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Look, Ma! No Weeds: Early Season Weed Control

Part 1: The basics of effective tillage techniques

Knowing just when to use just the right tool for just the right weed is critical to early season weed control.

By Klaas and Mary-Howell Martens
Posted January 27, 2005

Missed one?

Farm-at-a-Glance

The Martens' Farm

Location: about 60 miles

Welcome to the first installment in this three-part series--a basic primmer about weeds, tools, and techniques--which will be followed by a more in-depth look at equipment and cultivation techniques.

Organic weed control is not rocket science, but it does take understanding the anatomy and physiology of the crop plants, the weeds and the soil, as well as a cultivated anticipation of how each will respond to the implement used. Weed control strategies must consider the prevailing weed species; their size, condition and age; the soil condition; the available equipment; the species of crop; crop plant size; and the weather.

There are three main ways to kill weeds by cultivation:

1. Burying them
2. Uprooting them so that they desiccate (dry up)
3. Severing or damaging the weed enough so that neither part can regenerate

Weeders and cultivators generally do a combination of these three. It is important to be aware of exactly what the cultivator is doing to the weed seedlings while it is operating in order to time the operation correctly and make proper adjustments effectively.

Weed species vary widely in their susceptibility to cultivation equipment and in the length of time after germinating during which they are most easily controlled. Ragweed sends down a taproot very quickly, making it difficult to uproot almost as soon as it comes up. Mustard has very shallow roots at first and is easily plucked out until it is quite large. Summer annual grasses form small seedlings with few reserves that are easily destroyed by burying or uprooting them. Large-seeded weeds like velvetleaf that can emerge from deep in the soil are very resistant to shallow cultivation with weeders. Redroot pigweed is very difficult to kill by burying or uprooting once it gets a few inches tall, because it can push up out

southeast of Rochester, NY, on the western shore of Seneca Lake
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Crops: corn, soybeans, spelt, wheat, barley, oats, triticale, red kidney beans, sweet corn, snap beans, cabbage, edamame soybeans
Livestock: sheep, pigs, chickens for our own use
Regenerative farm practices: diverse long term crop rotations that incorporate legumes and small grains, under seeding all small grains with red clover, actively increasing soil organic matter
Marketing: corn & small grains are sold to Lakeview Organic Grain LLC, our organic feed business. Soybeans, red kidney beans, and spelt sold to brokers and processors. Some spelt is sold as kosher organic spelt. Sweet corn, snap beans and edamame are sold to processors who freeze them under brand name labels. Cabbage is made into sauerkraut and packed under the Cascadian Farms label. Some of the oats, wheat and barley are being grown from Foundation Seed to produce Certified Organic Certified Seed.

of fairly deep soil when buried and can re-root. Pigweed can also grow even if pulled all the way out and left lying on top.

Dessication

High humidity, cool temperatures, cloudy skies, and rain reduce the effectiveness of desiccation. The easiest time to kill weeds by desiccation is on a sunny, windy, hot afternoon. Weeds will often wilt and die under these conditions even if they are only partially uprooted.

In periods of drought, weeds may go into a semi-dormancy, leading farmers to stop cultivating or to set cultivators less aggressively. Soil often becomes hard under these conditions, making it difficult for equipment to penetrate to the proper depth. In a drought, deep-rooted weeds are tightly held in the soil and have large root systems relative to the size of the tops. A cultivator that is run too shallow can bury these weeds without disturbing the roots significantly. Such fields may look very clean at first but, if drought persists, the weeds will push back out of the dry soil ready to grow rapidly from a large well-developed root system. It is important to uproot and desiccate these weeds thoroughly, because burying them in the loose dry soil is not very effective (unless they are buried quite deeply).

Burying Weeds

During wet weather, burying weeds becomes the more effective approach, particularly if rain follows shortly after the cultivation. A rain on freshly cultivated soil will make it stick together and become tight. Often the soil surface will crust slightly as it dries. Under these conditions, weeds that are buried will die quickly and will seldom manage to push back out. It is important to note that any crop plants that are buried by weeders or cultivators just before a rain are usually lost, as well.

Tillage

Organic mechanical weed control consists of 4 distinct phases, each one very important to the overall success of your weed control program. These phases are:

1. Tillage

2. Planting

3. Blind cultivation

4. Row cultivation

The goal of early mechanical weed control is to eliminate the bulk of the weed population before it competes with the crop and to create as large a crop-to-weed size differential as early as possible. When crop plants are bigger and more vigorous than the weeds, the weed pressure will usually not jeopardize the crop. Therefore, effective early weed control, before weeds present a visible threat to the crop, is absolutely essential.

Appropriate tillage of fields is critical to:

- Create a good seed bed for uniform, vigorous crop emergence
- Prepare the ground adequately for successful subsequent mechanical weed control operations
- Kill weeds that have already emerged, including tearing up and burying perennial weeds with large underground root systems

The sun on the soil surface brings the shallower weed seeds out of dormancy in the spring, preparing them to sprout. The warm soil, full of weed seed ready to grow, responds to tillage quickly with a new flush of weeds. Moldboard plowing inverts the soil, bringing deeply buried dormant weed seeds to the surface and burying germinated weeds down below where they can't grow. When this

surface soil is turned under cleanly with a load of germinating weeds, deeper soil is brought to the surface. The newly surfaced weed seeds that had been laying dormant deep in the soil will often not begin to grow until after the crop gets started. Chisel plowing does not invert the soil and can result in a heavy flush of weeds that will compete with the crop early in the season.

Another approach, called the stale seedbed technique, works well if there is enough time before planting. The soil is plowed early, encouraging as many weeds to sprout as possible; then they are killed as the ground is tilled again. If several cycles of weed emergence and tillage occur before planting, we will have greatly reduced the weed seed bank, thus eliminating most of the weeds that were likely to germinate to compete with crops.

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There are many microbial species in a biologically active soil that attack weed seeds and the rhizomes of perennial weed species. Tillage adds air to the soil and stimulates biological activity as microbes feed on organic materials and break them down. This accelerated decomposition is often said to be burning organic matter. This is not neccessarily bad. Destroying weed seeds and helping crop residues break down are important benefits of tillage. Tillage helps mineralize nitrogen and phosphorus, cycling it from less available forms into ones that crops can readily use. It is only when tillage is excessive or poorly timed, or combined with poor rotations, lack of cover crops, high usage of nitrogen fertilizer, and other related poor farm-management practices that tillage actually damages the soil. When this happens, more organic matter is used up each year than is replaced, and soil degradation results.

In seedbed preparation, the goal is to prepare an environment that helps the crop to emerge as quickly and uniformly as possible without encouraging weeds. The seedbed should be smooth and level to allow for effective weeding and cultivation latter in the season. Large clods, rough spots, sod clumps and debris at planting will interfere with subsequent cultivating and weeding.

All perennial weeds need to be plowed under completely when the field is prepared. Rhizomous weeds such as quackgrass can often be killed by pulling the rhizomes to the surface with a spring-tooth harrow to dry out on a sunny day.

Planting

Planting equipment must be adjusted carefully to insure that the seed is planted at the proper depth for the crop and that it is planted uniformly for even emergence. Planting when the soil is too damp can cause a large flush of weeds to germinate very quickly from the moist packed soil at the surface. A dry, crumbly or even slightly cloddy surface with moist, fine soil at seeding depth gives the crop a good head start over the weeds. Basket rollers can produce finer soil at seeding depth with a looser and coarser surface than cultipackers or rollers.

It is important that planting equipment is in good repair. Disc openers worn past the point that the manufacturer recommends should be replaced. The gauge wheels must contact the disc openers exactly as the owners manual suggests, and the press wheels must follow straight behind the openers with the proper amount of down-pressure for the soil conditions.

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Planters often plant seeds deeper when the soil is soft and slightly damp and shallower where it is dry and a

little cloddy. The planting depth should be checked in lumpy spots as well as where the seed bed is ideal. Older John Deere 7000 planters sometimes put seeds almost on top in lumpy spots while dropping them in just right where the soil is softer. This can happen when there is a big enough gap between the disc opener and the gauge wheel for dry clods to push up in between and then drop into the seed trench ahead of the seed. The seeds are then placed into dry soil from the surface wherever the field is somewhat dry and lumpy. Replacing worn parts and proper adjustment of the planter can eliminate this problem. One after-market company builds replacement seed tubes that insure seed placement at the bottom of the seed trench while others sell attachments to better push seed down into the V left by the seed openers.

perfectly clean crop with minimum effort."

Corn and other crops with axillary roots must be planted deep enough to allow the plant to set roots above the seed. The tiny radicle on a corn seed only provides a small start for the plant. There has to be good soil contact with the stem to allow roots to form above the seed. Corn should usually be planted a minimum of 1.75” deep to allow for normal root formation. If corn is planted too shallow, it will have poor rooting and be prone to lodging. Soil hilled up around the corn plant as it grows stimulates further axillary root formation.

Clay soils are often worked slightly wet to get them fine. This can lead to crusting and a heavy early flush of weeds. A slightly rougher surface doesn’t look as nice, and care must be taken to avoid uneven emergence, but weed control is usually much better. Soybeans can germinate and emerge from much dryer soil than most weeds or even corn can. A dry, lumpy soil with just enough moisture to get a stand of soybeans started will often produce a perfectly clean crop with minimum effort. When a field gets too hard and lumpy at planting, running over it with a cultipacker or roller right after planting will often firm it enough to make soybeans emerge well but not the weeds.

Blind cultivation

Blind cultivation is the easiest and best opportunity to destroy the weeds that would be growing within the rows and presenting direct competition to the crop. In blind cultivation, the entire field is tilled shallowly with the implement, paying little attention to where the rows are.

The point of blind cultivation is to stir the top 1/2 to 1-1/2 inches of the soil, breaking the contact between the weed seedling roots and the soil and burrying the tiny weeds. This adds air to the soil, causing the millions of tiny germinating weed seeds to dry out and die. The larger crop seeds germinate below the level of the cultivation and are not usually damaged by this operation. Weed seedlings are very vulnerable to drying out and to burying at this stage. By doing an effective job of blind cultivation, you can achieve the biggest possible crop/weed size differential from the start. Blind cultivation also can break a soil crust, allowing crop seedlings to emerge.

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Usually, the first blind cultivation pass is done right before crop emergence, with a second pass done about a week later, depending on conditions. The most effective blind cultivation is done when the soil is fairly dry and the sun is shining. A wind also improves the effect.

Blind cultivation equipment includes rotary hoes, tine weeders, spike tooth harrows, springtooth harrows and chain link harrows. One resourceful farmer we know even drags a set of old tire chains over his fields for blind cultivation. NF

Part 2: Blind cultivation >>

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Look, Ma! No Weeds: Early Season Weed Control

Part 2: Blind cultivation

Get weeds before they become established and the battle is nearly won.

By Klaas and Mary-Howell Martens
Posted February 10, 2005

Lely finger weeder

Missed one?

Part 1: The basics of effective tillage techniques Knowing just when to use just the right tool for just the right weed is critical to early season weed control.

Part 2: Blind cultivation Get weeds before they become established and the battle is nearly won.

Part 3: In-row cultivation It's as much about the technique—and being able to adapt to fickle weather—as it is about the tools.

Farm-at-a-Glance

The Martens' Farm

Location: about 60 miles

The goal of blind cultivation is to remove the initial flushes of weeds when they are very small and most sensitive to disturbance. Blind cultivation takes advantage of the difference in size and sprouting depth between crop and weed seeds. Most weed seeds are smaller than crop seeds, and they germinate shallower in the soil. Annual weeds are most sensitive to disturbance from after germination to emergence. At these early stages, breaking contact between the tiny roots and the soil will kill most weed seedlings.

Blind cultivation works best when the soil is loose and in good physical condition and the crop is actively growing. By stirring and shaking the top inch of soil, early season weeding or blind cultivation creates a loose dry layer of soil that is too dry and airy for weed seeds to germinate or grow in. This layer also serves as a dry mulch that conserves soil moisture. The crop seeds are safely below this layer and are not hurt by a shallow weeding before emergence.

Field preparation stimulates many weed seeds to germinate. These annual weed seeds quickly sprout and emerge before or with the crop. At this point, a rapid and brutal race ensues which will quickly determine which type of plant will have dominance in the field. We must work decisively to give our intended crop the advantage and to reduce the competition. If our blind cultivation eliminates most of the first flush of tiny weeds, the crop will rapidly begin to suppress subsequent germinating weed seeds. Therefore, our goal in blind cultivation is to give the crop the greatest possible initial size advantage over the weeds before we come in with the row cultivator. If we can establish a favorable crop/weed size differential, the crop will then achieve dominance and we will then be almost assured a clean crop, or at least one where row cultivation will be much easier, faster, and more effective.

We have a short window of about two to three days, depending on weed species, when the first flush of germinating weeds are at their most susceptible. This window starts the day you can see the white hair roots when you scratch the soil surface with a stick or knife and continues until about a day after the weeds have emerged,

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depending on the weather. At this point you don't see any weeds from a truck window or tractor seat, but if you kneel down on the ground, there is a light reddish-green haze over the soil. Sometimes you can just see tiny weeds growing in soil cracks.

The success of the first blind cultivation is extremely important because it must give the crop an initial head start. The intention, of course, is to remove the weeds without harming the crop. The first pass usually takes place just before the crop emerges. At that stage the crop is able to survive a fairly aggressive weeding and weeds are usually small enough to be easily destroyed. Crop susceptibility to weeder damage is very low until the tip of the plant shoot is near the soil surface. The potential for crop damage rises rapidly as the crop emerges and until after the first leaves extend.

The crop can suffer some of the same types of damage by the weeders as the weeds do, and because of that, we have to be aware of what the weeders are doing. If the crop has emerged but is too small, it can be buried too deeply to re-emerge and may be suffocated. The crop can also be broken or plucked out. Soybean hypocotyls, for instance, are very fragile in the crook stage. If the weather is cool during this time, they are much more brittle. Usually the crop and the weed points of greatest susceptibility don't coincide. However, sometimes when our timing is less than ideal, it is important to assess how much crop damage is occurring and to get a sense for how much damage can be tolerated.

If we do the first pass too early, the crop may need a second weeding before the crop is large enough to withstand the action of the weeder; too late, and the weeds will be already resistant to the weeders, and/or the crop may be at a stage where it is too sensitive to survive an effective aggressive weeding. It is always best if we can hit this 'sweet spot', with the crop, weeds, weather and equipment at the ideal point for control!

The timing of the second blind cultivation is critical to eliminate the 'second flush' of weeds that emerged after the first weeding. The second pass must occur before weeds are big enough to become tolerant to the weeder action. We try to wait until the crop is as large as possible so the machine can be adjusted to a more aggressive setting, reaching more of the weeds. This is often a rather delicate balance, tempered by weather and labor. But when we can hit the second weeding right, the crop is off to a good start and we have several weeks of a breather before we have to come in to row-cultivate.

We need to have the tools available that can take out the weeds without doing excessive damage to the crop in all the different situations that we may have to deal with. This is why, on our farm, we have several different blind cultivation tools with varying configurations. This isn't an exact science, and there are some days when we switch between two or three tools before we are satisfied that we have chosen the best one for the conditions.

An experienced operator with a clear understanding of his soil, the weeds species, the crop stage, and the influence of the weather can do a great job with less-than-ideal equipment. The fanciest or most expensive equipment will not ensure good weed control. Instead, success is determined by the skill of observation and the agility to make the right decisions at the right time. When the relative stages of the crops and the weeds don't occur as we want, or when the weather prevents weeding at the right time, having the right equipment and the skills and experience to make the right adjustments can help make the difference between success and a weedy field.

There are a number of tools used for blind cultivation. They fall into two main categories – the various types of harrows and the rotary hoe.

Tine weeders

Tine weeders, or flexible harrows, are the most widely used tools for blind cultivation. Examples of tine weeders are the Kovar coil tine harrow, the Einboeck tine weeder and the Lely finger weeder.

The action of a tine weeder is determined by tine shape, tine size, tine spacing, tine length, type of toolbar, and the suspension of the units. Tine weeders are effective in a wide range of crops and conditions. They perform well in stony soil and can pass over moderately large stones without being damaged. The variety of available tines and adjustments make doing a good job of weeding possible under difficult soil conditions and when weather prevents proper timing of operations.

Most tine harrows are either drawn by a toolbar and suspended from chains or attached to 'U' shaped pieces, or "wishbones", that can self-level laterally and be leveled from front to rear with a hydraulic top link that tips the toolbar back and forth.

The tine harrow wishbone can self-level laterally and be leveled from front to rear with a hydraulic top link that tips the toolbar back and forth.

It is important to operate tine weeders so that all the tines penetrate equally and the units are level. In the more rigidly mounted models, this can be accomplished by adjusting the length of the top link until all the tines are running evenly. Using a hydraulically adjustable top link makes fine tuning the weeders very easy. With the chain suspended models, this adjustment is more difficult to achieve, especially in hard or crusted soil. The front tines often have to work harder than the others to break the soil. This tends to lift the rear tines or to spring the front tines back farther than the ones at the back of the implement. To compensate, we need to raise the toolbar so that the front chains pull up at the front of the unit, leveling it and forcing the rear teeth deeper into the soil. This is much easier to do on three-point hitch mounted machines than in trailing models. Adding a little weight to the rear of the tine units may also help make them run level.

If chain-mounted weeder units begin to hop, rock, or lunge while weeding, the tines can't move properly in the soil. The springs may all bend back and then snap out of the soil together causing the whole weeder unit to jump. This action repeats in a cycle that makes the whole unit jump up or twist around in a regular rhythm. When this happens, the unit moves, instead of the teeth. Reducing speed usually stops this erratic motion. The most common cause of this problem is hard or crusted soil with too much speed for the conditions. Sometimes units running in wheel tracks will jump while the rest of the units are working fine. This is due to the compaction in the wheel tracks. To address this problem, the operator must slow down or use rigidly mounted weeder units.

Straight-tine weeders freely move forward, backward, and side to side, producing a rotating action. They move soil sideways and level the land by filling low spots and knocking down ridges. This action covers weeds more than it uproots them. Small seedlings are easily killed by this tool, and even most large weeds are covered with soil. The sideways movement of the tines can damage young soybean plants by knocking off leaves and breaking stems and can also bury small corn seedlings. Corn that is buried between emergence and the 2 leaf stage can push back out of loose soil if rain doesn't come too soon after weeding. If it rains before the buried corn seedlings push back out, they can be sealed in the

ground and die.

Some farmers operate weeders at an angle to the rows on the first pass and then with the rows when they make the second pass. The cross hatch pattern that results covers the field very thoroughly. This approach works well in large wide fields but is more difficult to use in long narrow strips.

It is important to check how much additional soil is pulled over the rows, especially when weeding a field that is soft. It is possible for the weeder to bury the yet-to-emerged crop much deeper than it had originally been planted. With small seeds or seed with low vigor, this could hurt the stand quite severely. This can be especially true if a hard rain after weeding causes crusting. If this happens, it is important to weed the field again to break the crust and help the crop emerge. A rotary hoe or bent-tine weeder may be better than a straight-tine weeder for helping a crop emerge through a crust. These tools are more gentle and tend to lift the soil at the surface from over the buried seedlings rather than pushing it across the top of them.

The straight-tine weeder is excellent on any large seeded crop that has not yet emerged. It's aggressive action is very effective on weeds and does very little crop damage when used pre-emergence. Once the crop has emerged, it becomes much more vulnerable. Crops are softer and less likely to break off in hot weather and, if possible, should be weeded in the afternoon during the hottest part of the day. Corn becomes more vulnerable to damage when the leaves begin to unroll. Soybeans are most sensitive after emergence but while still crooked.

In soft, loose, uncompacted soil, it is possible to operate a weeder at a much higher ground speed than when the soil is hard. The straight-tine weeder does not perform as well in crusted or hard tight soil. In crusted soil, it helps to add some weights to the back of the units to make them go in better. John Saeli, an organic farmer in Geneva, New York, has added a hitch to the back of his units so that they can be turned around and pulled backward in hard soil. The tines are worn on an angle from being pulled in the normal direction so that the sharpened points cut through the crusted soil quite effectively when pulled in reverse. A second pass immediately after the first will often improve weed control in hard soil. Driving at an angle to the rows may also help. Kreher Farms, in Clarence, New York, has had good success in crusted soil by row cultivating with a Danish tine cultivator first to break the hard crust and following a day or so latter with a weeder.

It is very important to weed early if a crust begins to form to prevent it from becoming hard. Once a soil crusts, it must be broken up as soon as possible to stop it from getting worse. A crust will continue hardening and become thicker if it isn't broken up. It is important to get air back into a crusted soil as quickly as possible.

In a wet season, it is better to bury weeds than to uproot them. Seedlings re-root easily when they lay on top of damp soil. Weeders with straight tines that level the field and can move soil sideways will cover weeds more than uproot them. Rain after a weeding is very likely to seal the surface enough to prevent even shallowly buried weeds from coming back up. When soil is hard or crusted, some extra weight on the back of the weeder sections may help. Transferring some weight from the toolbar to the units by changing to the newer self leveling supports may help.

Forty-five degree bent-tine weeders are very good for loosening tight or crusted soil. The 45°tines are more effec tive at uprooting weeds than they are for covering them. The longer tines are better able to follow the surface of the soil so that they loosen the soil evenly. These tines will give the same action in low spots that they do in high spots. Because of this, there is much less soil leveling in the action of these weeders than with the straight tine units. The 45°teeth loosen soil uniformly but do not move muc h soil sideways. For this reason, these tines are usually less damaging to emerged soybeans than the straight tines. They are less likely to bury small crops deeply but more likely to pull plants out.

Peter Martens showing the possible angle adjustments on a Kovar coil tine harrow with 45 degree teeth.

The angle of the tines on the 45° units is adjustable from a very flat swept back orientation to an aggressive angle where the teeth are pointed forward so that they pull themselves in. These units will penetrate a hard soil much better than straight tines, especially when the teeth are set into their most aggressive position. We have found that the close spacing and the stiffness of the tines on the Einboek machine can be overly aggressive with some soils and crops, especially when the weeders are equipped with the shorter (390mm), stiffer, and larger-diameter tines. The Kovar machine has widely spaced, long flexible tines (25-inch) that sometimes deflect sideways away from ridges, leaving narrow strips on each side of the rows unweeded. This has not been a problem as long as the cultivator is adjusted properly, because the cultivator cleans up these strips of missed weeds if they occur.

Eighty-five degree bent-tine weeders will penetrate deeper than other weeders. An example of such a weeder is the Lely finger weeder. The angle of the teeth, rather than down pressure or the weight of the units, causes the 85° teeth to pull into the soil. This type of tooth can lift and break up a heavy crust despite the small light teeth. These weeders are exceptionally well suited for tap-rooted crops. The hooked tine goes in deep but does not pull out soybeans, kidney beans or other crops with a straight tap root. Instead, weeding seems to stimulate the crops' growth.

While the 85° tine is very gentle on beans, it can do serious damage to crops with branching root systems, such as corn and small grains. Corn produces axillary roots that branch off from the stem. The 85° bent tines will penetrate deep enough in soft soil to get under the branched roots and pull out the small corn seedlings. If an 85° tine weeder is to be used in this type of crop, it must be watched carefully and adjusted to stay above the branches of the crop roots. The crop should be examined carefully for damage after going a few yards, and the operator needs to be aware of areas in the field with softer soil where the tines can go deeper to be sure that the crop roots are not being damaged.

In warm, dry weather with good sun and/or wind, the newer weeders with longer bent tines work better to uproot weeds, lay them on top and dry them out. The 45° tooth works well with corn and beans, while the 85° tooth weeders are better on beans or other tap-root forming crops. The branching roots of corn are damaged and pulled out by the aggressively hooked teeth of the Lely type weeders, while the straight tap roots of beans are unaffected.

The 85° tines primarily break the connection between the soil and the weed roots. They are particularly effective at uprooting weeds because they penetrate so deeply. They are the most effective weeders for quackgrass because the tines can pull up quack roots very efficiently. In fields with a lot of quackgrass, these weeders may plug with roots and so may need to be cleaned out by hand or sometimes by shaking the weeder up and down by the lift arms. This should be done outside of the field over a ditch or in a

driveway to insure that the roots can't reestablish themselves. This also prevents the tangled weed piles from plugging cultivators later in the season.

Rotary hoes

Rotary hoes are best used from before weed emergence to very early post emergence. Weeds must be very small or not yet emerged for good control. It's very important to keep hoe tips in good repair as they lose their effectiveness quickly with very little wear. "Hoe-bits" are replacement tips that can be welded onto the worn tips; these actually make the hoe more effective than it was originally. Rotary hoes generally work by uprooting and desiccating (drying out) tiny weed seedlings. They are very gentle on the crop and can be used when more aggressive weeders cause too much crop damage. Best results with a rotary hoe come right after a light rain when the soil is just lightly crusted and breaks apart easily into 'chips'. It's important to maintain high speed when using a rotary hoe.

Rotary hoe: When we add new wheels, we put them over the rows first because early in-row weed control is most important.

The height of the tool bar together with the strength of the 'down pressure springs' on a rotary hoe determine the ground pressure of the hoe wheels. This adjustment is usually controlled by setting the position of the tractor lift arms. In tight or crusted soil, it may be necessary to add some weights to the tool bar to achieve enough down pressure to do a good job. If the tractor has a quick hitch, this adds enough weight to hold the tool bar in the right position under most conditions. Rotary hoes generally need to be set to be level with the ground. In extremely hard soil, extending the top link to tip the machine back may increase the ground pressure slightly, but this should only be done if none of the other adjustments are sufficient to make the machine penetrate correctly.

Ground speed with a rotary hoe should usually be between 8 and 12 mph, and the hoe tips should penetrate deep enough to go through any crust that has formed. In soft soil, the hoe tips may penetrate as deep as 1.5 to 2 inches without excessive harm to most crops. A very shallowly planted crop, however, can be damaged by a rotary hoe that is set too deeply. Some farmers have improved the weed control by adding a second set of hoe wheels behind the first set so that the crop is actually hoed twice with each pass, or by going over the field twice.

Rotary hoes work primarily by uprooting weeds and/or by loosening the soil from the tiny roots of the weed seedlings. Stony soils can present a serious problem to rotary hoes. Large stones can bend and damage the delicate parts of these machines. Smaller stones, especially those 2- to 3-inches in diameter, can get stuck between the hoe points, bending them or stopping the wheels from rotating. If this happens directly over a row and is not immediately detected, it can tear out a long section of a row in a very short time.

Other harrows

Spike-tooth harrows have been used as weeders for many years. They were probably the first tools to be used by farmers as weeders.

German farmers used spike-tooth harrows extensively to control weeds in small grains fields before the coming of herbicides. American corn farmers throughout the United States used spike-tooth harrows as weeders in the early part of the twentieth century. George Washington Carver promoted their use widely in the American South by taking some of the machines from town to town to demonstrate how effective they were. Spike-tooth harrows fell out of use around World War II with the advent of chemical weed killers.

Spike-tooth harrows are very effective weeders. They can both uproot and bury weeds. The angle of the spikes can usually be adjusted with a handle from straight up and down to angled back at a flat angle to the soil. Rocks are a big problem with spike-tooth harrows. Rocks can easily get caught in the harrow and take out a row of crop, or they can roll under the harrow and lift the teeth out of the ground so that the weeds aren't controlled.

Spike-tooth harrows can sometimes be overly aggressive and damage the crop especially in cool weather when plants are brittle. Spike-tooth harrows work best on very hot afternoons when the corn is soft and flexible. Tine weeders have largely replaced spike-tooth harrows because they are effective and have better crop safety.

Spring-tooth harrows are extremely aggressive, but they are sometimes used for weeding. Because of their potential to do crop damage, spring-tooth harrows are generally only used in emergencies where the crop will otherwise be lost. If a field is so infested with big, grassy weeds or crusted so badly that no other tools can loosen it, a spring-tooth harrow may be able to save it. This is a drastic measure but it often works as a miracle rescue if done carefully.

A drag (springtooth harrow) with worn teeth set just as shallow as possible while still having all the teeth in the soil should be used. Often, the drag is drawn across the rows rather than with them. The tractor needs to be run slowly, and the driver should be prepared for a scary sight when they look back. Corn treated like this often perks up and starts to grow rapidly after being dragged. The stand loss from the dragging is usually high. But in cases where nothing else will work, there is really nothing to lose by trying this tool, because the stand would be worthless anyway if nothing is done.

Chain-link harrows are more commonly used on pastures, but they can do a good job of weeding. If plugging is not a problem and no other tools are available, a chain-link harrow can do a good job of controlling weeds before crop emergence. A chain link harrow would not be a good choice for post-emergence use because of crop damage. NF

Part 3: In-row cultivation >>

THE NEW FARM www.newfarm.org

Look, Ma! No Weeds: Early Season Weed Control

Part 3: In-row cultivation

It's as much about the technique—and being able to adapt to fickle weather—as it is about the tools.

By Klaas and Mary-Howell Martens
(with help from Peter Martens)
Posted March 17, 2005

Peter Martens--at 16, already a veteran in the field--and his friend Shawn cultivate corn in June 2004. Peter (left) drives a Ford 5000 with an International front cultivator with trip shanks and Glencoe rear cultivator with C shanks. Shawn drives a John Deere 3020 with john Deere front cultivator with trip shanks and a homemade track digger with Danish tines.

Missed one?

Part 1: The basics of effective tillage techniques
Knowing just when to use just the right tool for just the right weed is critical to early season weed control.

Part 2: Blind cultivation Get weeds before they become established and the battle is nearly won.

Part 3: In-row cultivation
It's as much about the technique—and being able to adapt to fickle weather—as it is about the tools.

Farm-at-a-Glance

The Martens' Farm

Location: about 60 miles southeast of Rochester, NY, on the western shore of

In-row cultivation is the last piece in effective non-chemical weed control on an organic farm. In many ways, cultivation is the 'crown jewel'; it is here where the skill, ability, observation and timing of a good operator makes or breaks the effort (much more so than the choice of any particular piece of equipment).

Successful organic weed control is the sum of all operations and cultural management. The purpose of the cultural methods (crop rotation, soil fertility management, sanitation, good seed, cover crops, etc.) and early season weed control (blind cultivation) is to achieve the greatest possible crop-weed size differential, especially when there are many acres to be cultivated. The last stage, in-row cultivation, is the final performance in the whole package of organic weed control strategies.

From the very start, it is important to consider in-row cultivation as a 'cleanup' procedure, not as the primary weed control. Well-timed early weed control is absolutely essential to reduce the size of the weed population before it becomes a threat to the crop. Even with a good job of blind cultivation, there are usually some escapes (weed seeds that get away and resprout), and, especially when wet weather prevents proper timing, there may be lots of escapes. Subsequent in-row cultivation is then necessary to provide clean, productive fields.

When it is necessary to in-row cultivate crops that are very small, it is impossible to do a good job on more than a few acres per day. Weeders allow delaying the first cultivation until the crop is large enough to cultivate deeply and rapidly. Many organic farmers don't have weeders, don't have the right weeders, or don't know how to operate them to get optimum weed control. The first two articles in

Seneca Lake
Important people: Klaas and Mary-Howell Martens, Peter, Elizabeth, and Daniel. Plus Robert Hall (employee/asst farm manager)
Years farming: We've farmed this farm together since 1991. Klaas has farmed all his life.
Total acreage: 1500
Tillable acres: 1300
Soil type: Honeoye Lima silt loam
Crops: corn, soybeans, spelt, wheat, barley, oats, triticale, red kidney beans, sweet corn, snap beans, cabbage, edamame soybeans
Livestock: sheep, pigs, chickens for our own use
Regenerative farm practices: diverse long term crop rotations that incorporate legumes and small grains, under seeding all small grains with red clover, actively increasing soil organic matter
Marketing: corn & small grains are sold to Lakeview Organic Grain LLC, our organic feed business. Soybeans, red kidney beans, and spelt sold to brokers and processors. Some spelt is sold as kosher organic spelt. Sweet corn, snap beans and edamame are sold to processors who freeze them under brand name labels. Cabbage is made into sauerkraut and packed under the Cascadian Farms label. Some of the oats, wheat and barley are being grown from Foundation Seed to produce Certified Organic Certified Seed.

this series describe basic weed control principles and blind cultivation techniques and equipment.

Cultivation also provides many other beneficial effects far beyond the weeds. Indeed, cultivation is very important for aerating the soil, stimulating crop root growth, conserving soil moisture, and providing insulation from the hot sun with a loose, dry soil mulch.

Few conventional farmers who cultivate their crops spend much time adjusting their cultivators. Herbicides take care of most of the weeds, and skilled cultivator operators are hard to find. Many conventional farmers feel that if they can keep the machine between the rows and avoid taking out too much crop, then they can ‘cultivate’. This careless approach will not work on organic farms. Indeed, we prefer not even to consider that type of field operation ‘cultivation’ at all. Getting the weeds between the rows is the easy part! The real art and skill of cultivating is whether you can also get the weeds within the row without excessively damaging the crop plants.

Timing is everything

When the crop rows are clearly visible and the corn plants are 8 to 10 inches tall, or soybeans are in the third trifoliate stage, it is time to begin in-row cultivation. On most New York organic grain farms, usually two cultivation passes are required. The first pass is the most critical to determine the season’s weed control, but the second pass is often necessary to eliminate the weeds that were stimulated to grow by the first cultivation, to ‘hill up’ the crop, and to further aerate the soil.

The stage of the weeds and the weather usually dictate how we time our cultivations. The period of greatest vulnerability for most weeds comes at a different time after planting than that of the crop plants. Because crop seeds are generally large and are planted deeper than most weed seeds, their window of maximum vulnerability mismatches that of the weeds. We have to take this difference into account when developing our weed control strategy.

The vulnerability of plants to mechanical disturbance goes through a predictable cycle, starting with a seed that has not yet started to germinate. At that stage, seeds are virtually indestructible by anything other than biological activity. Until a seed imbibes water and begins to grow, weeders and cultivators have little effect. A seedling is most vulnerable from the time it germinates until after the plant has fully emerged from the soil. Once the cotyledons are fully extended and true leaves begin to develop, the seedling again becomes harder to injure. The exact timing of these stages varies between species; generally, once plants are past the unifoliate stage, most seedlings are much more difficult to damage.

Timing is indeed everything. Unfortunately, knowing the correct timing and being able move forward are not always the same thing because of challenging weather conditions. Often, we have to do the best we can; by combining the effects of two blind cultivation passes with one to two in-row cultivation passes, we have much more flexibility with sub-optimal conditions (and usually this results in good weed control). This is an important point to make, since there is an oft-repeated fallacy out there that organic farmers have to cultivate many, many times during a season for adequate weed control. This is not true! It is the timing and skill with which the operations are performed that is most critical, not the number of passes made. If everything else is done right, and if blind cultivation is timed correctly with the right equipment, one to two passes with a row cultivator should be sufficient for good weed control in organic row crops.

Badly timed weedings can actually make the weeds worse. Making a large number of poorly timed or poorly executed passes will result in failure, no matter how many trips are made over the field.

These soybeans had to be cultivated much earlier than the Martens' would have liked. Rain prevented them from doing the first weeding when it should have been done, and cultivating was slow-going.

When the first blind cultivation is timed just right, the weeders can be run very aggressively and will achieve almost complete control over the first flush of weeds. When this happens, the second blind cultivation can wait until the crop is large enough to allow another aggressive weeding. However, if our first blind cultivation leaves too many escapes or if the first weeding fails to sufficiently decrease the second flush of weeds, we may have to do our second weeding before we really want to and then may have to come in with the cultivator before the crop plants are really big enough. Cultivating crops that are too small is slow, difficult and requires much fatiguing concentration to avoid injuring the crop plants.

It is important to remember that whenever soil is disturbed, a new flush of weeds will be stimulated to germinate. Fortunately, these later weeds are much easier to control, but they still must be considered in the timing of cultivations and weeding operations.

Tines have changed

Most cultivators built in recent years were not well-designed to control weeds in the row. While it is sometimes possible to do a reasonably good job with a modern rear-mounted cultivator, when the conditions are difficult or weeds are heavy, the shovels next to the row can't be adjusted with enough precision nor can it be operated close enough to the row to take out the in-row weeds.

Front-mounted or belly-mounted cultivators, or pusher cultivators on bi-directional tractors, are far easier to keep on the row and work close enough to the crop plants. The operator needs to be able to easily see all of the cultivator shovels. Carefully watching the soil flowing around the front cultivator shovels and crop plants helps the operator to keep the shovels adjusted precisely where they need to be. It is important to continually adjust speed and down-pressure on the go to respond to variations in soil conditions across the field and to always keep the action of the cultivator as aggressive as possible without excessive crop damage. This is not possible when the operator can't look at the cultivator while steering the tractor.

Danish or S-tine teeth will allow the greatest operating speed, they are not easily damaged by rocks, they will handle the most crop residue without plugging and they are relatively inexpensive, but they do not penetrate as well in hard soil and large-rooted weeds may slip around the flexible teeth, thereby avoiding damage. When this happens, putting on narrower shovels will make them penetrate deeper and give better control. Of different types of cultivator teeth, the operator has the least control over the action of the flexible Danish tine teeth.

C-shank cultivator teeth are more rigid and give the operator better control over the action of the shovels. These may be the best teeth

for hard or rocky soil and for heavy infestations of quackgrass and other weeds with underground rhizomes. They are less likely to plug in grassy conditions than trip shanks but much better able to take out large weeds than Danish tines.

Trip-shank teeth are the most rigid and allow for the slowest progress, but they give the operator superior weed control and adjustment ability. These are also the most expensive, large rocks can break the trip-shanks, and it takes a more experienced operator to make the necessary adjustments to get the full benefit of trip-shank teeth.

There are many different types and widths of points that can be put on the different cultivator teeth. Danish tine cultivator teeth offer the least opportunities to vary point type, while trip-shank teeth offer the greatest choice. The most versatile type of points are probably half sweeps next to the row and full sweeps between the row. Each type of point works best under specific conditions and on certain weed species. For example, a type of point called a 'beet knife' is particularly effective on nutsedge. Narrow spikes may sometimes be used to advantage to aerate waterlogged soil.

A Ford 5000 sporting an International front cultivator with trip shanks and Glencoe rear cultivator with C shanks.

We use a double cultivator arrangement, with trip-shanks on the front cultivator and half sweeps next to the row to get good weed control within and immediately next to the row. The rear-mounted cultivator, which has C-shank teeth with full sweeps, covers the between-row area. While this combination is slower than a single Danish tine cultivator, it gives excellent control of most types of weeds, even under an unfavorable crop/weed size differential. Other New York organic farmers have had success with rear-mounted Danish tine cultivators with 5 shanks and 2 1/2-inch duck feet points between each row. If the ground is hard or there is a quackgrass problem, 1-inch spikes angled forward to dig deeper can be used.

Cultivating technique

There are as many 'right' ways to set a cultivator as there are farmers who can get their fields clean of weeds. Every farmer who is good at cultivating develops their own unique combination of equipment, settings and special 'tricks' that are especially well-suited to the soils, crops, and conditions found on that farm. No two farmers will do the job exactly alike, yet each one can be a master in his own right. Until the late 1940s, cultivating was a skill that every farmer had to possess. The skill was passed down from one generation to the next. Every community had 'good' farmers who could be called upon for advice when you weren't quite getting the weeds (or for any other problem that you might encounter).

Our communities have lost countless farmers who held this important knowledge with no one to pass it on to. Our mentor is an older farmer named Clifford Petersen. He set a very high standard and has no tolerance for weedy fields. He often told us that when

his son complained that it took him too long to get the cultivator adjusted right, he would say “If you don’t think you’ve got time to do the job right, think about this: Every weed you miss now is one you will go back and pull!” It took Klaas three years before he could cultivate a field well enough to win a compliment from Cliff. Cliff often said that he couldn’t tell someone how to cultivate right, he had to show it.

However, this attention to detail and perfection must be balanced with a view of the whole farm and an honest assessment of how much time it will take to cover all the acres adequately. Taking too much time to get every last weed in one field may make it impossible to cover all the rest of the acres on time. It’s important to keep the whole crop in perspective and not spend too much time making the first few fields immaculate. You also have to know when to stop and say you have done your best. Tractor operations after canopy closing will usually crush and tear crop plants excessively and may be of no further benefit, as shade from crop leaves will kill weeds trapped under the canopy.

If at all possible, it really helps to work with an experienced farmer to learn to evaluate how the soil should flow past the cultivator teeth, how much side pressure on the row is best, how much dirt should be pushed into the row to bury the weeds, how to make the proper adjustments, and how hard you can treat the crop without hurting it. The real art of cultivating is learning how to make the right observations and then figuring out how to match those observations to making appropriate—and changing—adjustments.

There is a big advantage in being able to get on a perfectly adjusted cultivator when you start out and to see how the soil flows when a real master has set the shovels to match the crop and soil conditions. As adjustments are needed, it is much easier make the right ones when you have seen what ‘working right’ looks like. Once we know exactly how we want the machine to achieve, it is much easier to get and keep it there.

Front view of John Deere front cultivator with trip shanks and a homemade track digger with Danish tines.

Our 16 year old son Peter has been cultivating on our farm for the past four years. Last summer, he taught his friend Shawn to cultivate. The two of them covered many acres together, the camaraderie, cooperation and their iPods keeping boredom and monotony to a minimum. Peter’s cultivation experience has been gained during the past five excessively wet years; through these tough conditions, he has learned to achieve acceptable weed control even when it is very difficult to do anything ‘right’.

When soil is very dry, it is tempting to run the cultivator shallower to ‘save’ moisture or to stop cultivating altogether, because corn curls right after it is cultivated when in the air is dry. Don’t give in to this temptation! Remember that weeds can push back up out of dry soil unless they are buried fairly deep. Escaped weeds are far more damaging to crop yield in dry weather than when there’s sufficient rain. The soil that the cultivator hills up around the row provides a dry mulch and stops water from being brought to the surface and lost by capillary action. Soil moisture in the hill is much higher than in uncultivated soil, and the crop grows far more roots in the loose

soil of the hill than when the soil is left uncultivated.

Conventional wisdom says that cultivating deep and disturbing roots in dry soil hurts the crop. We have never seen any evidence to support this assumption. We find that new roots grow quickly into the loose soil left by cultivator shovels and the crop responds with a spurt of growth. Many organic farmers say that a pass with the cultivator has the same effect on the crop in dry weather as a half inch of rain.

Adjusting to change

There are many adjustments that can be made while cultivating to match the effect of the machine to the conditions and needs. Choosing the appropriate adjustments is not easy to summarize because conditions constantly change, across the field, in different crops, in different soils, even over the course of a day as the weather and moisture conditions change.

In general, there are five main cultivator adjustments possible:

1. tractor speed
2. angle of the shovels, laterally and horizontally to the row
3. depth of the shovels
4. down pressure on the gangs, on cultivators with springs
5. distance of the shovels from the row

Relatively little adjustment is possible with Danish tines other than varying speed and depth and by changing the type of the points. With C-shanks, it is possible to change the angle to the soil and to the row slightly, but because they are springs, this adjustment changes in the soil as the cultivator moves. This is not a major problem when the cultivator is set deep and working between the rows, but it limits the success of controlling weeds within the rows. Trip-shanks allow wide adjustment of the angle of the points, both to the row and to the soil.

Depth of the point is also easily adjusted. Because trip-shanks are rigid, the adjustments remain constant while cultivating. For example, by twisting the shank toward the row, a much greater amount of soil will be pushed into the row. Conversely, by twisting the shank away from the row, the soil thrown into the row is reduced. Changing the angle of the point to the soil can adjust for hard or soft soil. Under the right soil conditions, setting the points at an extreme angle to the soil can create a bulldozer effect, squeezing the crop row tightly with soil and thereby killing many weeds growing between the crop plants (and burying the rest).

Peter says that it is very important to have a well-equipped toolbox on the tractor, complete with all the sizes of wrenches you might need, along with Vise Grips, hammers and spare shovels. This permits in-field adjustment and repair, saving considerable amounts of time and aggravation. Usually, we try to avoid cultivating in overly wet conditions. When weeks of nonstop rain come at critical times of the year, we sometimes have to go into very wet fields to save the crop. Having a log chain along can be a real convenience during the wet, muddy summers we have known recently.

When cultivating, Peter tries to drive as fast as he can without damaging the crop. This aggressive cultivating takes out the most weeds and, when done well, does little damage to the crop. Higher speed also throws up more of a hill in the row, which can stimulate a greater amount of axillary rooting (especially in corn) and can be more effective in conserving soil moisture. Peter feels that one of the biggest challenges is to correctly identify the ‘guess rows’, or the end rows of the planter where the spacing can vary. Guess rows are called by different names in other parts of the country. If these rows are not correctly accounted for, the cultivator will take out crop.

Rear cultivator at work in a field of corn: Aggressive, or high-speed cultivating, throws up more of a hill in the row, which can stimulate a greater amount of axillary rooting (especially in corn) and can be more effective in conserving soil moisture.

Peter is also careful to do daily preventative maintenance before starting each day, thoroughly servicing both the tractors and the cultivators. He and Shawn make sure that all the grease fittings are filled, all the joints are tightened, and all parts are in proper alignment before they begin each morning. Peter also takes mental notes on each field while cultivating, noticing where there are special weed problems or conditions, and he regularly enters these observations into the master field notebook.

Peter has noticed that soil conditions really affect the ease and effectiveness of cultivation. When soil has had a chance to dry out gradually after a rain, the soil is looser and there are substantially fewer lumps, which allows for greater cultivator speed and a larger hill. Conversely, if the soil is wet, slabby or when the surface dries too fast after a rain, soil lumps or soil ribbons ('turds' in farmer slang) develop and roll onto the plants, doing more crop damage and requiring the cultivator to go much more slowly. If you have to cultivate in wet conditions, twisting a piece of wire around the shovel can help break up the slabs of dirt.

Another logical but often-overlooked point in successful cultivation, was suggested to us by Cliff Peterson. For the second cultivation in a field, he recommends driving the opposite direction on each row. It is important to remember the pattern of the first cultivation and reverse the direction for the second cultivation. This can get weeds that were not fully removed in the first cultivation and can compensate for gaps in cultivator coverage.

Plan on spending a lot of time when you first get out in the field, adjusting the cultivator to get it to work right for the particular field conditions. As Cliff told Klaas when we were starting out, "'Almost' isn't good enough!" Don't be satisfied with 'almost'! In most cases, the first cultivation pass 'makes or breaks it'; the results of the first pass will usually determine whether you are going to have a clean field or not. If you miss the weeds in the row the first time, cultivating more often later in the season will not make up for it.

Adjustments will need to be done continuously through the day as soil moisture and field conditions change and as shovels wear or go out of adjustment. All rows need to be watched for adjustment needs. As you move along, watch all the rows, don't just lock in on only one row. If you don't watch all the rows, you can go along quite a ways—and can do lots of crop damage and miss lots of weeds—before you realize something is wrong.

It is essential to really focus on the rows and the job while cultivating because even a slight drifting in one row can rapidly result in large sections of the corn or bean row being very effectively hoed out. For this and numerous other reasons, we don't like to

use cab tractors to cultivate, because we can better see the rows and the cultivators—and respond must faster—if we are not so isolated. However, we have installed canopies on all the cultivating tractors for operator comfort and safety.

Cultivating can be a very hot, boring job, especially when the crop plants are small. For the sake of the operator's health and attention span—and the health of the crop—it makes good sense bring a water bottle, and to stop if you get sleepy. Staying alert is important. This is both for the sake of safety and for doing a decent job of cultivating. We'll be the first to admit that cultivating can be very monotonous. The 'glamour' of cultivating is much more in the theory and the results than in the actual doing. Stopping for 10 or 20 minutes to nap in the shade is time well-spent if you are having trouble staying alert. Having a snack and some caffeinated beverage can help, as can listening to music or a good 'book on tape' on a head-set cassette player. Carry a cell phone if possible to call for repair parts, a snack, or relief when needed.

Just a reminder—alcohol and gasoline don't mix. Our community has an oft-repeated story of a farmer who didn't believe this to be true and drove his cultivator over the edge of a deep gully twice (with trees fortunately catching the very relaxed farmer and his tractor). Another local farmer can gauge which of his men stayed out too late the night before by the number of 'lightning strikes' in the newly cultivated rows the next day.

Icing on the cake

Our friends Eric and Ann Nordell, who farm about 7 acres of market vegetables with horses in northern Pennsylvania, have done such a good job of cultural weed control that they don't really need to cultivate to get rid of weeds. Their soil is essentially weed seed free, due to conscientious use of cover crops, mulches, and rotation. Yet the Nordells still cultivate their crops to achieve the other important benefits of cultivating. Eric says they cover crop for weed control and cultivate to control moisture.

We agree and have noticed how crops will green up and 'jump', growing noticeably taller soon after each cultivation. Loosening and letting air into the soil keeps it aerobic and stimulates soil organisms. It also stimulates nitrogen mineralization and nutrient cycling in the soil, and the CO_2 that escapes from loose, freshly cultivated soil enhances crop growth.

In-row cultivation is in many ways the heart of what makes an organic farm productive and successful, especially on grain farms where weeds are the primary challenge. However, like the heart of an organism, cultivation works best when it is part of a complex and well-coordinated choreography of soil improvement, crop rotation, cultural methods, and other mechanical weed control operations, along with cooperation with the weather.

When all that happens, the healthy weed-free rows of organic crops are indeed a beautiful sight. NF