Conservation Tillage on Organic Farms

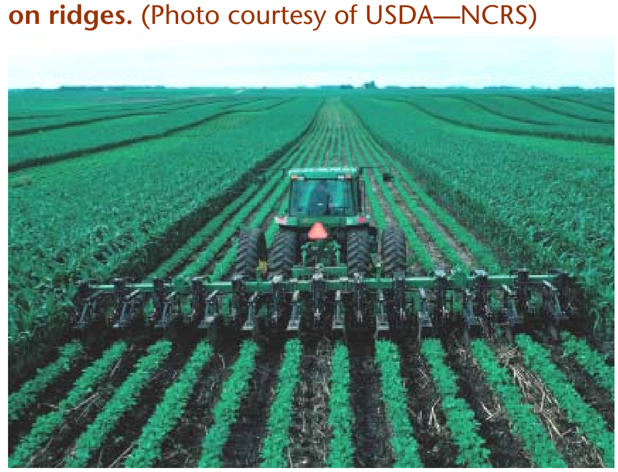
by Keith R. Baldwin

Two-hundred years of tillage have taken their toll on America's farm soils. The moldboard plow, extensive tillage, and other soil management practices have promoted wind and water erosion, costly nutrient losses from farm fields due to runoff and leaching, and a serious depletion of soil organic matter.

For too long, American farmers simply had to write these losses off as the necessary downside of crop production. If you farmed, it was a given that you used a moldboard or chisel plow to turn the sod bottomside-up, leaving no plant material on the surface. Then, in secondary tillage operations to create a seedbed and grow the crop, you crossed the field several times more with a disc, harrow, and cultivator. The opened soil was vulnerable to wind and water erosion.

Such damage to farm soils is an all-too-common occurrence in many production regions, including the agrarian South. For two centuries we have extensively cleared land for row-crop production of tobacco, cotton, corn, and soybeans. The resulting

Figure 1. A farmer cultivates soybeans grown on ridges. (Photo courtesy of USDA—NCRS)



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loss of topsoil and organic matter has degraded soil quality. Many farm fields have decreased fertility, aggregation, and water-holding capacity as a result.

A growing number of American farmers, however, are attempting to stem the degradation to our soils by adopting a cropping system known as *conservation tillage* (CT). In this publication, we will describe conservation tillage and discuss how it affects management practices on organic farms. We will focus on these topics:

- **How conservation tillage works**, including the obstacles and benefits it presents for organic farmers.
- **Conservation tillage and management practices on organic farms**, including the practices that affect organic matter, soil fertility, cover crops, pests, and compaction.
- **CT equipment** for vegetable production.

Conservation Tillage Is on the Rise
A growing number of U.S. farmers are switching to conservation tillage. From 1990 to 2000, the number of U.S. cropland acres planted without tillage more than tripled to 51 million acres. In the Southeast, farmers during the 2000 to 2001 cropping year used no-till systems in planting 39 percent of the corn, 20 percent of the cotton, and 58 percent of the soybeans grown in the region.

HOW CONSERVATION TILLAGE WORKS

In CT systems, farmers disturb the soil as little as possible by using special equipment, such as disk-chisels, no-till planting drills, and subsoilers. A protective cover of residue from the previous crop—a minimum 30 percent coverage—is retained as mulch on the soil surface. This residue provides a number of benefits. During the growing season, the residue suppresses weeds, retains soil moisture, and reduces erosion. As organic matter increases over time, soil fertility improves and biological diversity increases.

CT Systems: No-Till, Ridge-Till, and Strip-Till
These are the three main systems of conservation tillage:
No-till is a method of planting crops that requires no seedbed preparation other than opening the soil so that the seed can be placed at the intended depth. In its simplest form, no-till planting is a one-pass operation accomplished with a multi-component implement that slices through surface residue and the top 3 or 4 inches of soil, drops seeds into the slot, and squeezes the slot back together over and around the seed, leaving little or no visible evidence that the crop has been planted. This system produces the least soil disturbance of the three systems.
Ridge-till is a method of preparing the seedbed and planting on a pre-formed ridge remaining from the previous year's crop. The soil is left undisturbed until this single operation takes place. Ridge tillage differs from no-till planting in that some cultivation is required during the current growing season to form the ridge for next year's crop. This system produces some soil disturbance, but not as much as the strip-till system.
Strip-till is a method of preparing a seedbed on a strip 2 to 12 inches wide and 2 to 8 inches deep. Soil remaining between strips is left undisturbed. Often strip tillage equipment will include a 12-inch subsoil shank to break any tillage pans that may be present. A conventional planter may be used in this system. Of the three systems, this one produces the most soil disturbance.

In an effective CT system, each field eventually begins to resemble a beneficial ecosystem in the way it conserves soil, water, and energy, and in the way it recycles nutrients. Leaving a field primarily intact can reduce soil erosion by 10 to 90 percent. Nonpoint-source pollution from farm fields is also reduced because the land is better able to retain water, applied fertilizers, and chemical applications.

Conventional versus Conservation Tillage
Conventional tillage is a system that combines primary and secondary tillage operations to prepare a seedbed. These operations include moldboard or chisel plowing, disking, harrowing, and cultivating. Essentially no residue is left on the surface after conventional tillage is completed.
Conservation tillage is a system that retains protective amounts of crop residue as mulch on the soil surface. After planting, at least 30 percent of the soil surface remains covered by residue.

Obstacles

For organic producers, however, conservation tillage can present some obstacles. While conservation tillage practices and organic practices are both undertaken to enhance soil quality, conservation tillage often relies on herbicides for weed control. Herbicides, of course, are prohibited on organic farms. Consequently, most organic farmers continue to use intensive tillage as a means to control weeds. Four to eight cultivations in a single season on an organic farm are not uncommon. Ironically, this kind of intensive tillage contributes to poor soil quality and thwarts the goals of organic farming.

This isn't to say that organic farmers are not concerned with soil quality or don't understand the consequences of excessive tillage. They simply strive for soil quality improvements in different ways. Organic growers seek improvements in soil fertility, biological activity, and physical properties through a management system that emphasizes the integration of component farm processes into a whole farm system. In their soil building efforts, they make use of such practices as crop rotations, green manuring, and biological pest control. When possible, they also try to reduce the number of tillage operations on a crop. It would be advantageous to organic farmers —and consequently America's soils—if we can find ways to adopt conservation tillage practices, where possible, in organic operations.

It bears repeating that under a wide range of soil, crop and environmental conditions, conservation tillage can reduce soil loss by 10 to 90 percent over conventional tillage.

Benefits

Organic Matter Increases. Switching from conventional tillage to a CT system will generally bring about an increase in organic matter, most noticeably at the surface and within the top 2 inches of the soil. In conventional tillage, plant residues, fertilizers, and other amendments become homogenized and diluted as they are mixed deeply into the soil. But with conservation tillage, the residues and amendments reside in a layer near the soil surface, and plant roots tend to proliferate in the top 2 inches of soil where the nutrients are located.

Biological Activity Increases. As organic matter, in particular soil organic carbon, increases in CT systems, soil biological activity increases. This enhances the diversity of organisms and the ecosystem functions they perform. Chief among these functions is nutrient cycling. Soil microbes decompose organic matter. In doing so, they derive energy for themselves by breaking the long chains of carbon molecules that compose organic matter. As they do this, many plant nutrients attached to these chains are released. These nutrients are absorbed by the organisms themselves or cycled to plants. When the plants or microbes die, nutrients can be recycled once again. Thus, adding organic matter adds energy to this system and promotes nutrient cycling. The soil microbial biomass serves as both a source and a sink for nutrients. This biomass includes other organisms that perform additional functions, such as improving soil aggregation and inducing resistance to plant diseases

The soil biological community in CT systems differs from that found in conventional tillage systems. In conventional tillage, plowing and other tillage operations bury plant residues deeply into the soil, where they decompose rather quickly, primarily because bacteria are the decomposers. But in conservation tillage, when the soil is left undisturbed and plant residues remain at the surface, the primary decomposers are fungi. Decomposition is much slower. Slower decomposition results in an increased accumulation of organic materials and a rise in populations of assorted *secondary decomposer* organisms, such as nematodes and arthropods (insects and spiders). Earthworms and other tunneling invertebrates, such as the larvae of some beetles, proliferate in this soil environment. This community of decomposer organisms helps to maintain soil structure and improves infiltration and aeration within the soil. Plant root growth proliferates in the tunnels and channels these organisms provide.

Carbon and Nitrogen in CT Systems

Some intriguing things happen with carbon and nitrogen in the soil when CT is used:

- CT cultivations, even without additional organic amendments, produce an increase in levels of soil organic carbon, total nitrogen content, and soil microbial biomass carbon and nitrogen. This is in stark contrast to long-term conventional tillage, which usually brings about a decrease in these parameters. In many cases, soil organic carbon concentrations can be more than 50 percent greater with CT operations than with conventional. For instance, on one Kentucky farm with silt loam soils where conservation tillage had been used in some fields and conventional tillage had been used in others, the concentration of soil organic carbon in the surface-to-6-inch layer of soil in a no-till field was 70 percent more than in a plowed field after 10 and 20 years of using each system.
- Farmers have found that seasonal changes, as well as the availability of crop residue, can affect the abundance and dynamics of organic carbon and nitrogen in the soil. For example, a mid-summer drought can kill populations of soil microbes, the small organisms that keep soil "alive." As the dead microbial biomass decomposes, carbon and nitrogen are mineralized, and both may be subject to leaching with subsequent rainfall. Understanding how seasonal changes can alter active carbon and nitrogen pools can help farmers minimize losses of inorganic soil nitrogen.
- Some scientists believe that CT systems play an important role in reducing global warming by increasing and sustaining organic carbon sequestered in the soil. Concerns about the effects of atmospheric greenhouse gases on global warming have led to this conservation strategy, rather than promoting organic carbon conversion to carbon dioxide gas (CO_2) through wide-spread and frequent tillage. Fewer tillage operations also save tractor fuel, reducing CO_2 emissions.

Soil Structure Improves. A primary benefit of soil biological activity is that it builds soil structure, which produces good crop growth and yield. Organic compounds produced during decomposition and other microbial processes act as glues to bind individual soil particles together into aggregates. Soil aggregates are important for maintaining soil *tilth* (tillability) and *friability* (looseness). The stability of these aggregates is also important. That is, soil should maintain its structure while allowing water and nutrients to flow freely. Tillage destroys aggregate stability and promotes compaction and crusting. CT systems help to build and preserve the aggregate stability of soils.

Conservation tillage, in particular no-till, increases water-holding capacity and reduces runoff. Surface residues keep the soil temperature cooler and reduce water evaporation. Plant residues on the soil surface decrease runoff during heavy storms by increasing the infiltration of water into soil. Residues also protect the soil surface from any crusting caused by raindrop impact.

CONSERVATION TILLAGE AND MANAGEMENT PRACTICES ON ORGANIC FARMS

Organic Matter

Many organic farmers typically manage weeds by tillage and, therefore, cannot focus on building soil structure in the same way as CT practitioners. Instead, they use innovative practices to improve the soil structure and conserve soil organic carbon. Organic farmers attempt to improve soil tilth and friability with frequent additions of organic matter, which is either applied or grown in place. Organic matter improves water and nutrient retention capacity and promotes strong root growth.

It's clearly in the best short-term interest of beginning organic farmers to regularly incorporate organic matter into the soil. As soil health improves, a rotational CT system can replace annual tillage practices. In a rotational system, farmers incorporate organic matter and conventionally till soils only at selected times within a long-term rotation. Other organic matter additions (manure, composts, cover crops, and the like) are left on the surface of the soil in no-till years.

Under such a plan, the full-tillage years give farmers an opportunity to incorporate lime and other amendments and to address the nutrient stratification that can result from continued application of organic nutrients to the soil surface. Tillage provides an ideal opportunity to break up any nutrients that may have formed in deeper soil horizons and to disrupt pest and pathogen cycles.

In other years, growers can practice no-till or strip-till, with green manures or other organic matter amendments applied to the soil surface but not incorporated. Organic matter additions will continue to contribute to improved soil quality, but benefits will primarily accrue at the soil surface.

Solving a Chronic Seasonal Problem
In North Carolina, farmers are finding that a system of minimum soil disturbance and maximum soil cover is helping them avoid a chronic seasonal problem—tilled, bare soil that erodes in heavy rains from April through July. Principal CT crops in North Carolina are currently corn, cotton, and soybeans, but there is a growing interest in CT production systems for vegetable crops.

Soil Fertility

Taking soil samples in fields where conservation tillage is practiced is a little different than in conventional-till fields. Instead of the usual 6-to-8-inch soil core sample, the sample in a CT field is taken in the top 2 to 4 inches of soil. Sampling at this depth will ensure that soil pH (acidity) is accurately measured. If the soil surface has not been significantly disturbed (by plowing, disking, chiseling, or bedding) for three years or more, a sample of the soil from the top 2 inches should be collected along with a typical soil sample (6-to-8-inch core). If the 0-to-2-inch sample calls for lime while the 0-to-8-inch sample does not, one-half the suggested rate should be applied.

Nitrogen Application. Farmers intending to broadcast organic nitrogen on CT fields may be concerned that nutrients will remain on the surface, especially where there is heavy residue from the previous crop or a cover crop. For that reason, it may be necessary to apply slightly higher amounts of nitrogen. Nitrogen losses at the surface will be due to *immobilization* (uptake by soil microorganisms), *dentrification* (losses of N_2 gases in saturated conditions), and *volatilization* (conversion to ammonia gas). In spite of these potential losses, yields for many crops are often higher under conservation tillage than conventional tillage. These higher yields are probably the result of greater soil water retention on CT fields. Other factors, such as the rotation effect, may be involved as well. This may result in a considerable advantage for CT at equivalent nitrogen rates.

Organic farmers have several options to consider for improving nitrogen use efficiency in CT systems. They can lower the risk of denitrification by delaying the application of most, if not all, of the nitrogen fertilizer until later in the season when soils are drier and warmer. Placing the fertilizer below the surface mulch can decrease immobilization of nitrogen and volatilization losses, but this may require additional labor or specialized equipment.

Nutrients Near the Surface Enhance Production

Do conservation tillage systems and infrequent plowing mean that nutrients won't be adequately incorporated and distributed throughout the root zone? Studies have shown that under most circumstances, the concentration of nutrients and soil organic matter near the soil surface may actually **enhance** the nutrient uptake process. Research also shows that plant roots proliferate in the upper 2 inches of soil in CT systems. That is because the soil near the surface is moist and rich in nutrients and organic matter, making it highly conducive to plant root growth.

Phosphorus Application. Because phosphorus is so important to seedling growth, farmers should band phosphorus near seeds or transplants at planting. The most effective phosphorus fertilizer placement is a band 2 inches to the side of the row and 2 inches below the seeds. This may be easier said than done because many organic farmers may not have the specialized equipment required. In addition, organic phosphorus starter fertilizers that can be banded are costly and not widely available.

Many organic fields receiving annual applications of raw and composted manure have high to very high soil test levels of phosphorus. It is unlikely that additional phosphorus will increase crop yield in these fields, although starter applications may still be recommended. In locations where soil test results indicate a need for phosphorus, amendments can be broadcast and incorporated when the rotation permits.

In the short term, conservation tillage reduces phosphorous availability. In the long term, however, concentrations of available phosphorus are higher in CT systems compared to conventional tillage systems. Increased organic matter in the top 2 inches of soil provides sites for increased storage of plant-available forms of phosphorous. Plant roots have ready access to this soil zone.

Fertilizer Layering?
Try Row Placement
Stratification (layering) of nutrients with conservation tillage can be offset simply by row placement of fertilizers. Placing required nutrients close to the developing plant appears to be the best insurance when growers are concerned about the effectiveness of surface-applied fertilizer.

Cover Crops

Cover crops are very beneficial in CT systems for a variety of reasons. They are the main sources of surface residue, which reduces soil erosion during dry and windy or rainy weather in the winter and early spring. Residues also help to build soil organic matter. Cover crops are also used to scavenge the nitrogen leftover from a previous crop. And, as they develop, they provide nutrients to the following crop. Cover crop residues help conserve soil moisture during the summer growing season by reducing water evaporation from the soil surface before the full crop canopy has been established.

"The truth is that no one has ever advanced a scientific reason for plowing. The entire body of reasoning about the management of the soil has been based upon the axiomatic assumption of the correctness of plowing."
—Edward Faulkner, 1943
In his book Plowman's Folly, *Faulkner boldly challenged the validity and wisdom of using the moldboard plow. He was considered a fanatic by the academic community of his time. Today, however, there is wide acceptance of conservation tillage systems throughout the world.*

Choosing a Cover Crop. In vegetable systems, the cash crop will often determine the appropriate cover crop. Grasses offer good protection against soil erosion and provide ample, early-season residue for plantings of potatoes, lettuce, and cole crops (such as broccoli, collards, and cabbage). Legumes can provide a significant proportion of the nitrogen requirement, as well as residue for warm-season vegetables, such as tomatoes, sweet corn, snapbeans, and squash.

Timing. Farmers should be aware that rapidly growing cover crops may deplete the soil moisture needed for germination and emergence of the following cash crop, and poor, uneven stands may result. Therefore, the timing of cover crop kill is critically important. Although some nitrogen production by legumes will be sacrificed, in dry years the best strategy is to kill cover crops approximately two weeks before planting. In most years, sufficient rainfall will occur either two weeks before planting time or immediately after planting. If weather patterns or reports suggest that adequate rainfall, soil moisture, or both will be present throughout the planting window, farmers can let cover crops grow later in the spring.

CT Seedbeds: Points to Remember

While CT planter performance has improved considerably over the years, the seedbed environment in a CT system dictates these guidelines:

- Seeding rates should be 10 to 15 percent greater than those for conventional tillage.
- Lower soil temperatures under a cover crop residue make it imperative to select a cultivar that demonstrates excellent germination and seedling vigor under cool, wet conditions.

Killing Cover Crops. In many conservation tillage systems, cover crops are commonly *desiccated* (killed) with herbicides. Organic farmers, however, must mechanically kill the cover crop before planting a subsequent crop. Or, alternatively, they can plant into a living mulch. If the cover crop will be left on the surface as mulch, organic growers generally undercut, mow, or roll the cover crop to kill it.

Using an undercutter. An undercutter consists of a sharp steel bar and a roller. The sharp steel bar slides approximately 2 inches deep under the bedded cover crop, severing the crop's roots from its tops. The roller follows to lay the residue parallel to the bed. This system leaves cover crop biomass intact and on the surface. Therefore, decomposition is much slower and residue remains in place much longer than if it were chopped or otherwise cut into smaller pieces. The mulch enhances weed suppression longer into the cropping season. Slower decomposition also decreases the rate of mineralization, meaning that less nitrogen from legume residues will be available in the early stages of crop growth.

Other equipment. Many types of mowers are available that will kill cover crops, such as bush hog, flail, and sickle bar mowers. Ideally, the equipment used should leave the cover crop biomass as intact as possible — the smaller the pieces of residue, the more quickly they will decompose. Sickle-bar mowers serve this end best, but they are relatively ineffective in hairy vetch stands. Bush hog mowers place residue in a windrow in the field, leaving some soil exposed. Flail mowers represent the best mowing alternative because they drop the residue right in place, covering the entire soil surface.

Some summer cover crops may regrow after mowing. Cowpeas and other viney legumes are particularly troublesome, and undercutting is a more effective means of killing them. If regrowth occurs after undercutting, tillage may be required.

Other methods. One alternative method is to strip-till the cover crop, plant the cash crop in the tilled strips, and then let the cover crop die in its own time. Several growers are experimenting with strip-tilled, perennial cover crops. These systems offer exciting potential, but organic farmers should be very cautious of them because perennial plant roots will compete with crop plant roots for nutrients and water. Another innovative planting system that has shown promise in the Southeast is allowing a winter crimson-clover cover crop to reseed itself naturally between tillage strips.

Studying Cover-Crops in No-Till Vegetable Systems

Many researchers are studying the best uses of cover crops in no-till vegetable systems. Michelle Infante, an agricultural agent at Rutgers Cooperative Extension, and co-researcher R.D. Morse transplanted broccoli into desiccated cover crop plots in 1996. Cover crop residues were either left on the soil surface as mulch (in no-till plots) or incorporated to leave a clean surface (conventional-till plots).

They found that weed suppression and marketable broccoli yield with no-till were equal to or higher than with conventional-till. Overseeded clover living mulches did not affect broccoli yield compared to the control plots, and they suppressed weeds as well as herbicide treatments. These results supported those of Hoyt et al. (1994), Morse (1995), and Morse et al. (1993), who found that establishment of transplanted vegetables in no-till systems resulted in greater yield stability and often achieved yields equal to or greater than those achieved with conventional tillage.

Pests

Weeds. Certified organic growers should employ every weapon in their arsenal to control weeds in CT systems. These include crop residues, cover crops, appropriate crop rotations, and some tillage with CT cultivators. Growers can also select competitive crops that shade weeds and inhibit the emergence of weed seedlings. Special care should be given to planting rates and depths because stand establishment is more difficult in CT planting, and skips (missing plants) will result in greater weed problems. Later plantings can be made in narrower row spacings to provide quick shading. Using transplants when possible will also increase the competitiveness of the cash crop over weeds. Heavy residues from cover crops also aid in weed control. For example, cereal rye residues suppress the germination of some large-seeded broadleaf weeds.

Perennial weeds are often difficult to control in organic systems. So conventional tillage may be required for a number of years before CT (especially no-till) systems are practical. Before any transition is made to organic production, eradication of perennial weeds—such as Johnsongrass (*Sorghum halepense*), bermudagrass (*Cynodon dactylon*), nutsedge (*Cyperus rotundus*)—and other noxious species in heavily infested fields should be a priority goal. The reliance on tillage as a primary tool in a comprehensive and effective organic weed control program is an obvious reason for including it at some point in a rotation.

Diseases and Insects. Integration of disease control measures, such as planting resistant varieties, using integrated pest management (IPM), and employing crop rotations, is perhaps more important in CT systems than conventional tillage. Destruction of vegetable debris in the fall with a CT practice, seeding a small grain cover crop, and implementing a rotation that provides a host-free period will help minimize disease carryover problems.

Destruction of crop debris after harvest can be very important in minimizing disease and insect problems in organic systems, especially when the same crop or a related one is continuously grown in the same field year after year. Unfortunately, leaving residue on the surface in conservation tillage can slow degradation of pathogen-infected residue. Plant pathogens overwintering on residue can move to the lower foliage of subsequent crop plants via splashing. For example, pathogens of early blight can splash on tomatoes, and phytophthora blight can splash on peppers.

Tillage may sometimes be necessary to reduce insect pressure in succeeding crops. Fields are usually tilled in the fall or early spring when many kinds of insects are in the overwintering stage within the soil or in crop residues. Direct destruction of the insect or its overwintering chamber, removal of protective cover, elimination of food plants, and disruption of the insect life cycle generally kills many of the insects through direct contact, starvation, or exposure to predators and weather.

Accumulated plant litter at the soil surface provides food and cover for certain invertebrate animals, primarily insects, spiders, mites, and earthworms. It also modifies the effects of temperature and moisture on these creatures. Because there is no physical breaking and mixing of soil to temporarily remove food hosts, eliminate cover, or destroy and disrupt invertebrate animals and their tunnels, significant beneficial ecological changes occur in fields where tillage is greatly restricted (House and Brust, 1989). For example, increases in decomposer organisms resulting from the presence of more surface litter attract predacious arthropods. Research at North Carolina State University indicates that biological control of cutworm larvae, corn earworm pupae, and corn rootworm eggs and larvae by predatory mites and beetles occurs more often under CT systems (Van Duyn and House, 1989).

The soil ecosystem is dynamic. All of its components—both *abiotic* (lifeless) and *biotic* (alive)—work together to achieve some degree of ecological stability. Generally, that stability is greater in untilled than in tilled soil. Beneficial organisms capable of suppressing plant diseases may be better adapted to a more stable, no-till environment. Long-term use of CT farming practices may provide the soil stability necessary for establishing beneficial communities of organisms that will suppress pathogen populations. Promoting crop health and growth by consistently striving for improvements in soil physical, chemical and microbiological properties is integral to insect and disease management. Vigorous, healthy plants are less susceptible (and possibly less attractive) to insects and diseases.

Compaction

Theoretically, conservation tillage reduces soil compaction. This is partly because fewer trips are made across the field. With less tillage, there is less disruption of the natural soil structure, resulting in more durable aggregates with load-bearing capacity. Moldboard plows are not used, minimizing plow-pan formation. With several years of conservation tillage, the organic matter content near the soil surface increases, resulting in improved soil structure.

Unfortunately, traffic patterns in CT systems often are not controlled carefully. If much of the field's surface is traversed over time, the surfaces of CT soils can become excessively compacted. Because farmers recognize that the bearing capacity of untilled soils is greater than that of tilled soils, they tend to drive over untilled soils when they are too wet, aggravating the problem.

Thus, prolonged conservation tillage can sometimes lead to compaction in some soils. This soil compaction can lead to increased runoff, resistance to root penetration, and poor aeration. Compaction also reduces the total pore space in the soil, particularly the proportion of large pores. Large pores drain quickly after soil saturation and provide most of the oxygen supply for roots during wet periods. There are several ways to reduce or eliminate compaction from wheel tracks in CT systems:

- Establish and use controlled traffic patterns year after year—for example, by establishing permanent beds.
- Use a rotation system (*chisel plow–plant* or *chisel plow–disk–plant*) every few years to break up the compacted soil.
- Employ a rotation system that allows full tillage at some point of production to reduce compaction.
- Use deep-rooted crops (such as mustard) in rotations, if subsoils aren't too acidic for root growth, to alleviate compaction.

The lower soil temperatures that CT systems often produce can affect seed germination, shoot emergence, and root growth. In general, wet soils and those with more surface crop residue (like CT soils) remain cooler in the spring. Low soil temperatures may slow early-season growth of some summer vegetable crops (such as tomatoes and melons), possibly resulting in delayed maturity and lower market prices later in the season. In some cases, lower soil temperatures may favor plant pathogens (for example, the pathogens that cause damping off of vegetables).

CT EQUIPMENT FOR VEGETABLE PRODUCTION

With at least 30 percent of the soil surface covered by residues in CT systems, special implements are needed for land preparation and planting of vegetable crops. The implements most often used include heavy disk harrows, chisel plows, disk-chisels, field cultivators, subsoilers, and paraplows. To enhance stand and reduce seedling diseases, farmers may want to consider slot planters and furrow openers that prevent or reduce the contact of seeds or transplants with residues.

CT transplanters are available for planting vegetable crops into both crop residues and cover crops. Equipment used for transplanting vegetables like tomatoes, peppers, and the cole crops by conventional methods are suitable for planting these same crops in strip-tillage culture.

Large-seeded vegetables, such as sweet corn, snap beans and squash, may be planted in undisturbed cover crops or residues using existing no-till field corn and soybean planters. No-till planters with seed plates can be used for some vegetables by carefully matching plates to seed size. Plateless, no-till planters can accommodate a wider range of vegetable crops. CT planters for small-seeded vegetables that must be directly seeded (such as carrots and radishes) are not widely available. The strip-tillage approach may be most appropriate for these vegetables (and perhaps others) because seeds can be planted in the prepared seedbed strip using conventional planters.

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