

Weed Control in Organic Vegetable Cultivation

During the conversion to organic farming, abandoning the use of herbicides is unquestionably the most difficult hurdle for a vegetable farmer. Without herbicides, farmers lack a sure method to save their crops from being overrun with weeds.

Weed control thus is a main focus in the organic farmer's strategy. Preventative measures can limit the negative effects of weeds and the related costs. The timing of these measures directly affects the amount of manual weeding that is needed and thus also the profitability of the crop.



Weed control, a key factor in growing vegetables

Give the crop a head start

In organic agriculture, weed control involves using a combination of cultivation techniques such that the crop is always more mature than the weeds. The younger the weeds, the more effectively they can be suppressed. They are most sensitive to damage from machines or heat from the time that they sprout until the 2-4 leaf stage. Effective weed control must take place in the early stages of development.

Crops have different periods of sensitivity to weeds

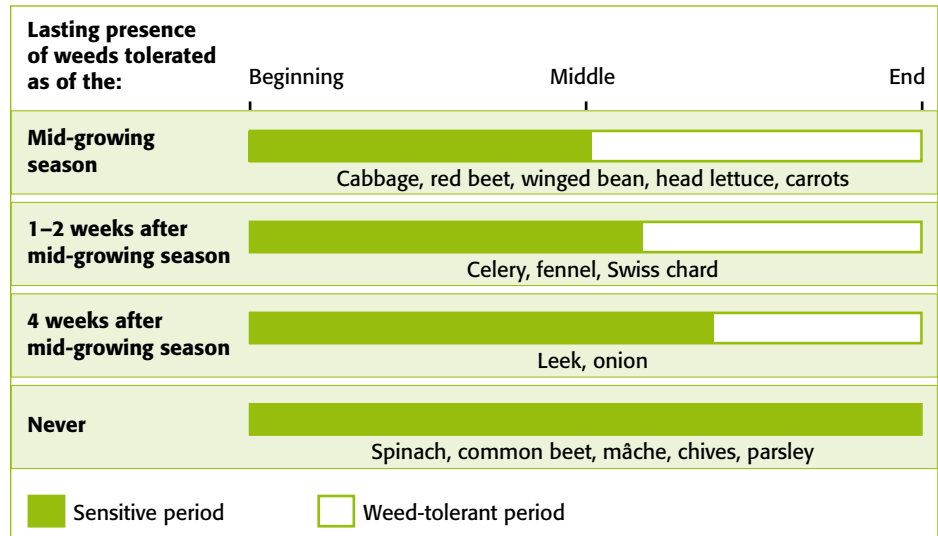
Crops do not necessarily need to be kept free of weeds for their entire growth cycle. However, when they are immature and most susceptible, they must not face competition from weeds. After this time, weeds may grow without damaging the crop. The sensitivity period varies for different crops based on how quickly they grow. In general, it is sufficient to control weeds until the end of the first half of the growing cycle. However for non-competitive or moderately competitive crops, weed control must continue for 2–4 additional weeks so that weeds do not disperse their seeds or impede machine harvesting.

In order to maintain a clean product, leafy vegetables must be weeded until harvest.

The amount of manual labor determines profitability

Aside from harvesting, weed control is the operation that requires the most labor. The workload depends on how much manual weeding must be done. While manual weeding requirements are generally low for field crops, they can be quite high for seeded vegetable crops such as carrots, onions, red beets, spinach and sweet corn. If bad weather prevents the cultivator from being run, the manual labor load can increase significantly.

Weed sensitive periods of vegetable crops



The break-even point is established on the product's selling price. In general, if the cost of manual weed removal (22.5 CHF/H) surpasses 1/3 of the gross product sales, then it is practically impossible to make a profit. Often it is more cost-effective to plow under a crop that is too overrun with weeds and reseed. However, this decision must be made quickly, before too much labor has already been invested.



Even when weeds are not threatening crops, selective manual weeding can be useful to prevent the dispersion of unwanted seeds.

Positive secondary effects

Mechanical weed control also is a means of working the soil. It serves to break up compressed soils after long periods of rain. Operating a cultivator under optimum conditions also aerates the soil, which provides oxygen to plant roots and microorganisms and encourages the mineralization of organic nitrogen.



Labor time for manual weeding of some vegetable crops (in labor units/ha)

	Goal	Acceptable for open-field cultivation	Upper limit for early produce and tunnel cultivation	Possibility of eliminating manual labor?
Head lettuce	0	40	100	Yes
Celery	60	120	300	Yes, if possible.
Red Beets	100	200	400	No
Carrots	100	200	800	No
Processing Spinach	50	100	200	No
Processing String Beans	30	60	100	No

Preventative techniques

Minimize the weed population from the start

With preventative planning, it is possible to limit the weed population and reduce weed removal costs. These techniques must be used far enough in advance to coordinate properly with the rest of the cultivation process.

Measures	Notes	Effects
Variety choice	■ Choose competitive varieties with rapid initial growth.	● (●)○
Seedlings rather than seeds	■ For example, transplant onions in the 3–4 leaf stage (with 4–6 seeds per pot)	●●●
Prevent seed dispersion	■ Prevent weeds from seeding, especially in plots with few weeds. ■ Use compost that is free of weed seeds.	●●○ In the long term
Land plot choice	■ Avoid using plots of land that are overrun with weeds for non-competitive seed crops (like carrots and onions). ■ Avoid land with hardy weeds such as thistle, dock and quack-grass for multi-annual crops like asparagus and herbs.	●●●
Seedbed preparation	■ Prepare a level, finely-textured seedbed (aids in planting and mechanical weed control). ■ Allow plenty of time for false seedbed techniques.	●●○ ●●●
Soil coverage	■ Either use mulch, a cover crop or a complementary crop.	●●○
Promote crop growth	■ The faster the crop grows, the more competitive it will naturally be. Maintenance and proper soil fertilization is important.	●●○
Crop rotation	■ Create a varied rotation with at least 20 % temporary grass-lands and green fertilizer; alternately plant non-competitive and highly competitive crops.	●●●
Precise seeding and planting	■ Sow and plant in a precise manner to ensure regular sprouting and not compromise further work: use straight rows and consistent furrow depths and flatten seedbeds with a roller.	●●○

●○○ = Little effect ●●○ = Moderate effect ●●● = Strong effect

Prevent weed germination using different types of mulch

Covering the soil with mulch prevents weed growth and keeps the crop clean and dry, which is particularly important for leafy vegetables like lettuces. Although in the past environmentally unsound plastic sheets were used, today there are excellent paper and liquid mulches available. If these are used only on the rows themselves, costs can be kept low. In this case, mechanical cultivation should be used between the rows to increase aeration and the mineralization of organic nitrogen.



Partially decomposed bio-degradable mulch sheet (Mater-Bi)

Cover crops and complementary crops

Cover crops provide competition for weeds during the germination process. However, if they are planted too early, they too can compete with crops and cause quantitative and qualitative losses. Cover crops must be planted near the end of the sensitive period with small seed drills like those produced by Krummenacher. Conclusive research on cover crop use has been conducted on leeks, cabbage and sweet corn. Suitable varieties for use as cover crops include subterranean clover (300 g/are) or English ryegrass – white clover mixtures (marketed as a corn cover crop, 200–300 g/are).

Rather than using a cover crop for leeks, they can be cultivated simultaneously with celery or celeriac, which covers the ground faster and more completely than leeks. These two crops can be planted and harvested at the same time using mechanical processes.

Types of mulch available on the market

Product (Many)	Material	Usage	Advantages (+) and Disadvantages (-)
	Paper	Non-competitive vegetables that must be clean when harvested such as lettuces and fennel	+ Biodegradable + Effectively smothers weeds + Clean, dry harvest – Tears easily during implementation – Disintegrates too quickly on the edges
TerraStar	Cellulose	Granules to be spread on seeded or non-competitive plants (at the 3-leaf stage)	+ Biodegradable + Effectively smothers weeds (>4 months) + Adjustable dosage + Easy to spread – Costly
Mater-Bi	Amidon + biodegradable plastic	Comparable to paper; also can be used for gherkins	+ Biodegradable + Inexpensive and lightweight + Does not tear easily – Strict planting requirements and difficult to apply
(Many)	Polyethylene sheets	Non-competitive vegetables that must be clean when harvested such as lettuces and fennel as well as gherkins, zucchini and greenhouse crops	+ Easy to apply + Effectively smothers weeds + Clean harvest + Inexpensive – Not environmentally sound – Must be removed at the end of the growing season, but the process is difficult – Costs for disposal or recycling
Mypex	Woven fabric	Tomato, eggplant, peppers, gourds, pumpkins, and hearty herbs	+ Highly durable and reusable + Water-permeable – Costly – difficult to remove at the end of the season.

Direct control techniques

A good strategy is to destroy weeds before the crop emerges, thus giving the new plants a head start. To do so, both mechanical and thermal tactics can be used.

Principles of direct weed control

- The younger the weed, the more effective the suppression will be. As soon as the crop has emerged and the weeds have germinated, mechanical cultivation using protective disks or shields is recommended.
- Light, crumbly, well-leveled soil is easier to work than heavy, hard soil.
- The weed control will be more effective on well-dried soil.
- Use consistent spacing that facilitates the use of machinery
- The closer the machine is to the crop, the less manual weeding will be needed within the row. Working 1 cm closer to a given row using a four row machine over one hectare of land saves a total of 500 sq. meters of weeding, the equivalent of 10–30 hours of manual labor. Driving slowly and precisely can quickly add up to big savings.
- Avoid manual cultivation when there will be wet weather conditions before, during or immediately afterward, as this can stimulate weed re-growth.
- Adjust the machines in advance and keep a light tractor available in order to take advantage of favorable weather conditions.

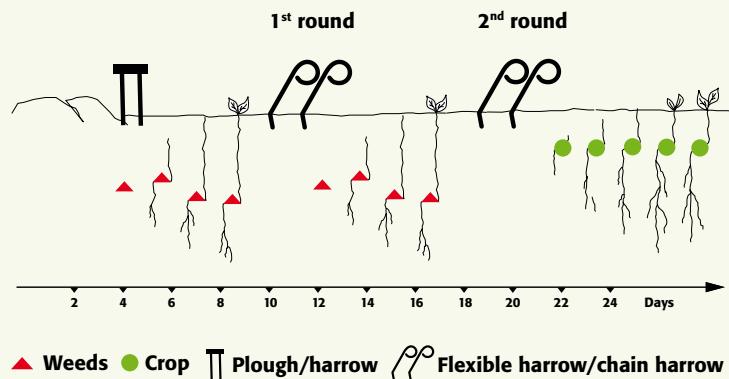
Direct pre-sowing or pre-planting techniques

- Procedure:** False seedbed
Usage: Seeded or planted crops
Machines: Chain harrow, other tractor-pulled harrows or a circular spike harrow if needed
Notes: Effectiveness can be limited if the soil temperature is lower than 10 °C; greater effectiveness if soil is covered (higher germination rate)

What is a «false seedbed»?

Prepare the seedbed 2–4 weeks before seeding or planting. Let weeds germinate. Then, at regular 7–10 day intervals, use a harrow to destroy the weeds (3–5 cm deep). Keep in mind that each instance of mechanical cultivation stimulates the germination of new seeds. To avoid damaging the soil structure PTO machines are preferable to friction-driven machines.

False Seedbed



Flaming before crops emerge is sometimes necessary, especially for crops that require shallow planting and germinate slowly.

Direct pre-emergence techniques

Procedure: Blind harrowing
Usage: All deeply seeded crops (for example, beans, peas, sweet corn, and spinach)
Machines: Flexible-tine harrow or flexible harrow
Note: Seed depth >3 cm

Procedure: Flaming
Usage: Non-competitive crops with a slow germination period (for example, carrots, onions, spinach, red beets and scorzonera)
Machine: Flamer
Note: Seed depth >3 cm

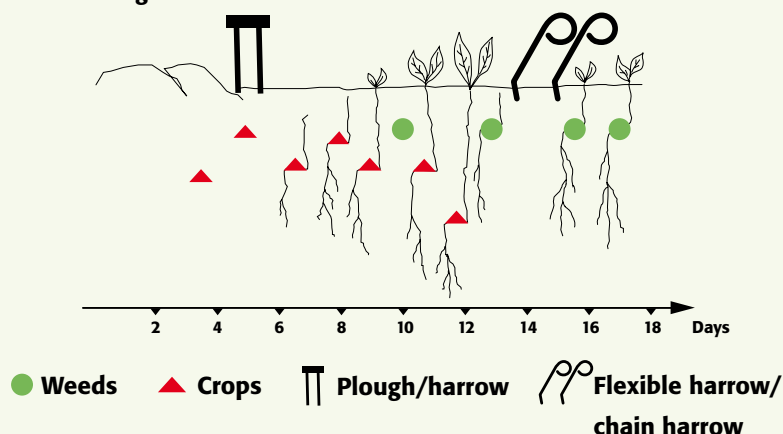
Flaming

The young shoots are in essence «blanched»: a one-second exposure to 60–70 °C heat results in the coagulation of cell proteins. Then a 1/10 of a second blast at 110 °C causes the cells to explode and release the cellular fluid such that the plants dry out completely. Propane is best suited for flaming as it heats more quickly than butane. Flaming is costly, both in terms of energy and money, so it is recommended only if mechanical weed control is not feasible. Under optimum conditions, flaming has an effectiveness rate of near 100 %.

What is «blind harrowing»?

Blind harrowing involves running the chain harrow between sowing and emergence such that the germinating seed is below the level reached by the harrow. Ideally, the crop is sowed when the weeds have already germinated (if blind harrowing is combined with false seedbed use, it would be conducted 1–2 weeks after the last harrowing). In this way, the weeds will be further ahead in the growth cycle than the crops, which enhances the effects of harrowing. The harrow tines must be adjusted so that they reach no deeper than 2–3 cm to reduce the strain on the soil.

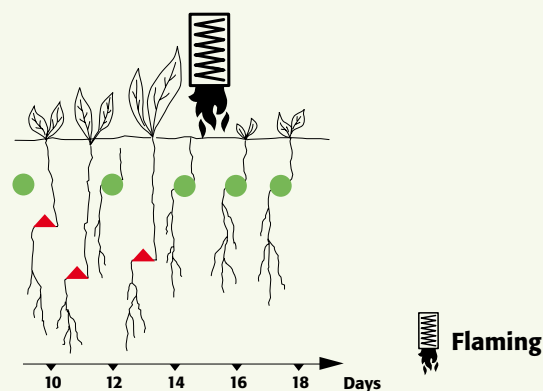
Blind Harrowing



What is «pre-emergence flaming»?

Pre-emergence flaming is based on the same principles as blind harrowing. To determine the best time for flaming, create a monitoring area by covering a small part of the field with plastic or fabric. In warm or humid conditions, inspect it regularly after the 5th day. As soon as the cultivar begins to grow in that area, inspect the rest of the field. Begin flaming right before the crop is ready to emerge. Only use flaming if there are visible weeds. If it is a very dry period, light irrigation can be used to stimulate weed germination.

Flaming



Optimum conditions for flaming:

- Young weeds: weeds are heat-sensitive from germination until the 4-leaf stage.
- Dry plants: drops of water on the plant leaves slow the heat's effect.
- Minimal wind: in windy conditions, unprotected flammers lose their effectiveness.
- Finely textured seedbed: clumps protect weeds from the heat.
- Usage limitations: Flaming is not effective on weeds with underground reserves such as thistle, quackgrass and yellow marsh cress, or monocotyledons like grasses. Burned grasses grow back as their vegetation point is protected inside the plant. Flaming results are often insufficient when crops are sowed early.



Calibration test: As a means of regulating the speed of the vehicle, the gas pressure and the position and angle of the burners, press a burned weed between two fingers. If they leave a lasting mark, then the flaming was effective. If the mark does not remain, drive more slowly or increase the gas pressure. If the leaves are shriveled and brown on the perimeter, or smoke is visible, drive faster or reduce the gas pressure. Recommended speed: 4–6 km/hour.

Direct post-emergence and post-planting weed control techniques

Inter-row techniques

Multiple types of machines effectively remove weeds between rows. The protective shields mounted on brush cultivators and other machines must be as narrow as possible.

New machines allow cultivation to occur closer to rows:

- Some machines can adapt their cultivation span based on the development of the crops. For example, some cultivators are equipped with a hydraulic device that allows the width of the cultivation area to be changed as needed.
- Others are guided by sensors (first models just released on the market).



Left : Vegetable crop, which was weeded with a properly adjusted machine.

Machines for inter-row weed control

Tine cultivators

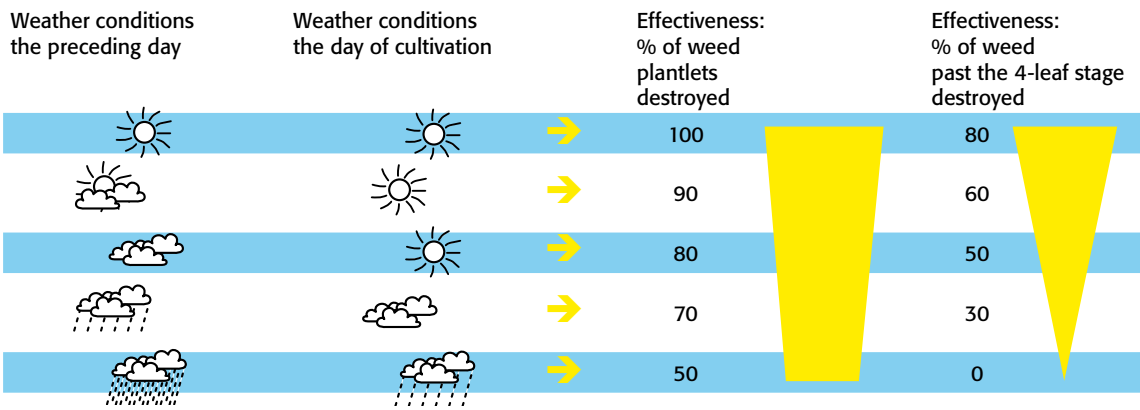


Rotary hoe



Operating mode	Cut and cover with soil	Uproots and covers with soil	
Effect on soil structure	Till soil 3–5 cm deep	Tills effectively 5cm deep.	
Effect on mineralization	Moderate to good	Good	
Seedbed requirements	<ul style="list-style-type: none"> ■ Accommodates stones and clumps relatively well (if the cultivated plants are protected with disks or shields). ■ Adapt well to the soil surface due to their suspension parallelograms. 	<ul style="list-style-type: none"> ■ Handles some stones. 	
Row spacing	44–50 cm (3 rows) or 33 cm (4 rows); minimum 16 cm	At least 40 cm, generally 50 or 75 cm	
Effect on rows (ridging)	<ul style="list-style-type: none"> ■ No ridging with angled tines at speeds under 3 km/h. Slight ridging with goosefoot tines at speeds over 3 km/h. ■ Significant ridging with ridging bodies 	<ul style="list-style-type: none"> ■ The rotating wheels can be regulated to have a ridging or de-ridging effect. 	
Weed stage for optimum performance	Effective against large, well-rooted weeds until the 4-leaf stage; effectiveness then drops quickly.	<ul style="list-style-type: none"> ■ From the cotyledon stage to the 4-leaf stage ■ Not very effective against developed grasses (such as millet) or weeds with rhizomes. 	
Crop stage for optimum performance	<ul style="list-style-type: none"> ■ Starting at the cotyledon stage if equipped with protective disks. Otherwise, starting at the 4-leaf stage and continuing until there is risk of crop damage. 	<ul style="list-style-type: none"> ■ From the 4-leaf stage until it begins to cause significant damage to the crop ■ It is possible to begin earlier if protective disks are used. 	
Suitable crops	<ul style="list-style-type: none"> ■ All row-crops (also in combination with a chain harrow) 	<ul style="list-style-type: none"> ■ Also appropriate for ridges 	
Labor in ares/hour (for a given volume of work)	50 ares (1.5 m)	150 ares (3 m)	
Additional information	<ul style="list-style-type: none"> ■ Use shallow cultivation (2–3 cm deep) ■ Work as close to the row as possible (with protective disks). ■ Sharpen tines regularly. 	<ul style="list-style-type: none"> ■ Significant equipment adjustment required 	

Effectiveness of tine cultivators and rotary tillers for inter-row cultivation on sandy or loess soils.



Source: Laber and Stützel, 1998

Brush cultivator



Rototiller



Combinations of machines can improve the effectiveness of the cultivation.

Uproots and leaves weeds on the surface	Cuts, uproots and covers with soil
Surface tilling only	<ul style="list-style-type: none"> No tilling, texture is too fine Risk of surface sealing
Low	Good
<ul style="list-style-type: none"> Well leveled seedbed Handles only small amounts of stones and clumps. 	<ul style="list-style-type: none"> Leveled soil Handles moderate stoniness (maximum).
20–30 cm (up to 40 cm)	30–40 cm
<ul style="list-style-type: none"> None 	<ul style="list-style-type: none"> Only if ridging bodies are used
<ul style="list-style-type: none"> From the cotyledon stage to the 4-leaf stage Can work very close to crops without damaging them. 	<ul style="list-style-type: none"> Starting at the 2-leaf stage Destroys even the oldest weeds.
<ul style="list-style-type: none"> From the cotyledon stage (with protective shields) until it begins to cause significant damage to the crop. 	
All row crops	All row crops
40 ares (1.5 m)	30 ares (1.5 m)
<ul style="list-style-type: none"> Can pulverize soil if rotation speed is too fast (possibility of surface sealing). Use beaver tail shovels if soil is too hard. 	<ul style="list-style-type: none"> Simulates the propagation of rhizome weeds. Recommended only as an emergency measure for highly developed weeds or after long periods of wet weather

Intra-row cultivation techniques

All machines must be used far enough in advance. They cannot be used right before emergence when the crop is most sensitive to competition from weeds. For this reason, the success of weed control depends heavily on the effectiveness of pre-emergence techniques. A significant developmental head start helps protect crops from competing weeds.

Chain harrow use

Chain harrows can be used both for pre-emergence techniques like false seedbeds and blind harrowing and also after emer-

gence. Chain harrows are especially well suited for crops with rapid initial growth (peas, string beans and sweet corn). In general, for seed crops, chain harrows can be used beginning at the 4-leaf stage. Transplanted crops have a considerable advantage over weeds. Thus, they are highly compatible with chain harrowing. However, do not use a chain harrow until the crops are firmly rooted. Conduct a test on a small area before proceeding.

Procedure for obtaining the best results:

- Select the best time for cultivation, either when the weeds are at the plantlet stage

or the cotyledon stage. At this time, they are almost invisible and can be seen only by kneeling and scratching under the surface of the soil. Starting at the 2-leaf stage, the effectiveness of the chain harrow decreases significantly.

- Work on dry soil and in fair weather, preferably at mid-day. This ensures that uprooted weeds do not reestablish themselves in the soil and prevents crop damage.
- Harrow only to a shallow depth (2–3 cm) without overly tilling the soil to avoid provoking the germination of new weeds. Adjust the pressure of the tines based on the soil and the crop.

Intra-row weeding machines

Chain harrow or flexible harrow



Finger weeder



Operating mode	Covers with soil, uproots.	Uproots, covers with soil.	
Effect on soil structure	Surface tilling	Surface tilling	
Effect on mineralization	Low	Low	
Seedbed requirements	<ul style="list-style-type: none"> ■ Well-leveled, fine to medium fine structure, no large clumps of earth or of grass ■ Light to medium light soil 	<ul style="list-style-type: none"> ■ Few stones and clumps 	
Row spacing	<ul style="list-style-type: none"> ■ Not applicable 	<ul style="list-style-type: none"> ■ Up to 30 cm (small finger disks) ■ Up to 50 cm (large finger disks) 	
Effect on rows (ridging)	<ul style="list-style-type: none"> ■ Chain harrow: moderate ■ Flexible harrow: good, but can cause crop damage 	<ul style="list-style-type: none"> ■ Ineffective for hard soils or against well-established weeds 	
Weed stage for optimum performance	From the plantlet stage to the 2-leaf stage	From the plantlet stage to the 2-leaf stage	
Crop stage for optimum performance	<ul style="list-style-type: none"> ■ When crop is firmly rooted, generally after the 4-leaf stage ■ Soon after planting for deeply planted species 	<ul style="list-style-type: none"> ■ When crop is firmly rooted, generally after the 4-leaf stage 	
Suitable crops	<ul style="list-style-type: none"> ■ Green beans, peas, sweet corn, various types of cabbage, red beets, leeks, celery, onions, spinach 	<ul style="list-style-type: none"> ■ Green beans, sweet corn, various types of cabbage, leeks 	
Labor in ares/hour (for a given volume of work)	250 ares (6 meters)	50 ares (1.5 meters)	
Additional information	See information above on use of chain harrows.	<ul style="list-style-type: none"> ■ Crop must be firmly rooted. ■ Equipment parts wear out quickly. ■ Large finger disks clog less easily. ■ Can be used in combination with rotary hoes or chain harrows. 	

Weed control using ridging

From the 4-leaf stage to the 6-leaf stage, weeds growing in rows can be largely eliminated by ridging. This involves the use of ridging bodies or a properly adjusted finger weeder. Ridging is effective against young or moderately developed weeds.

Once they have reached the 4-leaf stage, ridging can no longer cover them completely and thus almost completely loses its effectiveness. Many crops, such as leeks, sweet corn and cabbages respond well to ridging. Carrots can be ridged once they have reached a length of 15–20 cm. However, excessive ridging can render a

product too dirty (such is often the case with leeks).

Upright plants such as leeks, some types of cabbages and sweet corn can be planted in a shallow furrow to compensate for the automatic ridging effect that occurs after the first harrowing. The first pass refills the furrow and the second pass starts the actual ridging.

Attention:

No ridging: Lettuces, string beans, fennel and Chinese cabbage.

Only slight ridging: Celery, onions and spinach.

Post-emergence flaming

Post-emergence flaming should only be used for monocotyledons like onions, leeks or sweet corn. The weeds must not have passed the 2-leaf stage. Onion plants can withstand flaming as of the 1-leaf stage. It is recommended to burn soon after the apparition of a new leaf. Inter-row post-emerge flaming does not produce better results than harrowing, and it is more costly. It is recommended only for use in wet weather conditions.

«Torsion» harrow



Flamer



Recent innovations :



Uproots covered with soil	Destroys plant cells with a blast of heat
Surface filling	None
Low	None
<ul style="list-style-type: none"> ■ Few stones and clumps ■ No crust 	<ul style="list-style-type: none"> ■ Well-leveled ■ With no clumps of earth and few stones
25–75 cm	Flaming of full field or rows (spacing >30 cm)
<ul style="list-style-type: none"> ■ Good in loose soils ■ Insufficient in hard and heavy soils 	<ul style="list-style-type: none"> ■ Good
<ul style="list-style-type: none"> ■ Cotyledon stage to 2-leaf stage 	<ul style="list-style-type: none"> ■ Cotyledon stage to 2-leaf stage
<ul style="list-style-type: none"> ■ When crops are rooted firmly enough and ahead of weed development until the rows are closed 	<ul style="list-style-type: none"> ■ Pre-emergence: monocotyledons and dicotyledons ■ Post-emergence: only monocotyledons
<ul style="list-style-type: none"> ■ Green beans, leeks, sweet corn, various types of cabbage, lettuce, celery, red beets, herbs 	<ul style="list-style-type: none"> ■ Planted crops that germinate slowly and are non-competitive
50 ares (1.5 meters)	100 ares (3 meters)
<ul style="list-style-type: none"> ■ The nearer the ends are to the plants, the more aggressive the machine works. ■ For best results, the tines are turned slightly downwards. 	<ul style="list-style-type: none"> ■ Professional machines have an insulated cover and can flame weed a width of one to three beds. Propane consumption is 50 kg/ha if the full field is covered and 25 kg/ha for just the rows.

The Querstriegel works slightly more aggressively than the finger weeder or the Torsionshacke. It is suited for rather light and even soils.



The sensor-guided intrarow-weeder finds the rows automatically and recognizes the crop in the row, if it is clearly taller than the weeds. With its swinging tines it removes the weeds between the plants.



The pneumat blows small weeds out of the rows. This machine is usually combined with tines to remove the weeds between the rows, its effectiveness is good on light and even soils and in well-rooted crops.

Weed control strategies for various crops

Checklist before using a machine:

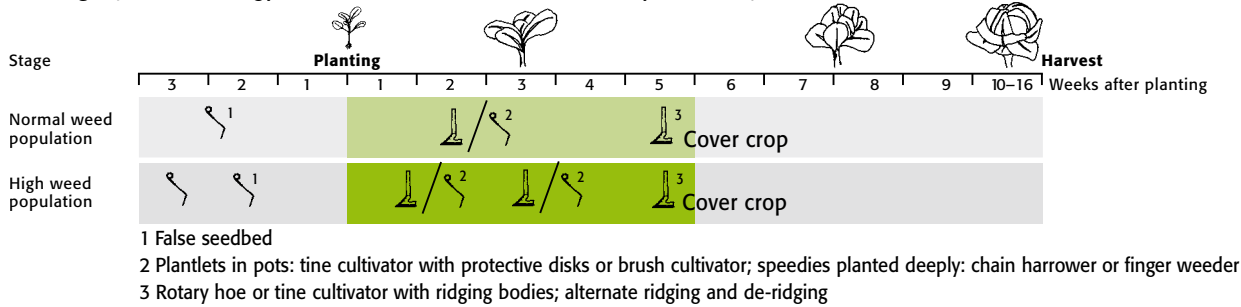
A Is the land appropriate?

B Are there weeds?

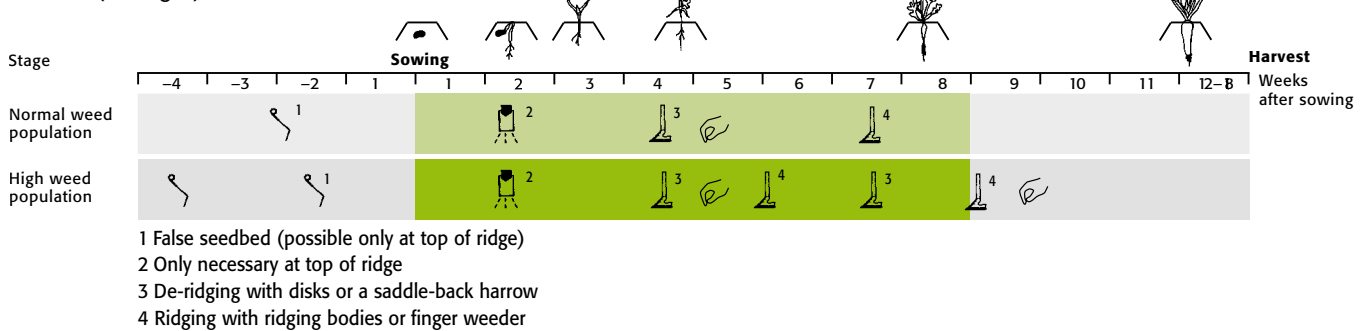
C What machine is the most suitable?

1. What machine offers optimum performance within the row?
2. What machine is best suited for the crop and its stage of development?
3. What machine will best combat the weeds in their current state?

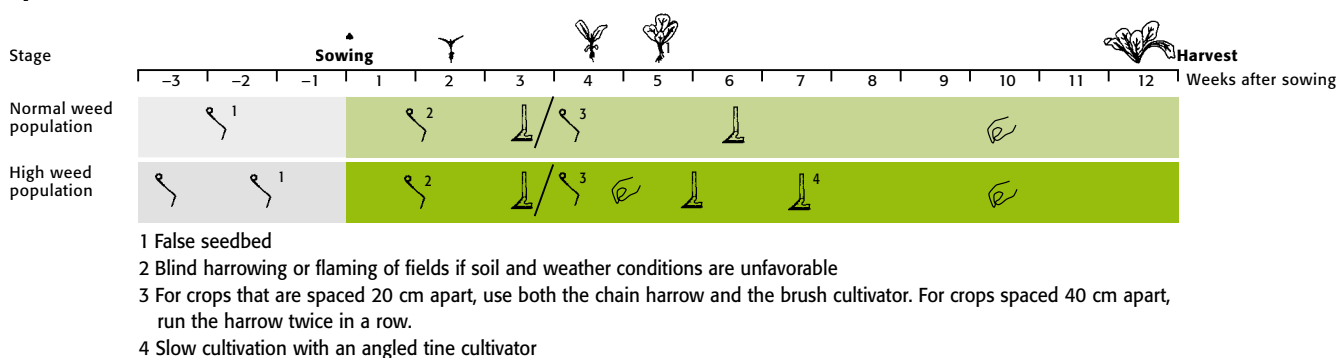
Cabbage (similar strategy for cauliflower, broccoli, Brussels sprouts, etc).



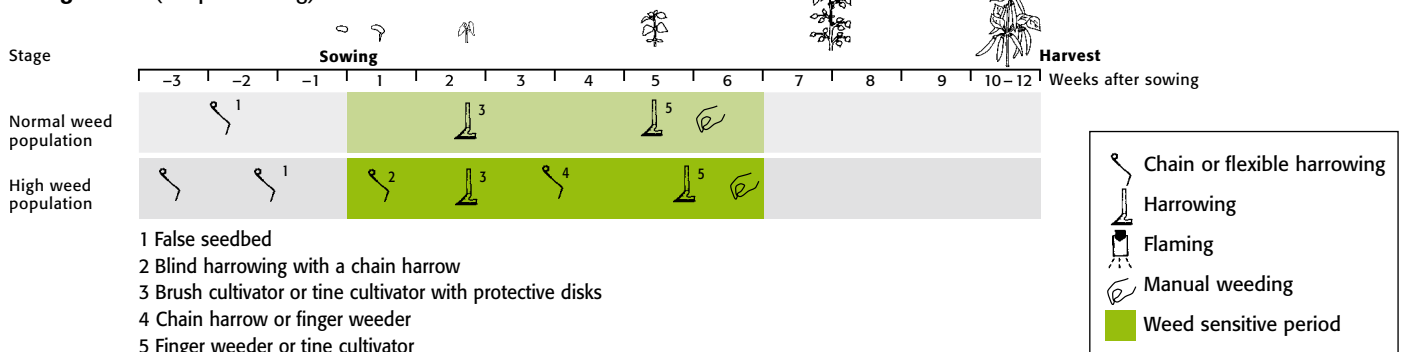
Carrots (in ridges)



Spinach



String beans (for processing)



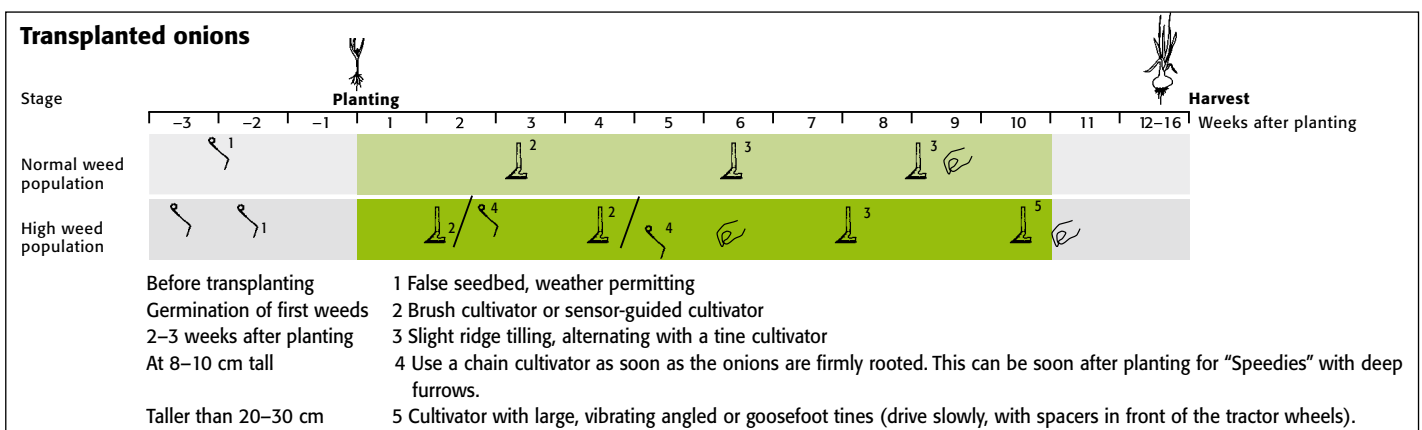
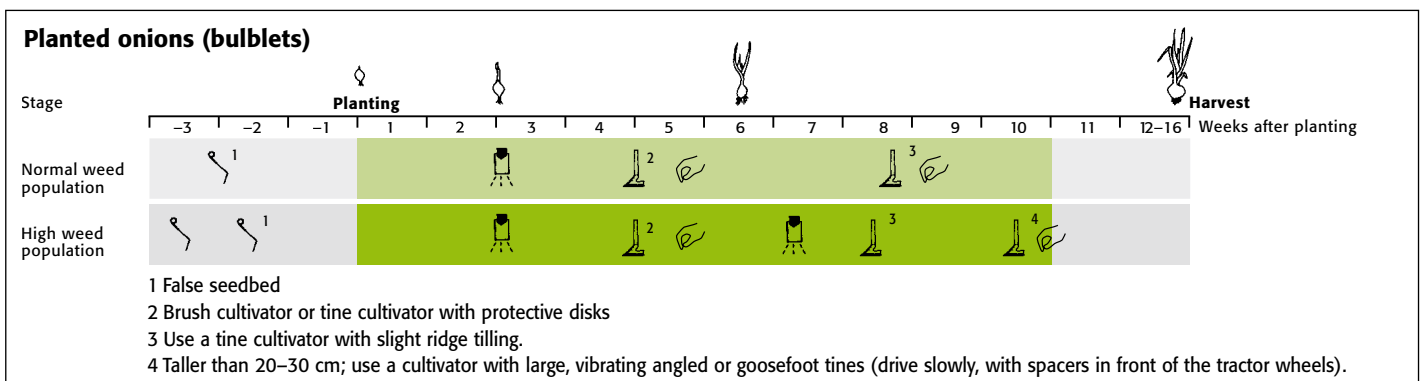
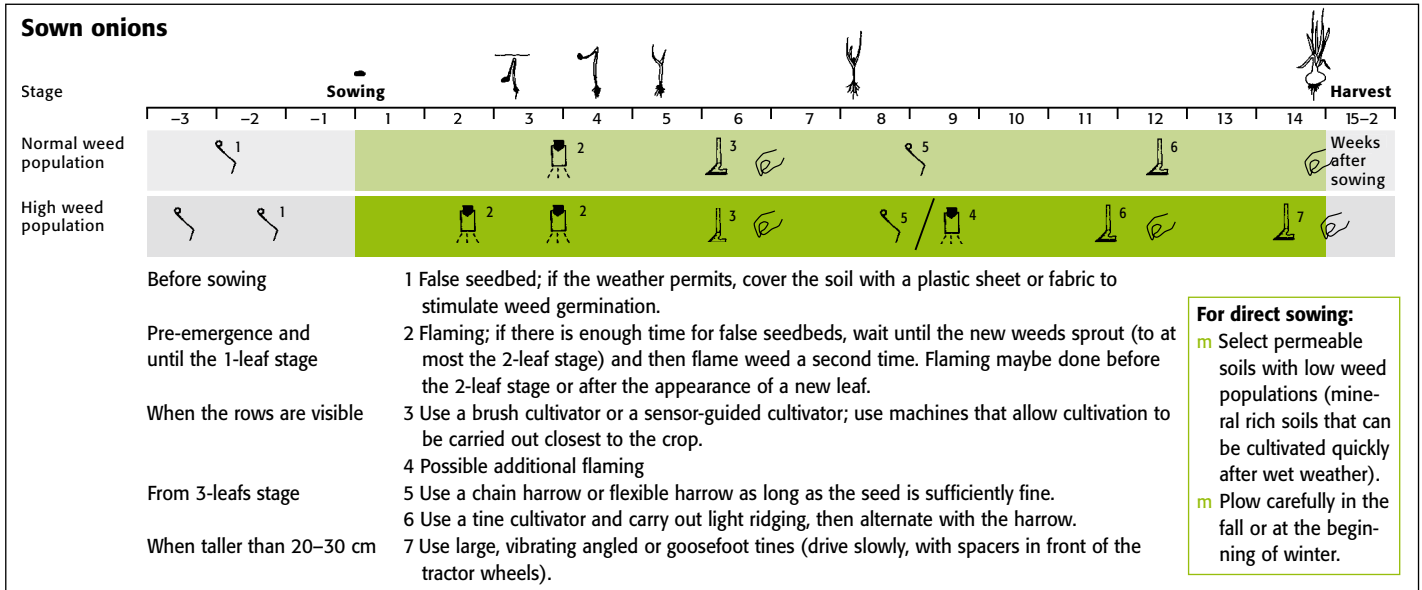
Onions as a case study: optimizing cost-effectiveness by selecting appropriate techniques

Growing onions without herbicides is a difficult task. There are three basic approaches for weed management: sowing seeds directly, planting bulblets, or transplanting seedlings (traditional or semi-automated).

Planting bulblets is more cost-effective than direct sowing if it saves more than 170 hours of manual weeding. Traditional transplanting is not cost-effective unless it saves 550 hours of manual weeding.

However, by reducing the cost of seedlings (Speedy) and rationalizing planting (semi-automated planting), transplanting becomes more of a viable option.

	Advantages	Disadvantages
Direct sowing	<ul style="list-style-type: none"> Low seed cost Long storage 	<ul style="list-style-type: none"> Slow early growth Low competitiveness Longer growing season
Planting bulblets	<ul style="list-style-type: none"> Rapid early growth Higher competitiveness Short growing season 	<ul style="list-style-type: none"> Higher cost Shorter storage life Possible infection with onion mildew (through the bulblets)
Transplanting	<ul style="list-style-type: none"> Early growth already partially complete, competitive due to advanced development Later planting allows more time to use false seed-bed techniques 	<ul style="list-style-type: none"> High cost of seedlings and planting



Effective weed control for ridge crops

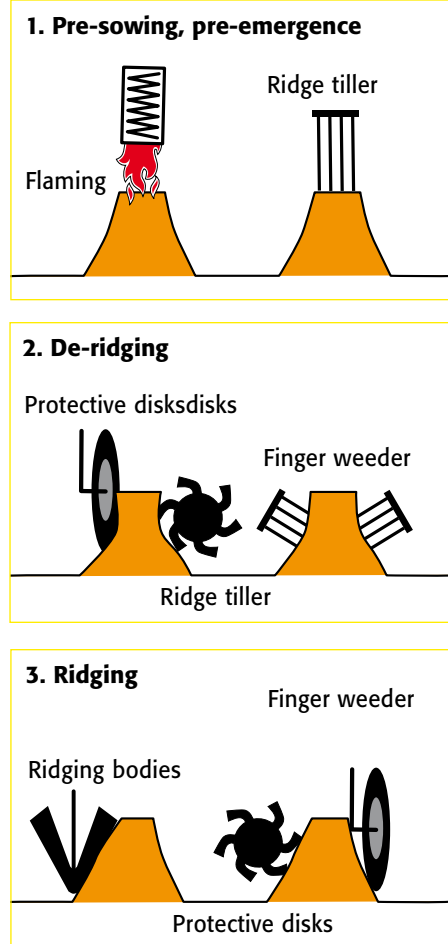
Ridges cultivation offers many advantages over traditional cultivation, including the ability to control weeds by ridging and de-ridging the soil. Manual weeding is only necessary on top of the ridges themselves.

How to proceed :

- Establish the ridges in advance and let rest for two weeks. Ridgers equipped with spreader plates ensure the best results. However, in soils that are susceptible to surface crusting it is better to avoid using them.
- Create a false seedbed and use a chain harrow over the top of the ridges before planting.
- Pre-emergence flaming is recommended on the rows.

Alternately ridging and de-ridging the sides of the rows is effective for both inter-row and intra-row weed control. The closer the cultivation comes to the plants, the less manual weeding is required. When the plants are 10 cm tall, ridging can destroy weeds within a row, but the quantity of earth deposited must be properly adjusted for the plants' stage of development.

Procedure:



Ridge spacing comparison

Spacing	Advantages	Disadvantages
50 cm	<ul style="list-style-type: none"> ■ Less area to be manually weeded ■ Higher yields 	<ul style="list-style-type: none"> ■ Less earth for ridging
75 cm	<ul style="list-style-type: none"> ■ More solid ridges ■ Plenty of earth for ridging ■ The same techniques used for potatoes applicable 	<ul style="list-style-type: none"> ■ Slightly lower yields

Well-planned investments lead to success

Investing in cultivation machines is very cost-effective, as cultivation is time-consuming and must be carried out at precisely the right time. Depending on weed volume, mechanical weeding can cost up to ten times less than manual weeding. Thus, cultivation machines should always be used and require minimal labor.

Tips on efficiency:

- Standardize row spacing (only one or two spacing distances for the farm).
- Equip the machines with rapid connection systems and arrange them for easy access (for example, on small carts). This reduces the amount of time needed to change or adjust them.
- Mount the cultivation machines either on the front of the tractors or between the axes (power-frame tractor).
- Use machines that work on larger surfaces like chain harrows; sow the seeds over 3 meters instead of 1.5 meters and cultivate using the same width.
- For greater efficiency, keep a light tractor with good visibility available at all times.
- Borrow specialized machines like rototillers instead of purchasing them
- For major weed overgrowth it is often more economical to plow the crop under and restart.

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This FiBL guide has been translated to English by OACC from its original Swiss German Edition. It was written and produced by FiBL for European organic producers, and reflects European conditions and terminology. Therefore, OACC recommends that Canadian growers consider the suitability of the information for their farms and adapt it only with awareness of the context of the original conditions. It is hoped that Canadian organic producers will nevertheless find much of the information beneficial.

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