

# MECHANICAL WEEDING EQUIPMENT

## FOR FIELD CROPS

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# The five most commonly asked questions about mechanical weeding equipment

## Question 1: How do mechanical weeders kill weeds?

Principles of action

### Rotary hoe



Spindled wheels with small spoons on the ends churn the soil surface.

Result: weeds are uprooted, buried or mutilated.

### Flex-tine harrow



(Photo: Einböck).

Springed tines in comb formation vibrate to disturb the soil surface.

Result: weeds are uprooted, buried or mutilated.

### Row cultivators



Sweeps, shaped like goose feet, work the soil sub-surface.

Result: small weeds are uprooted, buried or mutilated, larger ones are sheared off.

Stages of vulnerability for annual weeds



Optimal efficiency at the "white thread" stage.

Medium effectiveness at the cotyledon stage.



The aggressive action of the tines enables the destruction of weeds that have their first real leaves.



Depending on the model, they can kill weeds up to 4, 6 or even 12 in. high (10, 15 or 30 cm).

Perennial weeds

### Horsetail



### Quack grass



### Yellow nutsedge



Rotary hoes and flex-tine harrows have no effect on well-established perennial weeds. Row cultivators will slow their growth.

## Question 2: Can mechanical weeders damage the crop?

The use of a mechanical weeder does not affect crop yield if some basic rules are followed:

### Precautions to be taken with mechanical weeding

	Rotary hoes and flex-tine harrows	Row cultivators
<i>Seeding depth</i>	<ul style="list-style-type: none"> <li>♣ Seed at least 4 cm deep (1 1/2 in.) if preemergence cultivation is planned.</li> <li>♣ No modification necessary if there is no preemergence cultivation.</li> </ul>	<ul style="list-style-type: none"> <li>♣ No modification.</li> </ul>
<i>Seeding density</i>	<ul style="list-style-type: none"> <li>♣ Increase by 5-10%.</li> </ul>	<ul style="list-style-type: none"> <li>♣ No modification.</li> </ul>
<i>Seeding precision</i>	<ul style="list-style-type: none"> <li>♣ Seed at a uniform depth.</li> <li>♣ Do not leave unseeded patches.</li> </ul>	<ul style="list-style-type: none"> <li>♣ Seed at a uniform depth and with rows that are as straight as possible.</li> </ul>
<i>Equipment adjustment</i>	<ul style="list-style-type: none"> <li>♣ Adjust the equipment over a short distance before starting the rest of the field.</li> <li>♣ There should be less than 4% of the crop plants damaged (completely buried or uprooted).</li> </ul>	<ul style="list-style-type: none"> <li>♣ Adjust the equipment over a short distance before starting the rest of the field.</li> <li>♣ The sweeps should not cut the roots of the crop nor bury the plants excessively.</li> </ul>
<i>Stages of crop plant growth</i>	<ul style="list-style-type: none"> <li>♣ Avoid weeding when crops are at a vulnerable stage (see pages 18-23).</li> </ul>	<ul style="list-style-type: none"> <li>♣ Avoid weeding when crops are at a vulnerable stage (see pages 6-17).</li> </ul>
<i>Additional precautions</i>	<ul style="list-style-type: none"> <li>♣ Do not weed if crop is showing signs of drought stress or nutrient deficiencies.</li> </ul>	<ul style="list-style-type: none"> <li>♣ Use row shields when necessary.</li> <li>♣ Select a cultivator with the same width as the seeder.</li> <li>♣ Use a guidance system for increased speed and precision during weeding.</li> </ul>



*Example of cultivation between rows of corn that lacks precision and adjustment.*



*Example of cultivation between rows of corn that cut nodal roots, which are important for the absorption of water and nutrients. Cultivation was too close to the row and too deep for the corn's growth stage.*

## Question 3: Is mechanical weeding really effective?

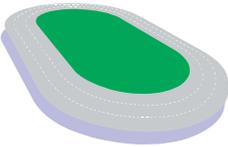
Mechanical weeding can be compared to car racing. The performance of the car depends on three main factors: the quality of construction, the ability of the driver and the conditions of the track during the race.

In the same manner, mechanical weeding can be effective if:

1. the selected weeding equipment has a high weed control capacity;
2. the weeding equipment is properly used and maintained by the producer;
3. the farm has characteristics that favour mechanical weeding.

The effectiveness of mechanical weeding is optimal when all of these conditions are met at the same time. Herbicide reduction can be as high as 100% while maintaining the same yield as that obtained when herbicides are used and without increasing the accumulation of weed seeds in the weed seed bank. The effectiveness of mechanical weeding decreases if one or more of these conditions are not met.

The potential effectiveness of mechanical weeding on your farm can be evaluated in the following chart. Check the boxes that correspond to your situation. The column with the most checks shows the potential effectiveness of mechanical weeding for your conditions.

					
<b>1. The Equipment</b> 	<b>Row cultivator</b>	<input type="checkbox"/> High-residue cultivator / ridge tiller	<input type="checkbox"/> Moderate-residue cultivator or rolling cultivator	<input type="checkbox"/> Low-residue cultivator	<input type="checkbox"/> Worn out equipment
	<b>Full-width cultivator</b>		<input type="checkbox"/> Flex-tine harrow (p. 22-23) or double rotary hoe (p. 21)	<input type="checkbox"/> Single rotary hoe (p. 19-20)	<input type="checkbox"/> Worn out equipment
<b>2. The Producer</b> 	<b>Meticulous</b>	<input type="checkbox"/> Very	<input type="checkbox"/> Usually	<input type="checkbox"/> Somewhat	<input type="checkbox"/> Not at all
	<b>Observant</b>	<input type="checkbox"/> Very	<input type="checkbox"/> Usually	<input type="checkbox"/> Somewhat	<input type="checkbox"/> Not at all
	<b>Gives priority to mechanical weeding</b>	<input type="checkbox"/> Always	<input type="checkbox"/> Often	<input type="checkbox"/> Sometimes	<input type="checkbox"/> Never
	<b>Ready to tolerate a few weeds if yield is not affected</b>	<input type="checkbox"/> In all fields	<input type="checkbox"/> In most fields	<input type="checkbox"/> In some fields	<input type="checkbox"/> In no fields
<b>3. The Farm</b> 	<b>Crop rotation</b>	<input type="checkbox"/> Including hay	<input type="checkbox"/> Three crops or more	<input type="checkbox"/> Two crops	<input type="checkbox"/> Monoculture
	<b>Reduced fertilization according to the needs of the plants using organic fertilizers</b>	<input type="checkbox"/> In all fields	<input type="checkbox"/> In most fields	<input type="checkbox"/> In some fields	<input type="checkbox"/> In no fields
	<b>Use of green fertilizers</b>	<input type="checkbox"/> Regularly	<input type="checkbox"/> Once in a while	<input type="checkbox"/> Intercrops*	<input type="checkbox"/> Never
	<b>Weed seed bank</b>	<input type="checkbox"/> Low	<input type="checkbox"/> Moderate	<input type="checkbox"/> High	<input type="checkbox"/> Very high
	<b>Targeted crop</b>	<input type="checkbox"/> Cereals	<input type="checkbox"/> Corn	<input type="checkbox"/> Soya at 30 in.	<input type="checkbox"/> Soya at 7-15 in.
<b>Potential effectiveness of mechanical weeding under your conditions</b> ➤		<b>Very good potential</b>	<b>Good potential</b>	<b>Low potential</b>	<b>Very low potential</b>

\* Growing a cover crop between the rows of a main crop.

## Question 4: Does mechanical weeding reduce costs?

Mechanical weeding equipment can often reduce production costs. The amount of reduction depends on the number of passes, the type of equipment used and the crop.

Crop	Mechanical weeding equipment		Chemical
	Strategy	Cost \$/ha*	Cost \$/ha**
Full-width seeding (cereals or soya)	1x hoe	\$11	Cereals \$19 Soya \$110
	2x hoe	\$22	
	1x flex-tine harrow	\$11	
	2x flex-tine harrow	\$22	
Row seeding (corn or soya)	2x hoe + 1x low-residue cultivator	\$35	Corn \$85 Soya \$110
	2x hoe + 2x low-residue cultivator	\$48	
	2x hoe + 1x high-residue cultivator	\$45	
	12 in. herbicide band + 1x low-residue cultivator	\$46	

\* All costs, including amortization (Chouinard *et al.* 2000).

\*\* Includes the cost of spraying (GR-MAX 1997-98-99).

## Question 5: Which mechanical weeding equipment should I choose?

Take into account the crops, the size of the area to be weeded, the presence of trash residue and the soil conditions.

Equipment	Characteristic	Crop	Residues	Soil
Low-residue cultivator	5-7 S-tines	Seeded in rows (corn or soya)	Light	Light
Moderate-residue cultivator	3 C-shank or S-tines		Light to medium	Light to medium
High-residue cultivator	1 rigid C-shank		Light to heavy	Light to heavy
Rolling cultivator	Spider wheels		Light	Light
Standard rotary hoe	Rows of close-set wheels	Seeded in rows (corn or soya)	Light	Light to heavy with a crust formation
Minimum-till rotary hoe	Rows of wider-set wheels	or full width seeding	Light to heavy	Light to heavy with a crust formation
Flex-tine harrow	Rows of tines	(cereals or soya)	Light	Light

Total area to be weeded	Recommended width	
	Rotary hoe	Flex-tine harrow
25 ha	3,0 m / (10 ft.)	4,5 m / (15 ft.)
50 ha	4,5 m / (15 ft.)	6,0 m / (20 ft.)
75 ha	6,0 m / (20 ft.)	9,0 m / (30 ft.)
100 ha	7,5 m / (25 ft.)	12,0 m / (40 ft.)
125 ha	9,0 m / (30 ft.)	12,0 m / (40 ft.)

This chart takes into account the speed of the equipment pass, a working window of two days and normal probability of rain. The widths indicated are sufficient for the majority of production years, even rainy ones.

Total area to be weeded	Recommended width (number of rows)	
	Row cultivator	Rolling cultivator
50 ha	4	4 or less
75 ha	6	4
100 ha	6 or 8	4
125 ha	8	6
250 ha	16	8-12

This chart takes into account the speed of the equipment pass, a working window of six days and normal probability of rain. The widths indicated are sufficient for the majority of production years, even rainy ones. Choose a cultivator with the same width as the seeder.

# LOW-RESIDUE CULTIVATOR

## Weeding Stages

■ Good   
 ■ Moderate   
 ■ Bad

<b>Weeds</b> (Stage or Height)	White thread	Cotyledons	First leaves							
				2"	4"	6"	8"	10"		
<b>Corn</b> (Stage or Height)	Preemergence	Point of emergence	Spike	2 leaves	4 leaves	6 leaves				
							18"	24"	30"	
<b>Soya</b> (Stage or Height)	Sprouted	Preemergence	Hook	Cotyledons	First leaves					
							18"	24"	30"	
<b>Cereals</b> (Stage or Height)	Sprouted	Preemergence	Point of emergence	1 leaf	2 leaves	3 leaves	4 leaves			
<b>Crop residues</b> Light	<b>Stones</b> Few to medium and small		<b>Soil</b> Sandy-loam			<b>Price</b> \$6,000 (6-row non-folding) \$10,000 (8-row foldable)				

## TECHNICAL SUMMARY

Low-residue cultivators have 3-7 vibrating S-tines per cultivating unit.

The sweeps break up and aerate the soil surface, pulling out or burying weeds and favouring the incorporation of fertilizer. A low-residue cultivator may throw a small amount of soil onto the crop row, but the amount is less than when a high-residue cultivator is used. The soil is worked at about 1-2 in. of depth and the operating speed varies from 6-10 km/h.

Depending on the manufacturer, low-residue cultivators are available in widths ranging from 2-18 rows, with a foldable frame starting at 8 rows. A low-residue 6-row cultivator weighs approximately 1,300 lbs. and requires a tractor with 50-90 hp.

Low-residue cultivators are used mainly on dairy farms where land is conventionally worked (plowing and harrowing) as they have a tendency to jam when there is too much crop trash. However, it is possible to modify them in order to improve their effectiveness when operating in trash residues (see the section on "Row cultivators - Tips and Accessories").



Weeds destroyed using a low-residue cultivator.



Soil with too much crop trash for a low-residue cultivator.



Each cultivating unit is harnessed to the frame by a parallel bar enabling it to follow the ground level. Pivoting parts require lubrication.



Each cultivating unit has a semi-pneumatic (full rubber) depth control wheel located in front of the tines. It is adjustable by the use of bolts.



A 6-row John Deere low-residue cultivator shows 5 S-tines and a depth control wheel per cultivating unit (3 tines for each exterior unit) mounted on a rigid 5 x 7 in. frame; there are 2 rolling crop protection shields for each row.



On this Kongskilde low-residue cultivator, the depth control wheel adjustment is done with a handle.



The coultter guide stabilizes the cultivator. The spring, which is removed during storage, protects the coultter from stones that it may hit.



Vibrating S-tines also called "Danish tines". This type of tine is intended for shallow cultivation in light soil (1-2 in.). Vertical clearance of 22 in.



Low-residue cultivators have 3-7 tines per cultivating unit. Depending on the make, the width is adjustable to rows ranging from 18-60 in.

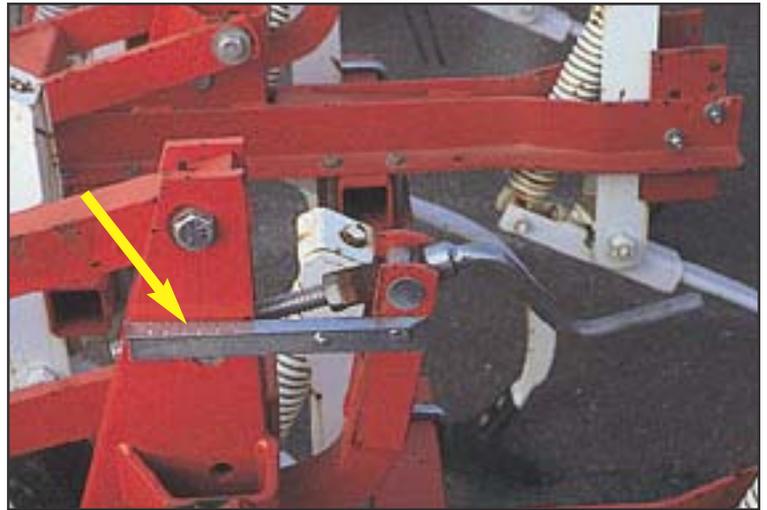


The sweeps overlap to weed in-between the rows, enabling a good incorporation of fertilizer. Notice the rolling shields in the lifted position. Spacing between the disks on the row is 7 1/2 in. The disks offer a vertical clearance of about 7 in. when they are on the soil.





*The tension of the back shank is adjusted by moving the bolts.*



*A handle changes the depth of the wheels. An etched scale facilitates the adjustment.*



*Moderate-residue Wil-Rich cultivator. Three C-shanks per cultivating unit (2 for each exterior unit) and a 5 x 7 in. rigid frame. Pneumatic depth control wheels. Vertical clearance of 24 in.*



*Layout of the 3 C-shanks. The back sweep is 10 in. wide. The front sweeps can have one side sheared off (6 in. width). The total cultivating area of the 3 sweeps is about 18 in.*



*The coulters and the pneumatic wheels give vertical and lateral stability to the cultivator. Note the row shields.*



*The rows shields, spaced between 7-8 in. over the row, protect crops from being covered over by soil and are used mostly when crops are young (corn at 4-6 leaves). Some farmers do not use row shields, preferring to reduce speed in order that less soil is thrown onto the rows.*

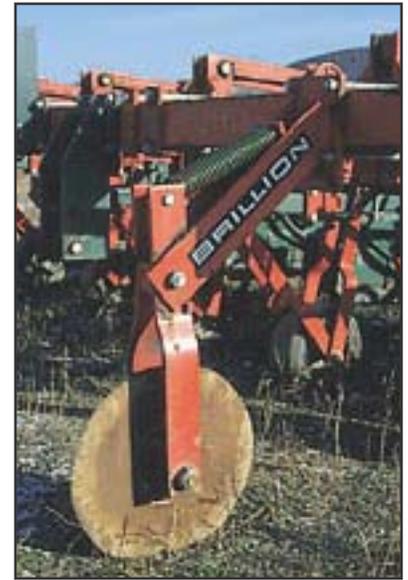
# MODERATE-RESIDUE CULTIVATOR

## WITH S-TINES

**Weeding Stages:** similar to those for a moderate-residue cultivator with C-shanks



Three tines per row unit (except for both exterior units). The sweeps on this Brillion cultivator cover a 13-in. width between rows. However, the soil has been churned and thrown over a wider surface area. The cultivation width is adjustable for rows spaced between 28-40 in. At this growth stage of corn, the cultivator could be used without the row shields. However, the shields are useful when corn is less than 4 in. (Photo: Club de fertilisation de Beauce).



Springed stabilizing coulter.

## TECHNICAL SUMMARY

C-shanks are generally found on moderate-residue cultivators but S-tines (more robust than those found on a low-residue cultivator) can be used successfully as well. S-tines usually cultivate the soil better, which can be advantageous when incorporating liquid manure, for instance.

The Brillion moderate-residue cultivator shown here is available in widths ranging from 4-12 rows, with a folding frame starting at 8 rows. An 8-row foldable model weighs approximately 3,500 lbs. and is used in the same way as a C-shank moderate-residue cultivator.



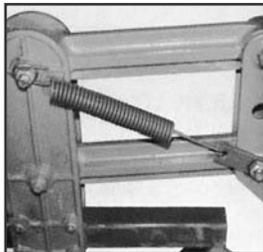
Cultivation units on moderate-residue cultivators are longer than those of low-residue cultivators in order for a better flow-through of crop trash. Row shields are 12 x 48 in. and the height is adjusted with chains. (Photo: Club de fertilisation de Beauce).

### CULTIVATING BETWEEN ROWS IS ADVANTAGEOUS

The advantages of crop cultivation are obvious and can mean a slight increase in yields. Cultivation stimulates mineralization of nitrogen, limits the water losses from the soil by breaking the surface capillarity, and promotes better anchored and more vigorous corn plants.

Some producers combine cultivation between rows with other operations such as the application of nitrogen and the local or band application of herbicide. Others cultivate after an application of liquid manure at postemergence in order to incorporate it into the soil.

*A spring can be installed on each parallel bar to increase pressure in heavy or packed soils. (Photo: Brillion).*



*Sturdy parallel bar. Pneumatic depth control wheel 4 x 16 in., adjusted by bolts (1 in. between 2 holes).*



*S-tine, stronger and longer than that of a low-residue cultivator.*



*Moderate-residue 4-row Brillion cultivator in corn at the 7-8 leaf stage. Three sturdy S-tines and a depth control wheel per cultivating unit (2 tines at each exterior unit). A 5 x 7 in. rigid frame with a vertical clearance of 25 in. Two row shields for each row and one coulter. (Photo: Club de fertilisation de Beauce).*



*The sweeps are 7 in. wide. They are attached with 2 bolts and have 3 adjustment holes. This enables setting the central sweep deeper than the other two sweeps.*



*Corn field where the right-hand section has just been cultivated. At left, the condition of the crop trash before a cultivation pass. (Photo: Club de fertilisation de Beauce).*



*A sweep with one side sheared off can be used to get closer to the crop row.*

# HIGH-RESIDUE CULTIVATOR

## Weeding Stages

■ Good   
 ■ Moderate   
 ■ Bad

<b>Weeds</b> (Stage or Height)	White thread	Cotyledons	First leaves						
<b>Corn</b> (Stage or Height)	Preemergence	Point of emergence	Spike	2 leaves	4 leaves	6 leaves			
<b>Soya</b> (Stage or Height)	Sprouted	Preemergence	Hook	Cotyledons	First leaves				
<b>Cereals</b> (Stage or Height)	Sprouted	Preemergence	Point of emergence	1 leaf	2 leaves	3 leaves	4 leaves		
<b>Crop residues</b> Light or heavy (up to 60%)	<b>Stones</b> Up to 10 lbs.			<b>Soil</b> Sandy-loam-clay (light to heavily packed)			<b>Price</b> \$25,000 (8-row)		

## TECHNICAL SUMMARY

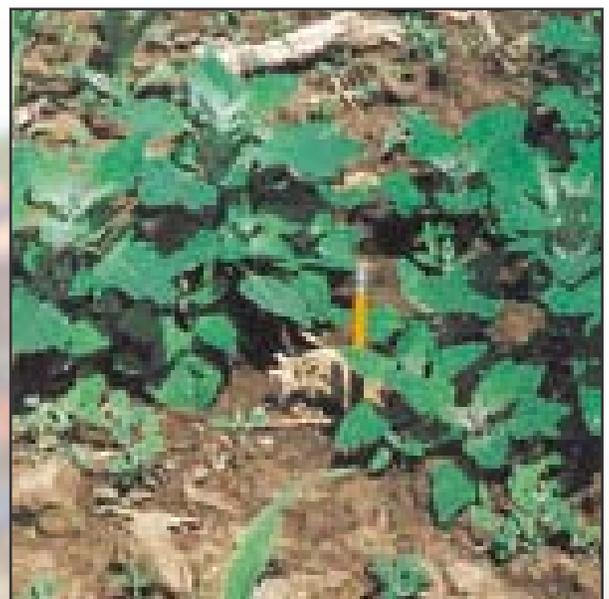
The high-residue cultivator has one rigid shank per cultivating unit.

It is ideal for farms using different methods of reduced soil tillage. Its weight facilitates penetration of the shank in the soil and the chopping of crop trash. Available in widths ranging from 4-24 rows, it requires about 12 hp per cultivating unit at speeds varying between 6-10 km/h. It is usually equipped with C-shanks even though some have sturdy S-tines for improved soil cultivation.

Cultivation can be performed early in the season (1st trifoliate leaf for soya, 4-6 leaves for corn). Cultivate deep enough (2-4 in.) as the aim is to have a deep seedbed that will facilitate subsequent ridge tilling.

Ridging is usually performed when corn is 18-24 in. high. Make a fairly flat 8-in. ridge rather than one that is pointed. Row shields can help make flatter ridges. Ridging earlier in the season, but in a lighter fashion, is also possible when corn is at the 7-leaf stage.

The combination of a high-residue cultivator and ridging is probably the best non-chemical weeding method for row crops. However, this method must always be combined with another in-row weeding technique: a pass with a rotary hoe, the application of banded herbicide or a good break-up of the ridge during seeding which will throw the weed plants and seeds between the rows.



Example of weeds that will be easily killed by a high-residue cultivator.



A 17-21 in. sweep cuts down weeds in between the rows. The crumbled soil is pushed on to the rows by a ridging wing in the back. The ridging wing can be lifted when cultivation is required.



Ridge tilling in corn using a Buffalo cultivator. The ridging wing pushes the soil onto the row to bury weeds about 3-6 in. high. (Photo: Ferme Monlou).



Open-top row shields allow the plants to pass through unharmed and are useful during ridging when corn is 18-24 in. high. (Photo: Ferme Monlou).



Hiniker high-residue cultivator with 7 x 7 in. frame. One C-shank and one ridging wing per cultivating unit. Springs give 500-800 lbs. of weight per shank. An 8-in. press wheel and coulters to chop up crop trash. Vertical clearance of 32 in.



Very effective cultivation device in soya. Two angled disks cut the soil near the row and push it in-between the rows. The wide sweep kills the weeds in-between the rows. (Photo: Ferme Monlou).



Early cultivation of soya at 1st trifoliate leaf stage. Ridging wings are raised and row shields lowered. Notice how easily this equipment can cultivate even when trash residue is present.



A narrow 5-in. band of soil is left after cutting by disks. On each side the soil is stirred by the sweep, bringing the weed roots to the surface to dry.

# ROW CULTIVATORS

Tips and Accessories

## Cultivating close to the row

Cultivating close to the row is advantageous as it reduces the need for herbicides. Here are some accessories to facilitate cultivation close to the crop plants.



**Notched disks.** They cut away the roots in young weeds as close as 4 in. on each side of the crop plants, plus serve as rolling shields to protect small crop plants from the soil thrown into the row. (Photo: Sukup).



**Spindled wheels** from a rotary hoe. Same role and results as notched disks. (Photo: Sukup).



**Ridging/cutting disks.** They cut the soil up to 2 1/2 in. on each side of the plants. Mainly used for early cultivation so that the root systems of crop plants are not damaged. (Photo: Buffalo).

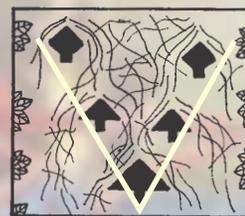


**Ridging wing.** Essential for permanent ridge tilling systems. They can also be installed to make temporary ridges. The soil moved on to the row can bury weeds from 3-6 in. high. However, the weeds will survive if they are not completely buried. (Photo: Sukup).

## CULTIVATING IN TRASH RESIDUE

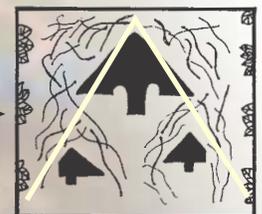
Some 5-tined low-residue cultivators can be modified to work in light to medium amounts of trash residues. Here are some modifications that can be made:

- remove one or two of the tines and put wider sweeps on the remaining tines;
- reverse the layout of the tines so that they form a "Λ" instead of a "V" which allows for the accumulation of crop trash at the base of the "V";
- use tines with a better vertical clearance (26 in.);
- cultivate with enough depth so that the movement of the soil clears any trash from the tines.



◀ Conventional V layout

▶ Λ layout enabling a better flow-through of crop trash



## Precision cultivation

Alignment systems help keep the cultivator sweeps at the right distance from the rows. They are advantageous as they reduce operator stress and fatigue and increase the precision and speed of cultivation.



*Guidance system with a groove marker. A marker installed on the seeder puts a groove in the soil, which allows the tractor to follow a precise path during the first cultivation pass. In this photo, the marker was installed on the cultivator in order to remake the groove for the next cultivation. This type of system is not expensive.*



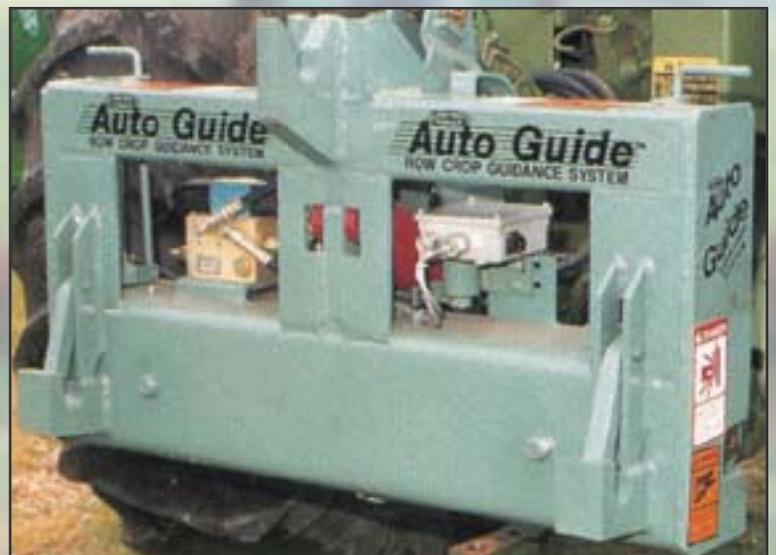
*Electronic and hydraulic guidance system with lateral movement. A hydraulic cylinder moves the cultivator laterally, with the three-point hitch being fixed. The cylinder is operated by an electronic box tied to metal rods that pivot depending on the presence of plants. The cultivator does not have to be equipped with stabilizing coulters. This type of system is sophisticated and fairly expensive. (Photo: Sukup).*



*Raised tire tread used with a marker guidance system.*



*A mirror is used to help control the precision of cultivation, especially during early passes when the crop is too short to activate other guidance systems. A panoramic mirror installed in the cabin or on the side of the tractor can also be used to view cultivation in several rows simultaneously. Note the tire with a single raised tread that follows the mark made by the marker. (Photo: Ferme Monlou).*



*Pivoting electronic and hydraulic guidance system. Hydraulic cylinders make this device pivot forward or backward to change the angle of the sweeps and adjust the alignment of the cultivator. The three-point hitch is mobile and stabilizing coulters must be installed on the cultivator. An elaborate system and fairly expensive. (Photo: Sukup).*

# ROLLING CULTIVATOR

## Weeding Stages

■ Good   
 ■ Moderate   
 ■ Bad

<b>Weeds</b> (Stage or Height)	White thread	Cotyledons	First leaves	2 leaves	4 leaves	6 leaves	8 leaves	10 leaves	
<b>Corn</b> (Stage or Height)	Preemergence	Point of emergence	Spike	2 leaves	4 leaves	6 leaves	18"	24"	30"
<b>Soya</b> (Stage or Height)	Sprouted	Preemergence	Hook	Cotyledons	First leaves	18"	24"	30"	
<b>Cereals</b> (Stage or Height)	Sprouted	Preemergence	Point of emergence	1 leaf	2 leaves	3 leaves	4 leaves	5 leaves	
<b>Crop residues</b> Light (spider wheels) to medium (notched disks)	<b>Stones</b> Light to medium		<b>Soil</b> Sandy-loam (spider wheels) Clay (notched disks)			<b>Price</b> \$11,000 (6-row non-foldable)			

## TECHNICAL SUMMARY

The rolling cultivator is a particularly effective piece of equipment for ridging row crops without damaging their root system. It can be used at a fairly high speed: up to 10 km/h when corn is 6 in. high and around 20 km/h when it reaches 18-24 in. Its action works the surface of the soil from 1-3 in. in depth depending on the effect desired, the soil condition and the adjustment of the equipment. It kills weeds by ripping them out or by burying them.

Spider wheel models are better adapted to light soils with little compaction. Some producers use a row cultivator to loosen the soil before using a spider wheel rolling cultivator. The notched disk model is better suited to minimum tillage conditions and for heavy or packed soils. Stones have a tendency to jam in the spider wheels.

The rolling cultivator is available in widths ranging from 1-12 rows, with a foldable frame starting at 8 rows. A 6-row rolling cultivator weighs approximately 2,000 lbs. and requires a tractor of about 95 hp. There is very little maintenance required for this type of equipment: the spider wheels are tough and remain effective for a long time.

Many accessories can be added to the rolling cultivator: row shields, spring-mounted coulters, mechanical guidance system (tracing a groove in the soil during seeding so that it can be followed during cultivation), soil loosening shanks in line with the tractor wheels, etc.



A 4-row Hatzenbichler rolling cultivator in corn at the 5-6 leaf stage. Two sets of 4 spider wheels per between-row unit (one set for each exterior unit.) The sets, mounted on metal bars, start rolling when they are pulled by the tractor. Frame of about 4 x 5 in. (Photo: Hatzenbichler).



A 6-row Bush Hog-Lilliston rolling cultivator with a 7 x 7 in. rigid frame. Two depth control wheels adjusted with a handle. A set of 5 spider wheels per longitudinal metal bar can be adjusted with bolts. A set of 5 spider wheels can cultivate up to 17 3/4 in. wide when set at the maximum angle. The equipment is adaptable for rows spaced between 20-36 in. Pivots enable each bar to independently follow the ground level. Adjustable springs apply pressure to vary the depth of cultivation. Spring-mounted shanks enable the installation of a sweep for finishing operations. (Photo: Bush Hog-Lilliston).



Notched disks are available for fields with a moderate amount of medium-sized surface residue. Note that there is only one set of notched wheels per bar. (Photo: Bush Hog-Lilliston).



Hatzenbichler rolling cultivator with coulters, a parallel bar supporting each between-row unit and a semi-pneumatic depth control wheel adjusted using a handle. A spring-mounted shank with adjustable depth control precedes a set of spider wheels mounted on the parallel bar.



Front view of a rolling cultivator shows 2 automatic controls guide coulters.



Rear view of the cultivator showing the layout for the sets of spider wheels. The sets can be adjusted to obtain a greater or lesser force of action on the soil: changes can be made to the positioning on the bar, the distance and angle of action with respect to the crop, and the ridging angle. 17



A set of double combs with 5 tines to each row, totally adjustable and removable using bolts. These comb sets kill small weeds in the rows.

# STANDARD ROTARY HOE

## Weeding Stages

■ Good   
 ■ Moderate   
 ■ Bad

<b>Weeds</b> (Stage or Height)	White thread	Cotyledons	First leaves																	
<b>Corn</b> (Stage or Height)	Preemergence	Point of emergence	Spike	2 leaves	4 leaves	6 leaves														
<b>Soya</b> (Stage or Height)	Sprouted	Preemergence	Hook	Cotyledons	First leaves															
<b>Cereals</b> (Stage or Height)	Sprouted	Preemergence	Point of emergence	1 leaf	2 leaves	3 leaves	4 leaves													
<b>Crop residues</b> Light (suitable for conventional tillage)	<b>Stones</b> Light to medium and small		<b>Soil</b> Sandy-loam-clay forming a light crust on the surface (not very effective in unpacked or loosely bound soil)				<b>Price</b> \$7,000 (6 m/20 ft.)													

## TECHNICAL SUMMARY

The standard rotary hoe is mainly used in plowed soils having little crop trash on the surface. It is available in widths ranging from 15-41 ft. A standard 20-ft. rotary hoe requires a tractor of about 70 hp.

This type of equipment must be used at a high speed in order to shatter the soil (10-20 km/h). The higher speed helps kill weeds, and a common mistake is to go too slowly. The main advantage of the rotary hoe is its ability to cultivate large areas in a short time. It is also the only equipment that can cultivate corn at the 1-2 leaf stage.

However, the rotary hoe has major weaknesses. It is not very effective in soils that do not have a light crust on the surface, such as loosely bound or sandy soils, and clay soils that harden. In addition, the window of operation for a rotary hoe is only one or two days. Finally, a rotary hoe wears out faster than flex-tine harrows.

Because of these disadvantages, many farms that plow will purchase a flex-tine harrow rather than a rotary hoe. The ideal situation is to have both pieces of equipment available, especially for farms growing corn.



Most makes of rotary hoe only have one wheel per arm, such as this Hiniker model. Each wheel adapts independently to the ground level. The spacing between the wheels of a standard hoe is always 3 1/2 in. The forward traction applied from the tractor makes the wheels of the hoe turn in the soil.

## Working the soil



When the wheels are spinning, the spoons break and throw the soil from 1-2 in. of depth. The young weeds are destroyed by being buried, pulled up or dried out.



Two springs apply 60-70 lbs. of weight on each arm.



Soil before and after a pass with a rotary hoe. This pass was effective as the entire zone was cultivated, leaving many small clods that facilitate the drying of weed plants.



A standard John Deere rotary hoe with a 4 x 4 in. frame. There are 52 wheels with a 20-in. diameter and 3 1/2 in. spacing, 2 wheels per arm, and 16 spoons per wheel. There is also a protection shield for stones.



A Yetter rotary hoe in action in very dry conditions in corn at the 3-4 leaf stage. The effectiveness of the cultivation was mediocre due to the loosely bound soil, as shown by the heavy cloud of dust.

## Trash and crop residues



Wheels of a standard rotary hoe jammed with trash wrapped around the narrow 1-in. axle. The jammed wheels will pull out crop plants and hinders weed control.



These trash residue conditions will cause plugging in a standard rotary hoe, such as in the picture at the left. A minimum-till rotary hoe must be used in these conditions.



Adequate soil conditions for a standard rotary hoe: little or no surface trash. Note the quantity and size of the stones in the foreground. The rotary hoe is generally not used in more stony conditions, as it would bring more stones to the surface.

# MINIMUM-TILL ROTARY HOE

Weeding stages: similar to those of a standard rotary hoe



A 15-ft. Yetter minimum-till rotary hoe. Two rows of 25 wheels with a 20-in. center-to-center spacing facilitates the trash flow. The lateral distance between the wheels is 3 1/2 in., the same as a standard rotary hoe. Extension arms connect the back set of wheels to the 4 x 4 in. frame. The operator has enlarged the rock shield.



Wide axle to avoid trash plugging.



The trash conditions above should cause little problem for a minimum-till rotary hoe.

## TECHNICAL SUMMARY

The minimum-till rotary hoe is practically the only equipment able to kill weeds in the rows with trash conditions. It is used in the same way as a standard rotary hoe and has the same strengths and weaknesses. It is the type of equipment generally chosen by farmers who carry out, or expect to carry out, minimum soil cultivation. The minimum-till rotary hoe can also be used successfully in fields without crop trash.

## ADJUSTMENTS TO MINIMUM-TILL AND STANDARD ROTARY HOES

- 1) adjust the hydraulic arms so that the equipment is level, both horizontally and vertically;
- 2) completely lower the hydraulic arm for better penetration of the spoon-tips in the soil (raise the arm in areas where the soil is less dense, such as organic soils);
- 3) ensure that maximum speed is reached as quickly as possible as the effectiveness of the rotary hoe depends on speed (at least 10 km/h);
- 4) cultivate when it is safe for the crop and when weeds are at a vulnerable stage;
- 5) cultivate during conditions that facilitate drying (between 10 a.m.-5 p.m. under the sun, or windy conditions);
- 6) try to cultivate when there is a light crust on the surface.



A cultivation pass over 1-2 leaf corn. A minimum-till rotary hoe is used at the same stages of weed and crop growth as a standard rotary hoe.

Minimum-till rotary hoe for use in ridge tilling. It can also be used in non-ridged fields, but a lot of attention is required to stay in line with the rows.



# ROTARY HOES

## Tips and Accessories



The wear on the spoon-tips must be checked every year. Spoons in good condition are shaped like thumbs; worn spoons are shaped like fingers.



Measure the widest part of the spoon-tip to evaluate wear.

17.0 mm = new or almost new spoon, very effective  
 15.5 mm = spoon with medium wear, effective  
 13.0 mm = very worn spoon, not very effective  
 11.0 mm = completely ineffective



A wheel is generally replaced when all the spoon-tips are worn. It is also possible to weld on replacement spoons as shown in the photo. Welding must be perfect so that the spoon-tips do not break.



Storage and greasing of the rotary hoe reduces wear on the spoons.



Remove any obstruction from the wheels (string, wire, rocks, mud, etc.).



Ensure that springs are not broken.



The addition of weight facilitates spoon penetration but is generally insufficient to obtain good results in very packed soils.



A double rotary hoe for ridge tilling modified by the operator:

- the addition of a second frame enables in-row cultivation with 7 wheels spaced at 1 3/4 in.;
- the additional weight enables aggressive cultivation, even in packed soils;
- depth control wheels precisely control the intensity of cultivation. (Photo: Ferme Monlou).



Folding sections for easier transportation.



Improvements to the rock shield by an operator.

# FLEX-TINE HARROW

## Weeding Stages

■ Good   
 ■ Moderate   
 ■ Bad

<b>Weeds</b> (Stage or Height)	White thread	Cotyledons	First leaves																	
<b>Corn</b> (Stage or Height)	Preemergence	Point of emergence	Spike	2 leaves	4 leaves	6 leaves														
<b>Soya</b> (Stage or Height)	Sprouted	Preemergence	Hook	Cotyledons	First leaves															
<b>Cereals</b> (Stage or Height)	Sprouted	Preemergence	Point of emergence	1 leaf	2 leaves	3 leaves	4 leaves													
<b>Crop residues</b> Light	<b>Stones</b> Light to medium		<b>Soil</b> Sandy-loam			<b>Price</b> \$6,000 (6 m/20 ft.)														

## TECHNICAL SUMMARY

The flex-tine harrow is used in light soils with very little trash residue. Vibrating tines work the soil surface (about 1 in. in depth) to uproot or bury weeds. It has a more aggressive action than the rotary hoe and can kill weeds with their first developed leaves. For many dairy farms with light soils containing little trash residue, it is more advantageous and performs better than the rotary hoe.

The passage speed at postemergence varies from 6-12 km/h, and faster speeds can be used at preemergence (10-15 km/h). It is recommended to take the time to adjust the equipment before every pass according to the stage of the crop and the weeds (vary the speed and the tension of the tines). In fields with rocks, the flex-tine harrow has a tendency to dig up the stones and to drag them over a short distance.

In normal conditions, a flex-tine harrow wears out slowly and needs little maintenance. Its resale value is generally high and, along with weeding, it can perform other tasks such as preparing a seedbed, burying seedings of green fertilizer, and manure spread on pastures, etc.

Depending on the manufacturer, flex-tine harrows are available in widths ranging from 10-50 ft. A 20-ft. flex-tine harrow weighs approximately 1,100 lbs. and requires a 40 hp tractor.



Maximum size of weeds killed by a flex-tine harrow.



A Hatzebichler flex-tine harrow in action in a corn field at the 4-leaf stage. Suspended sections follow the level of the ground.

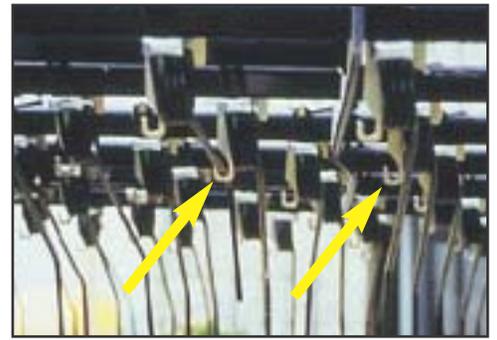


Two pneumatic depth control wheels adjusted with a pin (10 holes). Equipment that is 30 ft. (9 m) or more in width has 2 additional wheels.



A tine positioned every inch works the soil. The tines are 1/4 in. (6.5 mm) in diameter and 17 1/4 in. long (44 cm). Some models have tines up to 5/16 in. (8 mm) in diameter. These tines are more effective in packed soils but lose some of their vibrating action.

## Adjusting the tines



To work the soil every 2 in., tines from the first 3 rows can be hooked up in the hanging supports. Tines next to the rows can also be hooked up if the crop is at a vulnerable stage.



A 20-ft. (6 m) Rabe Werk flex-tine harrow in corn at the 4-leaf stage. Foldable frame. Two depth control wheels. Four 5-ft. wide suspended sections with 60 sprung tines per section.



The pressure of the tines on the soil can be adjusted by modifying the angle with the 2 handles and 5 adjustment holes. Each handle can adjust 3 rows of tines at a time.



◀ A flex-tine harrow can have numerous uses on a farm. (Photo: Einböck).



▲ The flex-tine harrow plugs easily in trash residue: corn stalks, quack grass rhizomes, clumps of turf, etc. This Lely flex-tine harrow rigid frame does not follow the ground level as well as models with suspended sections.



The angle adjustment for the tines on this Hatzenbichler flex-tine harrow is done with a single handle per section and has 10 settings.



On some Lely flex-tine harrow, the angle is adjusted separately for each tine.

## INTEGRATED PEST MANAGEMENT AND EFFECTIVE MECHANICAL WEEDING

Mechanical weeding is an effective means to use in a well-structured, integrated pest management program for weeds. If you are not already practicing integrated pest management, the following principles will help you to greatly improve the effectiveness of mechanical weeding on your farm.

### ✓ CARRY OUT PREVENTIVE DETECTION IN YOUR FIELDS

By walking in your fields you can see the condition of the crops, weeds and soil. Field observation is essential. With current means, and those to come, preventative detection can be quickly performed on large areas. Consider preventative detection as an investment rather than just an expense.

### ✓ TIMING IS IMPORTANT FOR INTERVENTION

If the timing of intervention is important when using herbicides, it is even more important when performing mechanical weeding. The window of intervention is only a few days for using flex-tine harrows and rotary hoes, and 7-10 days for row cultivators. The most common mistake is to cultivate too late because the rate of weed growth was under-estimated or because cultivation was not considered as important as other work on the farm. During the weeding period, the efficient farm operator must constantly be on the alert.

### ✓ TOLERATE WEEDS THAT DO NOT AFFECT YIELDS

It is possible to tolerate a certain quantity of weeds without affecting the economic yield of the crop and without increasing the accumulation of weed seeds in the weed seed bank for the following year. Guides are available to help reduce herbicide use and costs for corn and cereals : The Corn Weed Expert™ and the Cereal Scout's Helper™.

### ✓ USE A SET OF PREVENTIVE MEASURES

Diversified rotations, balanced fertilization, the use of green fertilizers, inhibiting the introduction of weed seeds and good seeding are among the best preventative methods to give crops a competitive advantage over weeds. These preventative measures will reduce the pressure from weeds on the farm and will compensate for some occasional deficiencies of mechanical weeding such as the impossibility to enter a field due to prolonged adverse weather conditions.

### ✓ USE ONLY EQUIPMENT THAT IS EFFECTIVE AND KEPT IN GOOD WORKING CONDITION

Weeds are too threatening to use equipment weakened by wear or that is inappropriate for your soil conditions. Make sure you only use effective weeding equipment in good working condition.

### ✓ TAKE THE TIME TO ADJUST THE EQUIPMENT

The majority of equipment gives you many adjustment possibilities. Use them! Test your equipment over a short distance before cultivating the whole field. Take a few minutes to observe the effect on the soil, on weeds and on the crop. Adjust the equipment according to your own conditions. This will result in the best method for weed control without damaging your crop.

### ✓ INNOVATE

With a little imagination and some testing, you can adapt the equipment to perfectly suit your own conditions and obtain the optimal destruction of weeds.

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## NOTE

The equipment shown in this pamphlet was chosen according to the availability of photos and technical information. The presence or absence of a trademark in this pamphlet in no way indicates a positive or negative recommendation from the organizations that financed this publication. The metric and Imperial measuring units were used according to general use by producers. The prices indicated are those at the retailers in 1999-2000.