic Farm (or System) Plan. The Organic Farm Plan is also considered the application for certification. The certifying agent may ask questions to assess the applicant's eligibility. The Organic Farm Plan Questionnaire must be completed, including farm maps and a three-year field history for crops planted and inputs applied. The completed Organic Farm Plan (the application), licensing agreement, and fees should then be submitted to the certification agency.

The certifying agent then 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. The certifying agent also verifies information regarding any previous certifications, notification of noncompliance, or denials of certification.

The next step of the process is an on-site inspection of the farm. 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. Inspectors need to verify information from the Organic Farm Plan. They inspect fields, farm buildings and equipment, assess contamination risks, fill out an on-site inspection report, and gather as much information as needed to determine if the operation is in compliance. Inspectors evaluate crop health and growth, soil tilth, the fertility management program, pest and weed management strategies, and the applicant's understanding and commitment to compliance. They also review records to ensure monitoring and compliance. The inspector may be authorized to take soil, tissue, or product samples for analysis. The inspector reviews identified noncompliance issues at the time of the inspection. The inspector conducts an exit interview to confirm the accuracy and completeness of the observations and information gathered, addresses the need for additional information, and discusses issues of concern. The inspector also 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. The inspection report and all associated paperwork are sent to the certifying agent.

Table 8-1. Organic certification federal standards

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

- three years (36 months prior to harvest) with no application of prohibited materials (no synthetic fertilizers, pesticides, or GMOs) prior to certification;
- distinct, defined boundaries for the 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;
- use of organic seeds, when commercially available (no use of seeds treated with prohibited synthetic materials such as fungicides); and
- use of organic seedlings for annual crops (see text discussion).

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 (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);
- sewage sludge or irradiation;
- raw manure and compost (see text discussion);
- any other prohibited substances on the National List; and
- field burning to dispose of crop residues (may only burn to suppress disease or stimulate seed germination – flame weeding is allowed).

In addition, organic operations 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); and
- maintain records.

A certification committee, staff member, or review committee reviews 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. If the certifying agent determines any minor noncompliances, the applicant has the opportunity to correct these noncompliances as a condition of certification.

To continue 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 minor noncompliances 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 to receive an updated certificate for the organic operation.

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. The applicant may re-apply for certification or request mediation with the certifying agent. The applicant may file an appeal of the denial of certification to the USDA National Organic Program Administrator. If the certifying agent has reason to believe that the applicant has made false statements or otherwise misrepresented compliance, the certifying agent may also deny certification simultaneously with issuance of notification of noncompliance.

Record-keeping Requirements for Certified Operations

Record-keeping is very important to organic certification. A certified operation must maintain records concerning the production, harvest, and handling of agricultural products that are intended to be sold, labeled, or represented as organic. The records must be adapted to the particular business that the certified operation is conducting. For example, an organic grain production farm must keep records pertaining to the particular operations that deal with the production, handling, and marketing of the organic grain crops, such as storage, clean-out, and transportation records. The records must also fully disclose all activities and transactions of the certified operation in sufficient detail as to be readily understood and audited. Records must be maintained for at least five years beyond their creation and be sufficient to demonstrate compliance with the National Organic Plan rules and regulations. 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.

Certification Agencies

A list of all USDA-accredited organic certifying agencies can be found on the Web at www.ams.usda.gov/nop/CertifyingAgents/Accredited.html or by request through the National Organic Plan (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 or recognizes. The location of inspectors that the certifier uses should also be considered, as most certifiers require the applicant to pay all expenses associated with the on-site inspection, including travel. Since the USDA requires that certifiers fully disclose all fees, an applicant can compare certifiers based on expense or fees. Also consider the turn-around time required by certifiers to obtain certification, and the experience the certifier has in certifying a particular type of operation. Some applicants choose their certifier based on the agency's level of involvement in organic certification policy and advocacy at state and national levels.

Specific Requirements and Suggestions for Organic Compliance in Grain Production

Isolation buffers
The size of isolation buffers between organic land and adjacent nonorganic land depends on land uses, prevailing winds, runoff directions, ditches, and other barriers. It is usually between 20 and 50 feet. However, cross-pollinated or wind-pollinated organic crops (such as corn), should be isolated from nonorganic crops of the same type by 660 feet to maintain seed purity. If an applicant can verify with a written statement from his or her neighbors that no prohibited materials are being used on adjoining land, then the applicant may not need a buffer at all.

Organic seed
Organic seed must be used when commercially available. However, in many cases, the crop or variety desired is not commercially available as organic seed. Generally, the applicant must contact at least three seed companies or sources that carry organic seeds in an effort to obtain organic seed of the crop or variety desired. The three seed sources contacted must produce or supply seed of the crop kind desired. The applicant must also 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). A copy of this documentation may be required by the organic certifier if seed is used that is not organic. Excellent resources for availability of organic seed for crop production can be found by contacting these organizations:

- http://attra.ncat.org/attra-pub/altseed.html
  National Sustainable Agriculture Information Service, 1-800-346-9140
  P.O. Box 3657, Fayetteville, AR 72702
- http://www.savingourseed.org/
  Save Our Seed, 540-894-8866
  286 Dixie Hollow, Louisa, VA 23093
- http://www.omri.org/OMRI_SEED_list.html
  Organic Materials Review Institute, 541-343-7600. Box 11558, Eugene, OR 97440

Split (nonorganic and organic) production
A split operation may require additional record-keeping and detailed auditing. The dates of use, cleaning, and purging of equipment (including field preparation, cultivation, harvesting, and handling equipment) used in both nonorganic and organic operations must be recorded.

Accidental contamination
Accidental contamination of a farm by prohibited substances can be a result 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. The DOT and electrical companies should be informed of the location of organic land and be specifically asked to avoid spraying the area.

Storage and product transportation

Organic and nonorganic grain (or field crops) must not commingle. Storage bins or containers and areas used for organic grains should be thoroughly cleaned before use and clearly labeled "organic." Documentation of the cleaning of transportation vehicles will be required. The date, previous product transported, organic product transported, cleaning activity, and name(s) of the driver(s) are generally needed for the documentation. Consult the certifier about specific cleanout procedures.

Pesticides

A number of pesticides—mainly nonsynthetic compounds and biocontrols—are approved for use in certified organic production systems. Insecticides include neem, *Bacillus thuringiensis*, *Beauvaria* 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 National Organic Plan.

The Organic Materials Review Institute (OMRI) publishes a list of commercially available products that can be used in certified organic operations for pest control: www.OMRI.org.

Chapter 9. Marketing Organic Grain and Oilseed Crops

Molly Hamilton, Crop Science Extension Assistant, NC State University

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 North Carolina farmers, the organic grain buyers are almost always farther away from farms than conventional markets, which means freight costs are an additional consideration. The National Organic Final Rule (NOFR) 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 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 North Carolina farmers, the livestock feed market is more easily accessible than the food-grade grain market. However, there are markets in North Carolina for food-grade organic wheat.

Marketing Plan

It is always a good idea to have a marketing plan, especially when marketing organic grains. Research for a market is a key component of success in 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 Web site: www.cropsci.ncsu.edu/organicgrains/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 consumer and when? What are the costs? Good record-keeping is also a key part of a marketing plan 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. Buyers sometimes 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. Often, a better price for the grain is offered a few months after harvest, so storage may also be an economic 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, and records of their contents should 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 40 pounds per 1,000 pounds of grain). Diatomaceous earth can be sprinkled on top of the corn while it is moving in the auger to the bin, and then on top of the corn after it is loaded. DE works because the surface of each particle 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 *North Carolina Small Grain Production Guide* or the *North Carolina Corn Production Guide* storage sections. These publications are available through county Extension centers or on the Web:
http://www.smallgrains.ncsu.edu/Guide/cover.html
http://www.ces.ncsu.edu/plymouth/cropsci/cornguide/

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 an essential part 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. It may be prudent to harvest the outside rows of organic grain fields (especially of wind-pollinated grains) first and store and sell this grain as conventional. Doing this eliminates much of the contamination risk associated with cross-pollination from transgenic crops.

Transportation

Organic grain buyers generally need the grain delivered to their facilities and they 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 thoroughly 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 may 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. However, some specialty organic grain crops, such as buckwheat 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 problems 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 Web site for organic grain: www.cropsci.ncsu.edu/organicgrains/marketing/buyers.htm. This list is not comprehensive and there may be other companies that will buy North Carolina 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 "middle man" 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 Web site: www.cropsci.ncsu.edu/organicgrains/marketing/buyers.htm.

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 has a small corn mill that he uses to process his own corn into meal, grits, and cracked corn for chicken feed. He then sells these value-added products, packaged, to retailers or markets 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.

Chapter 10. Crop Budgets

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These crop budgets are for planning purposes only. They do not take into account any transition period for converting from conventional production systems to organic production systems.

Table 10-1. Organic corn enterprise budget 2005.

A. Estimated cost and returns per acre, 75 bushel yield.

	Unit	Quantity	Price or cost/unit	Total per acre	Your farm
1. Gross receipts					
Corn	Bushel	75.00	$6.05	$450.00	_________
Total receipts				$450.00	_________
2. Variable costs					
Seed	Thou.	28.00	$1.80	$50.40	_________
Fertilizer					
Chicken litter	Ton	3.50	$14.00	$49.00	_________
Lime (prorated)	Ton	0.33	$31.50	$10.40	_________
Tractor/machinery	Acre	1.00	$25.99	$25.99	_________
Drying	Bushel	75.00	$0.12	$9.00	_________
Cover crop	Acre	20.00	$1.00	$20.00	_________
Hauling	Bushel	0.00	$0.10	$0.00	_________
Storage	Bushel	75.00	$0.25	$18.75	_________
Labor	Hour	2.46	$8.00	$19.68	_________
Interest on op. cap.	Dollar	$67.90	9.0%	$6.11	_________
Total variable costs:				**$209.33**	_________
3. Income above variable costs:				**$240.67**	_________
4. Fixed costs					
Tractor/machinery	Acre	1.00	$59.32	$59.32	_________
Total fixed costs				**$59.32**	_________
5. Total costs				**$268.65**	_________
6. Net returns to land, risk and management				**$181.35**	_________

Break-even yield		**Break-even price**	
Variable costs	35 bushels	Variable costs	$2.79
Total costs	45 bushels	Total costs	$3.58

Table 10-1 (continued)

B. **Per acre machinery and labor requirements for 75 bushel corn.**

Month	Operation	Times over	Labor (hours)	Machine (hours)	Variable costs ($)	Fixed costs ($)
3	Heavy disk 16'	2.00	0.29	0.26	4.06	7.70
4	Fertilizer spreader	1.00	0.13	0.12	1.16	4.12
4.5	Cultivator 6-row	2.00	0.37	0.34	2.64	4.58
5	Planter 6-row	1.00	0.19	0.17	2.46	5.28
5,6	Cultivator 6-row	1.00	0.19	0.17	1.32	2.29
5,6	Rolling cultivator, 6-row	2.00	0.37	0.34	2.78	5.00
6,7	Combine w/header	1.00	0.36	0.33	9.83	25.88
9	Rotary Mower 7'	1.00	0.32	0.29	1.74	4.47
Per acre totals for selected operations			1.90	1.73	$25.99	$59.32

C. Income above variable costs at differing yields and prices.

Yield in Bushels	Price ($/bu.) $5.40	$5.70	$6.00	$6.30	$6.60
68	$155.17	$175.42	$195.67	$215.92	$236.17
71	$175.42	$196.80	$218.17	$239.55	$260.92
75	$195.67	$218.17	$240.67	$263.17	$285.67
79	$215.92	$239.55	$263.80	$286.80	$310.42
83	$236.17	$260.92	$285.67	$310.42	$335.17

Table 10-2. Organic wheat enterprise budget 2005.

A. Estimated cost and returns per acre, 37 bushel yield.

	Unit	Quantity	Price or cost/unit	Total per acre	Your farm
1. Gross receipts					
Wheat (grain)	Bushel	37.00	$5.50	$203.50	________
Straw	Bale	20.00	$3.50	$70.00	________
Total receipts				$273.50	________
2. Variable costs					
Seed	Bushel	2.00	$15.00	$30.00	________
Fertilizer					
Chicken litter	Ton	3.00	$14.00	$42.00	________
Lime (prorated)	Ton	0.33	$31.50	$10.40	________
Tractor/machinery	Acre	1.00	$18.17	$18.17	________
Drying	Bushel	0.00	$0.12	$0.00	________
Cover crop	Acre	0.00	$1.00	$0.00	________
Hauling	Bushel	0.00	$0.00	$0.00	________
Storage	Bushel	37.00	$0.25	$9.25	________
Labor	Hour	1.11	$8.00	$8.88	________
Interest on op. cap.	Dollar	$50.29	9.0%	$4.53	________
Total variable costs:				**$123.23**	________
3. Income above variable costs:				**$150.27**	________
4. Fixed costs					
Tractor/machinery	Acre	1.00	$43.38	$43.48	________
Total fixed costs				**$43.48**	________
5. Total costs				**$166.71**	________
6. Net returns to land, risk and management				**$106.79**	________

Break-even yield		Break-even price	
Variable costs	22 bushels	Variable costs	$3.33
Total costs	30 bushels	Total costs	$4.51

Table 10-2 (continued)

B. **Per acre machinery and labor requirements for 37 bushel wheat.**

Month	Operation	Times over	Labor (hours)	Machine (hours)	Variable costs ($)	Fixed costs ($)
9	Rotary mower 7’	2.00	0.64	0.58	3.48	8.94
10	Heavy disk 16’	2.00	0.29	0.26	4.06	7.70
10	Fertilizer spreader	1.00	0.13	0.12	1.16	4.12
11	Cultivator 6-row	1.00	0.19	0.17	1.32	2.29
11	Grain drill 16’	1.00	0.14	0.13	1.80	3.49
6	Combine w/ header	1.00	0.36	0.33	9.83	25.88
Per acre totals for selected operations			1.11	1.01	$18.17	$43.48

C. Income above variable costs at differing yields and prices.

Yield in Bushels	Price ($/bu.) $4.95	$5.23	$5.50	$5.78	$6.05
33	$41.61	$50.76	$59.92	$69.08	$78.24
35	$50.76	$60.43	$70.10	$79.76	$89.43
37	$59.92	$70.10	$80.27	$90.45	$100.62
39	$69.08	$79.76	$90.45	$101.13	$111.81
41	$78.24	$89.43	$100.62	$111.81	$123.01

Table 10-3. Organic soybean enterprise budget 2005.

A. Estimated cost and returns per acre, 35 bushel yield.

	Unit	Quantity	Price or cost/unit	Total per acre	Your farm
1. Gross receipts					
Soybeans	Bushel	35.00	$13.00	$455.00	________
Total receipts				$455.00	________
2. Variable costs					
Seed	Bushel	0.67	$16.00	$10.72	________
Fertilizer					
Chicken litter	Ton	3.50	$14.00	$49.00	________
Lime (prorated)	Ton	0.33	$31.50	$10.40	________
Tractor/machinery	Acre	1.00	$25.71	$25.71	________
Drying	Bushel	0.00	$0.12	$0.00	________
Cover crop	Acre	20.00	$1.00	$20.00	________
Hauling	Bushel	30.00	$0.10	$3.00	________
Storage	Bushel	30.00	$0.25	$7.50	________
Labor	Hour	2.09	$8.00	$16.72	________
Interest on op. cap.	Dollar	$47.92	9.0%	$4.51	________
Total variable costs:				**$147.36**	________
3. Income above variable costs:				**$307.64**	________
4. Fixed costs					
Tractor/machinery	Acre	1.00	$57.56	$57.56	________
Total fixed costs				**$57.56**	________
5. Total costs				**$204.92**	________
6. Net returns to land, risk and management				**$250.08**	________

Break-even yield		**Break-even price**	
Variable costs	11 bushels	Variable costs	$4.21
Total costs	16 bushels	Total costs	$5.85

Table 10-3 (continued)

B. **Per acre machinery and labor requirements for 35 bushel soybean.**

Month	Operation	Times over	Labor (hours)	Machine (hours)	Variable costs($)	Fixed costs ($)
5	Heavy disk 16’	2.00	0.29	0.26	4.06	7.70
5	Fertilizer spreader	1.00	0.13	0.12	1.16	4.12
5	Cultivator 6-row	2.00	0.37	0.34	2.64	4.58
6	Planter 6-row	1.00	0.19	0.17	2.46	5.28
5,6,7,8	Rolling cultivator, 6-row	4.00	0.75	0.68	5.56	10.00
6,7	Combine w/header	1.00	0.36	0.33	9.83	25.88
Per acre totals for selected operations			2.09	1.90	$25.71	$57.56

C. Income above variable costs at differing yields and prices.

Yield in Bushels	Price ($/bu.) $5.40	$5.70	$6.00	$6.30	$6.60
32	$221.19	$241.67	$262.14	$282.62	$303.09
33	$241.67	$263.28	$284.89	$306.50	$328.12
35	$262.14	$284.89	$307.64	$330.39	$353.14
37	$282.62	$306.50	$330.39	$354.28	$378.17
39	$303.09	$328.12	$353.14	$378.17	$403.19

Resources for More Information on Organic Grain and Oilseed Production

Organic Grain and Oilseed Production

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

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
Web site: www.rodaleinstitute.org

North Carolina Organic Field Crop Production and Marketing Web site. Department of Crop Science, NC State University, Raleigh, NC.
Web site: www.cropsci.ncsu.edu/organicgrains/

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, VT05405-0082.

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

Hoyt, G.D., Wagger, M.G., and Crozer, C.R. (2004). *Soilfacts: Winter Annual Cover Crops*. (AGW-439-58). North Carolina Cooperative Extension, NC State University. Online: www.soil.ncsu.edu/publications/Soilfacts/AGW-439-58/AGW_439_58.pdf

Organic Certification Information

National Organic Program. USDA Agricultural Marketing Service.
Web site: www.ams.usda.gov/nop/

- Production and Handling Regulatory Text: www.ams.usda.gov/nop/NOP/standards/ProdHandReg.html
- Preamble to this text: www.ams.usda.gov/nop/NOP/standards/ProdHandPre.html
- National list of accredited certifiers: www.ams.usda.gov/nop/CertifyingAgents/Accredited.html
- National List of Allowed and Prohibited Substances: (http://www.ams.usda.gov/nop/NationalList/FinalRule.html)

ATTRA (See the listing under above under "Organic Grain and Oilseed Production" for contact and Web site information.)

Carolina Farm Stewardship Association (CFSA). P.O. Box 448, Pittsboro, NC 27312
Telephone: 919-542-2402; Fax: 919-542-7401. Email: cfsa@carolinafarmstewards.org
Web site: www.carolinafarmstewards.org

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

Growing Small Farms, Chatham County Center, North Carolina Cooperative Extension Service. Promoting awareness, understanding, and practice of sustainable agriculture. P.O.Box 279, Pittsboro, NC 27312. Telephone: 919-542-8202.
Web site http://www.ces.ncsu.edu/chatham/ag/SustAg/index.html
Organic Certification Guide, Online: www.ces.ncsu.edu/chatham/ag/SustAg/orgcertguide.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.
Web site: www.omri.org

Integrated Pest Management

North Carolina Integrated Pest Management Information, North Carolina Cooperative Extension
Web site: http://ipm.ncsu.edu

National Science Foundation, North Carolina State University Integrated Pest Management
Web site: http://cipm.ncsu.edu/

North Carolina Pest Management Information Program.
Web site: http://cipm.ncsu.edu/ent//ncpmip/

Nutrient Management

Natural Resource Conservation Service (NRCS), USDA
P.O. Box 2890, Washington, D.C. 20013
Web site: www.nrcs.usda.gov

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

North Carolina Division of Soil and Water Conservation
1614 Mail Service Center, Raleigh, NC 27699-1614
Telephone: 919-733-2302
Web site: www.enr.state.nc.us/DSWC/

Weeds

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.

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

Marketing

North Carolina Organic Field Crop Production and Marketing. Department of Crop Science, NC State University, Raleigh, NC.
Web site: www.cropsci.ncsu.edu/organicgrains/marketing/marketing.htm

ATTRA Organic Marketing Resources
Web site: www.attra.ncat.org/attra-pub/organicmarketing/pubs.html

North Carolina Coastal Plains Virtual Farmers Market: Organics
Web site: www.virtualfarmersmarket.com/PlantScience/organic.htm

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

Organic Trade Association. 74 Fairview St, P.O. Box 547, Greenfield, MA 01302. Telephone: 413-774-7511. Email: info@ota.com
Web site: www.ota.com

North Carolina Cooperative Extension Web sites, NC State University

Weisz, R. (2005). *North Carolina Wheat Variety Characteristics* (includes wheat variety heading date information): www.smallgrains.ncsu.edu/Varieties/Varieties.html

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

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

Bowman, D.T. 2004. *North Carolina Measured Crop Performance. Small Grain Official Variety Trials*: http://www.ovt.ncsu.edu/

North Carolina Cooperative Extension Online Publications, NC State University

Weisz, R.(ed.) (2004). *2004-2005 Small Grain Production Guide* (AG-580). www.smallgrains.ncsu.edu/Guide/cover.html

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/

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Additional facts sheets, including those describing specific manures (such as swine, poultry, and dairy) are available through the Department of Soil Science Web site: http://www.soil.ncsu.edu//

North Carolina Department of Agriculture and Consumer Services

Plant Tissue Analysis Web site: www.ncagr.com/agronomi/ptaflyer.htm

North Carolina Cooperative Extension publications can be obtained through local county Extension centers.