Fact Sheet Series 22-2

Blind Cultivation for Early-Season Weed Control in Organic Grains

SUMMARY

- Blind cultivation provides early-season control of both in-row and inter-row weeds, giving crops a competitive advantage and improving effectiveness of row cultivation later in the season.
- It is commonly used in organic corn and organic soybean production systems.
- It targets weeds germinating above the crop planting depth; germination depths for common weeds are in Table 1.
- Timing is critical because it is most effective against very young weeds.
- Tine weeders and rotary hoes are commonly used for blind cultivation, details on these tools are included below.
- Crop-specific recommendations are included in Tables 2-5.

INTRODUCTION

Successful weed management on organic farms integrates DIRECT control tactics that terminate weeds (e.g., tillage, flaming and weed zapping) with INDIRECT tactics that reduce weed pressure (e.g., higher crop populations, extended crop rotations and other practices that promote weed seed dormancy and mortality). This factsheet focuses on a multi-functional tactic called blind cultivation that efficiently terminates very young weeds AND reduces weed pressure by creating a soil surface zone unfavorable for germination. While the immediate impact of blind cultivation is not visually dramatic, the return on investment is often high, because blind cultivation is fast, cheap and targets the most vulnerable stage in the life cycle of many annual weeds.

UNDERSTANDING THE VALUE OF BLIND CULTIVATION

Early season weed control should be a high priority on organic farms because it gives crops competitive advantage and improves the effectiveness of row cultivation later in the season (1–3). Blind cultivation is an early season practice that targets weeds germinating above the crop seeding depth, so it is most appropriate in crops planted ≥ 2" and most effective in controlling weed species that germinate near the soil surface. It is commonly used in organic corn and soybean production systems but can be used in small grains including oats, barley and wheat (4) and in some vegetables.

Timing of blind cultivation is critical because it most effectively controls weeds between germination and emergence (the white thread stage) but recently emerged weeds can be controlled by aggressive blind cultivation. The most popular tools for blind cultivation are tine weeders and rotary hoes but other types of harrows are also used. Timing, tools and management for specific crops are discussed in subsequent sections.

MANY FACTORS IMPACT EFFECTIVENESS OF BLIND CULTIVATION

Planting depth: This is the first consideration for effective blind cultivation. There must be sufficient space for soil disturbance above the crop seed. This is one of the reasons why many organic farmers plant deeper than is typical on conventional farms with the same soils and crops. Other reasons may include soil drying after seed bed preparation, cloddy seed bed conditions and less concern about crusting because of the routine use of blind cultivation. Many annual weeds have very small seeds that typically germinate near the soil surface allowing termination and inhibition of germination by blind cultivation. Blind cultivation is much less effective in controlling annual weeds that commonly germinate from > 2" and has almost no effect on perennials. Emergence depths of some common Midwestern weeds are shown in table 1.

Timing: Blind cultivation is often performed both pre-emergence and during the first several weeks post-emergence before the crop is large enough for row cultivation. Blind cultivation before crop emergence is especially important for terminating early germinating

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Table 1. Emergence Depth for Common Midwestern Weeds

	OPTIMUM EMERGENCE DEPTH	NOTES
FOXTAIL	0.5–2.0"	Gemination from greater depths is poor and negligible below 4" (3)
VELVET LEAF	0.5–1.0"	Variable emergence at 2–3" and rare below 3" (3)
COMMON LAMBSQUARTERS	0.1–0.2"	Few seedlings emerge from deeper than 1.2" (3)
COMMON RAGWEED	1.0–2.0"	Some can emerge from 3.1", none emerge below 4" (3)
GIANT RAGWEED	0.5–2.0"	Many can emerge from 4" but none from 8 inches (3)
WATERHEMP	1" or less	Estimated based on seed size and related species (no direct studies, [3])
REDROOT PIGWEED	0.2–0.8"	Studies show a range of optimum emergence depths (3)

weeds in soil firmed during the planting operation (e.g., planter tractor wheel tracks and row zones). It is also a prime opportunity for controlling in-row weeds with minimal risk to the crop and is considered by many the most important timing for blind cultivation. Blind cultivation is also valuable post-emergence when the crop is better anchored and more tolerant of mechanical impact than very young weed seedlings and when germination of weeds can be delayed by a loose dry soil surface zone (sometimes called a dust mulch). It is important to pay attention to both crop stage and weed stage because if the weeds are too well anchored, it may not be worth the risk of damage to the crop.

Blind cultivation is most effective against shallow-rooted weeds when they are in the white thread stage (see photo) and decreasingly effective each day after weed emergence. Weeds in the white thread stage are not readily visible, and their growth is controlled by environmental conditions rather than the calendar so the best way to know when weeds are at this critical stage is to look for them by scratching the soil surface. Once weeds are past the white thread stage, they become increasingly resistant to termination by blind cultivation, so it is wisely stated that "one day early is better than one day late". It is also important to note that if too much time passes between blind cultivation and crop emergence, the next flush of weeds may occur when the crop is brittle or poorly anchored and thus more sensitive to damage during blind cultivation. Some farmers target the first blind cultivation ~ 3 days after planting and a second pass shortly before crop emergence but many farmers only do 1 pass shortly before emergence. Since blind cultivation normally obscures the tracks from the planting operation, additional passes prior to crop emergence are unguided unless GPS guidance or tracks strategically left by modified equipment are available. In summary, blind cultivation is most effective when weeds have germinated but not yet emerged and weather conditions promote rapid soil drying but many farmers have observed significant benefit with less than optimal weather conditions and rules of thumb (first blind cultivation ~3 days after planting) should be adjusted based on timing of pre-plant tillage and weed and crop growth stage.

Weeds mostly in the white thread stage

Photo credit: Matron of Husbandry. Available at https://matronofhusbandry.wordpress.com/2011/06/24/dont-fear-the-weeds/

Soil conditions: Blind cultivation is most effective when the zone of soil disturbance is intensively fractured causing white thread weeds to become disconnected from moist soil and rapidly desiccate. This is easiest to achieve when the soil has good tilth and has dried after a rain, creating a surface crust that is shattered during blind cultivation. If soil is too wet during blind

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cultivation, the soil will not fracture properly and tractor wheel tracks will not be removed, resulting in more germination of weeds in the tracks. Surface roughness (e.g., small ridges and valleys) can increase the action of blind cultivation tools because they tend to have a leveling effect, but excessive cloddiness will impede their effectiveness. Residues incorporated in the zone of soil disturbance can increase the action of blind cultivation tools but can also cause plugging or raking to occur if the blind cultivation tool is not designed for a high residue environment.

EQUIPMENT AND CROP-SPECIFIC RECOMMENDATIONS FOR BLIND CULTIVATION

The tools most commonly used for blind cultivation are discussed in detail in the following sections:

Key factors impacting the performance of tine weeders

Tool design and operation: Tine weeders (also called tined weeder, flex-tine weeder, weeding harrow, or flexible harrow) have flexible, narrow-diameter tines (typically 5-8mm) mounted on bars (typically 1 or 2 tines per foot of bar width) that are grouped into gangs (typically 3-8 bars each spaced ~ 12" apart). Each gang has 9-12 off-set tines per foot of gang width (1-1.5" between points of soil contact). Multiple gangs are attached on a tool bar that is normally designed to fold if the total width is greater than 10'.

Tines are made of spring steel and vibrate side to side as they are pulled through the soil (typically 1-2"deep). This action terminates very young weeds by a combination of desiccation and burial. It also creates a loose zone of surface soil that is unfavorable for germination and capillary rise. The aggressiveness of soil fracturing is adjusted by changing the contact angle of the tine tips, changing the down pressure on the tines (by adjusting the height of the gangs and/or tension on the springs) and by changing ground speed (5). Adjustability makes tine weeders more versatile than other types of harrows (6). Tine weeders work best in loose or lightly crusted soil and perform well in stony soil. Abundance, size and moisture content of residues reduce flow through tines and can result in raking (1,2). Models with fewer tines per lateral foot and greater spacing between bars allow more residue flow.

Over time, the tine tips tend to sharpen. Sharpened tips cause more damage to crops and less lateral fracturing of soil. Sharpened tips can be clipped off, but other parameters will need to be adjusted to achieve the same performance with shorter tines.

Tine characteristics and gang attachment on the tool bar both impact the action of a tine weeder. The springiness of the tines increases as tine length increases and decreases as tine diameter increases, but also depends on type of steel and coil design. Most often the tine tips are bent at angles ranging from 45° to 85° but straight tines are also available. Tines with 45° tip angles are good for most situations and work well with corn and soybeans. Tines with 85° tip angles penetrate deeper, which can work well with tap-rooted crops like soybeans but can be too aggressive for crops with a fibrous root system like corn and small grains. For small grains, 45° to 60° tip angles work best while 85° tip angles tend to uproot them. Stiff straight tines can effectively bury weeds but can also bury crop seedlings and are more appropriate for use pre-emergence. Rigid mounting of gangs on the tool bar results in more aggressive action while suspension from chains is gentler on crops. Tine weeders are typically operated between 4 and 8 mph but optimal speed varies depending on tool design and setting, soil conditions and crop growth stage.

Tine Weeding Pre-Emergence

Photo credit: Joel Gruver

Crop considerations: Tine weeders are most commonly used for corn, soybeans and small grains, with crop-specific adjustments (e.g., timing and depth of tine penetration) needed to maximize weed control

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Table 2 . Tine weeding condations for soybean by crop stage and weed stage.

	BEFORE EMERGENCE	CROOK	COTYLEDON	1ST UNIFOLIATE	1ST TRIFOLIATE	4-8" TALL	8-20" TALL
WEED STAGE	White thread	Not advised	White thread until 2-3 leaves				Not advised
SPEED	5-7 mph		1 mph	2 mph	3 mph	4 mph	
TINE AGGRESSIVITY	Moderate-high		Low	Low-moderate	Moderate	High	
DAMAGE TO CROP	None-low	High	Moderate	Low	Low	Low	High

Adapted from (7) by Vereecke and Gruver.

Table 3. Tine weeding recommendations for corn by crop stage and weed stage

	BEFORE EMERGENCE	COLEOPTILE to 2 LEAVES	3-4 LEAVES	4-6 LEAVES
WEED STAGE	White thread	Not advised	White thread until 2-3 leaves	
SPEED	5-7 mph		2 mph	2-3 mph
TINE AGGRESSIVITY	Moderate-high		Low	Low-moderate
DAMAGE TO CROP	None		Low to high*	Leaf tearing

Adapted from (7) by Vereecke and Gruver. *Depending on rooting depth.

and minimize crop damage. Timing recommendations for corn and soybeans based on crop stage and weed stage are provided in Tables 2 and 3. It is important to consider both crop stage and weed stage because if weeds are too established, it is difficult to achieve a desirable balance between weed control and crop damage. Tine weeding of soybeans during their fragile crook stage normally causes major stand loss, but final populations < 100k may be considered acceptable by some farmers if a high level of weed control is achieved. After soybeans have well developed taproots, they are surprisingly tolerant of aggressive tine weeding but some soybean varieties are more tolerant than others. Corn plants are most fragile from emergence to the 2-leaf stage. Larger corn plants are more robust but plants knocked over or partially buried during tine weeding are unlikely to fully recover. As a result, some farmers only use tine weeding pre-emergence in corn.

Soil conditions: Tine weeders can perform well in stony soils but hard crusts are problematic. When residue is moist, too abundant or poorly sized, tine weeders tend to rake residues. Soils with good tilth allow optimal soil crumbling and flow during tine weeding.

Timing: Ideally, the first pass with a tine weeder is timed so that the next flush of weeds doesn't emerge before a) the next blind cultivation OR b) when the crop is in a stage that is especially vulnerable to damage during blind cultivation (Tables 2 and 3). Some growers recommend waiting to perform the first pass until a few weeds have emerged. Tine weeding while crops are in a vulnerable stage requires careful consideration of the desired balance between weed control and crop damage.

Key factors impacting the performance of rotary hoes

Tool design and operation: Most rotary hoes have 1 or 2 rows of rotating spoon wheels comprised of 16 spokes with spoon shaped tips commonly referred to as "spoons." The spoons penetrate, fracture and flick out soil and small weeds as they rotate (5) but are less likely to damage or bury crops than tine weeders. The wheels are generally 3 inches apart and spoons penetrate the soil surface approximately every 2 inches as they rotate (8). Rotary hoes are typically set to penetrate ~2 inches but some farmers routinely target deeper penetration. Surface residues can plug spoon wheels, but models are available that can handle high levels of residues without plugging (2,5). Spoons become narrower as they wear and must be replaced or rebuilt to maintain the action of newer spoons (9). Some farmers follow a schedule for replacing spoons (e.g., every 3000 acres). Penetration can be increased by the addition of helper springs that double down-pressure from 18 to 36 lbs (10).

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Crop considerations: Rotary hoes are commonly used for corn, soybeans and cereal grains. Timing recommendations based on crop stage and weed stage for corn and soybean are provided in Tables 4 and 5. Rotary hoeing of soybeans during the fragile crook stage can cause significant stand loss but this may be an acceptable trade-off if good early season weed control is achieved. Post-emergence hoeing of corn is less likely to cause crop damage than tine weeding.

Soil conditions: Rotary hoes can perform well on crusted soils, but stony soils are problematic. Stones can damage spoons and also can cause wheels to jam and drag which will cause major damage to crop rows if the jammed wheel is located in a row. When soil is too wet, a rotary hoe may just poke holes. When soil is too hard, it is difficult to achieve adequate penetration.

Timing: Rotary hoes are most effective when weeds are in the white thread stage. Timing is critical because after emergence, many weeds will survive rotary hoeing unless the hoe is operated more aggressively. Options for increasing control of emerged weeds include: shattering a dry crust formed after an intense rain, surface roughness that is leveled during hoeing, greater depth of penetration, higher ground speed (keeping in mind that excessive speed can cause skipping) and double hoeing in opposite directions.

Rotary Hoeing Post-Emergence

Photo credit: Joel Gruver

CONCLUDING THOUGHTS

Intensive use of blind cultivation is a common thread connecting many organic farmers who are recognized for effective weed management. These farmers generally plant high initial populations and are willing to accept significant stand loss (especially soybeans) in pursuit of a high level of early season weed control. They tend to perform blind cultivation a day early rather than a day late and modify and upgrade their tools to maintain aggressive action. They often combine the use of multiple tools. For example, tine weeders and rotary hoes are discussed separately here but many farmers own both and use them in sequence (e.g., tine weed pre-emergence but rotary hoe post-emergence in corn). Also, if the first row cultivation

Table 4. Rotary hoeing recommendations for soybean by crop stage and weed stage

	BEFORE EMERGENCE	CROOK	COTYLEDON	1ST UNIFOLIATE	1ST TRIFOLIATE	4-8" TALL	8-20" TALL
WEED STAGE	White thread		White thread until 1-2 leaves				Not advised
SPEED	9-12 mph	<6 mph	6 mph (max)	7-9 mph	9-12 mph		
DAMAGE TO CROP	None	Moderate-high	Moderate-low	Very low	None		

Adapted from (7) by Vereecke and Gruver.

Table 5. Rotary hoeing recommendations for corn by crop stage and weed stage

	BEFORE EMERGENCE	COLEOPTILE	1-2 LEAVES	3 LEAVES	4-5 LEAVES	6-7 LEAVES
WEED STAGE	White thread		White thread until 1-2 leaves			
SPEED	9-12 mph	6 mph	6 mph (max)	7-9 mph	9-12 mph	
DAMAGE TO CROP	None	Moderate to high	Moderate	Low	Very low	Stem breakage

Adapted from (7) by Vereecke and Gruver.

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occurs when the crop is still small, some farmers follow with a blind cultivation pass that shatters soil from weed roots and improves the effectiveness of the row cultivation. In conclusion, blind cultivation is both a DIRECT and INDIRECT weed control tactic that can be highly effective when used at the right time and aggressiveness to achieve early season weed control within a soil tilth building cropping system.

Tine Weeder vs Rotary Hoe

- **Timing:** *Timing is more critical with a rotary hoe because the rotating action is typically less effective at removing emerged weeds than the continuous dragging action of a tine weeder.*
- **High surface residue:** *Residue can pose a challenge for both tools, but the rolling action of a rotary hoe is less likely to plug than the dragging action of a tine weeder and high-residue rotary hoe models are available.*
- **Soil types:** *Rotary hoes perform better on crusted soils than tine weeders. Tine weeders perform better in stony soils than rotary hoes, which are more likely to get damaged or jammed by stones.*
- **Ground speed:** *Rotary hoes are typically operated 1.5 – 2x faster than tine weeders.*
- **Overall performance:** *Tighter spacing of soil contact points (1-1.5" vs. 3") and continuous soil contact (vs. penetration approximately every 2") enables tine weeders to operate more aggressively and generally control more weeds than rotary hoes (6). One study found that tine weeding provided 80-90% weed control vs. ~80% for rotary hoeing; however, both methods can have variable results, with weed control as low as 20-30% (11).*

REFERENCES & FURTHER INFORMATION

Resources and videos in bold are especially recommended for further information

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We host a variety of events, support a producer listserv (join by emailing join-ograin@lists.wisc.edu) and provide resources for organic grain farmers.

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