Mechanical Weeding

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Factsheet about integrated weed management

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Introduction

Mechanical weed control is done with machinery that cuts, pulls, uproots or buries weeds. Mechanical weed control is a means of reducing the impact of weeds on crop growth, preventing seedlings from reaching maturity and reducing the buildup of weed seed- and bud banks. Available tools are: harrow, hoe, ridger, finger weeder and torsion weeder.

Applicability

Mechanical weeding can be applied pre- or post-emergence and selective during (early) vegetative growth. Combining these strategies will allow for better control of troublesome weeds such as annual grasses. In addition, tools need to be used in combination to ensure no weed is favoured by the mode of action of a particular tool.

Mechanical weeding solutions need to be adapted to your soil type and soil moisture levels. Success rates may vary as a result of climatic influences either providing favourable or unfavourable conditions for mechanical weeding. Due to unfavourable weather conditions certain tools might not be applicable and even delays in weed control may occur when soils are too wet. This can cause weeds to become too large and hinder further mechanical weeding.

Mechanical weed control can be applied both intra- and interrow. Interrow control is often well applicable, especially in row crops where row distances are about 30 – 70 cm. For small-grain cereals row distances are often smaller, making interrow control more difficult. Increased row spacing in certain crops may therefore be an adequate solution to overcome this problem, but may interfere with the preventive effects of an optimal seeding configuration.

Efficacy

The efficacy of different mechanical control tools depends on crop growth stage, size of weed plants, precision of the equipment and the environmental conditions. In general, combining control measures to overcome the selectiveness of individual measures increases the level of weed control. For instance, a

Table 1| Mechanical weeding in cereals (winter and spring) and grass seed.

Weeks/period	-2 → 0		1 →2		2 → 4	March / April	May	Until harvesting
Crop		sowing	Germination	emergence	2-4 leaves	End of tillering	Start of shoot elongation	Ripening
Weed			White filaments		Cotyledon to 2-leaf	2-4 leaves	6 leaves	Flowering and seed-bearing
Machinery	Harrow		Harrow		Harrow Finger weede Torsion weeder	Harrow Torsion weeder	Torsion weeder Ridgers	Hand weeding
Setting	Harrow tines, angle forward		Harrow tines at vertical setting Shallow harrowing, preferably chain-link harrow		Weeder elements separated	Harrow tines, angle forward Weeder elements against each other (overlap)	Weeder elements against each other (overlap) Ridge slightly	

strategy that combines pre-emergence hoeing, post emergence harrowing and stubble treatment is in general more effective than two or three harrowing treatments.

In recent years, inter-row cultivation techniques have developed significantly. Nowadays, machine-vision techniques can discriminate crop plants from soil and weed plants by a combination of light reflectance and recognition of crop row pattern[1]. This allows for weed control very close to the crop row[1]. A next step will be to replace tractor-mounted inter-row weeders by autonomous machines[3]. Currently, advanced inter-row cultivators are primarily being developed for high-value crops but are expected to become available for more crops in near future.

Costs

The costs of mechanical weeding largely depend on the availability of machinery and the extra labour requirements. Costs vary considerably across the different strategies but in general, the height of the costs are related to:

- Increased labour requirements;
- Increased costs and environmental impact of fossil fuels
- Possible investments in machinery, machine-vision techniques and robotics;
- Potential yield reduction due to crop damage. By increasing the crop plant density the yield reduction can be minimized, especially when yield losses occur from plant losses;
- Decreased costs of herbicides.

Equipment

Flex-tine harrows are most commonly used in Europe and can be used both pre- and post-emergence in a broad range of crops. Harrowing is a selective control measure using differences between crop and weeds in seeding depth or rooting as underlying mechanism. When the crop is larger, other tools are required as the harrowing can damage the crop plants.

Inter-row cultivators and hoes are often used in broad-sown crops. These cultivators can also be used when the crop is larger and when weeds are more difficult to control. Interrow control is often combined with finger or torsion weeders for intra-row weed control. In recent years, the use of machine-vision techniques becomes more profound, allowing for more precise control and operations closer to the crop rows. Allowing operations at about 1 cm closer to the crop rows can save up to 30 hours of weeding within the season. To further control weeds within the crop rows, control measures can be complemented by hilling.

Figure 2| Interrow hoeing with automated steering using vision techniques.

Figure 3| Configurations for interrow hoeing. Left: duck foot; right: flat design.

Figure 4| Finger weeder

Figure 5| Torsion weeders

Figure 6| Flex-tines

Core results

Up to 90% weed control in corn on a sandy soil can be achieved by combining two passes of preemergence weed harrowing with eight passes of post-emergence harrowing[4]. This does not result in yield declines.

[1] *Fennimore, Steven A., David C. Slaughter, Mark C. Siemens, Ramon G. Leon, and Mazin N. Saber. 2016. "Technology for Automation of Weed Control in Specialty Crops." Weed Technology 30(4):823–37.*

[2] *Kennedy, HannahJoy et al. 2020. "Crop Signal Markers Facilitate Crop Detection and Weed Removal from Lettuce and Tomato by an Intelligent Cultivator." Weed Technology 34(3):342–50.*

[3] *McCool, C., Beattie, J., Firn, J., Lehnert, C., Kulk, J., Bawden, O., . . . Perez, T. (2018). Efficacy of Mechanical Weeding Tools: A Study Into Alternative Weed Management Strategies Enabled by Robotics. IEEE Robotics and Automation Letters, 3(2), 1184-1190. doi:10.1109/LRA.2018.2794619*

[4] *Bo Melander, Ilse A. Rasmussen, & Paolo Bàrberi. (2005). Integrating Physical and Cultural Methods of Weed Control: Examples from European Research. Weed Science, 53(3), 369–381. http://www.jstor.org/stable/4047015*

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Extra information

See *https://iwmpraise.eu/publications/* for all crop diversification strategies and their definitions, and for more information on integrated weed management and the following inspiration sheets about mechanical weeding:

- Flex-tine weed harrowing in spring cereals
- Prototype of camera controlled-guided post emergence interrow cultivator
- Mechanical weeding technologies (for vineyards)

Table 2| Sown - large seeds - widely-spaced in the rows (beans, maize, peas, pumpkin, sugar beet and sunflower)

Weeks/period	-3 → 0		1 → 2		3 → 5	to 60% soil cover	Until harvesting
Crop		sowing	Precision sowing > 3 cm deep	emergence	Plant rooted 1 - 4 leaves	4-6 leaves (20 cm height)	> 60% soil cover
Weed	White filaments		Cotyledon		Cotyledon to 2-leaf	2 - 6 leaves	Flowering and seed-bearing
Machinery	Harrow		Harrow		Harrow Finger weeder Torsion weeder Pneumat	Finger weeder Torsion weeder Pneumat Ridger	Hand weeding
Setting	Harrow tines, angle forward		Harrow tines, angle forward		Harrow tines, angle forward Weeder elements separated	Weeder elements against each other (overlap) Hoeing, slight ridging	
					Risk of covering small plants	Finger/torsion weeder on hard soil: take care with cultivation depth High ridges for sunflower and maize Low ridges for pulses, beets, etc.	

Table 3| Sown - small seeds - narrowly-spaced in the rows (chicory, carrot, onion, redbeet, spinach)

Weeks/period	-3 → 0		1 → 3		3 → 4	4 → 6	6 → 8	Until harvesting
Crop		sowing	Germination	emergence	Cotyledon	1 to 3 leaves	3 to 5 leaves	30-100% soil cover
Weed	White filaments		White filaments or cotyledon		Cotyledon to 2-leaf	Cotyledon to 4 leaves	2 to 6 leaves	Flowering and seed-bearing
Machinery	Harrow		Harrow Flame weeding		Finger weeder Torsion weeder	Flame weeding Finger weeder Torsion weeder Pneumat Hand weeding	Finger weeder Pneumat	Hand weeding
Setting	Harrow tines, angle forward		Harrow tines at vertical setting Harrow as shallow as possible, above sowing depth Harrow as shallow as possible, above sowing depth		Weeder elements separated With small crops and loose soil elements approx. 1 cm apart With small crops and crust formation drive slowly and use discs	Weeder elements against each other (overlap) With small crops and crust formation drive slowly and use discs Flame weeding in the crop solely for onion (4-6 leaves) and chicory (3-4 leaves). Results in reduced yield.	Weeder elements against each other (overlap)	

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Table 4| Planted - low lateral growth (Chinese cabbage, endive, fennel, lettuce, module onion, onion sets, strawberry)

Weeks/period	-3 → 0		1	2 → 5	Until harvesting
Crop			Module plants / soil blocks	Rooted plant to 20 cm diameter	> 50% row distance covered
Weed	White filaments		Cotyledon to 2-leaf	2 to 4 leaves	Flowering and seed-bearing
Machinery	Harrow	planting	Finger weeder Torsion weeder	Intra-row weeder Finger weeder Torsion weeder Pneumat	Hand weeding
Setting	Harrow tines, angle forward		Weeder elements separated	Weeder elements against each other (overlap)	
			When plants have not yet rooted. Do not contact plants!	When using a Pneumat, make sure that soil is not blown into the plant's heart!	

Table 5| Planted - vertical growth (brocolli, Brussels sprouts, cauliflower, celery, curly kale, leeks, red cabbage, Savoy cabbage, white cabbage)

Weeks/period	-3 → 0		1	2 → 5	3 → 4	Until harvesting
Crop			Tray plants	Rooted plant	Diameter 5-20 cm	> 30% row distance closed
Weed	White filaments		White filaments to 2-leaf	Cotyledon to 4 leaves	2 to 6 leaves	Flowering and seed-bearing
Machinery	Harrow	planting	Finger weeder Torsion weeder	Harrow Finger weeder Torsion weeder Pneumat	Ridger Finger weeder Torsion weeder Pneumat	Hand weeding
Setting	Harrow tines, angle forward		Harrow tines, angle forward Weeder elements separated	Harrow tines at vertical setting Weeder elements against each other (overlap)	Pronounced ridging Weeder elements against each other (overlap)	
			When plants are not yet rooted and weeds germinate. Do not contact plants!			

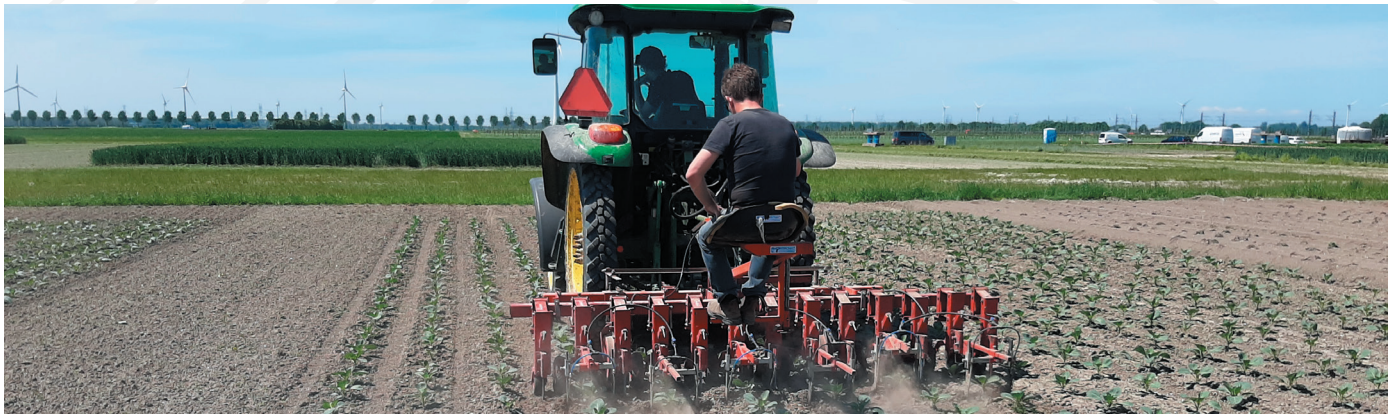

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Table 6| Ridge cultivation (potatoes)

Weeks/period	-3 → 0		1 → 4			4 → 5	5 → 7	Until harvesting
Crop		planting and slight ridging	Potato sprouted		emergence	Emergence	Foliage crown 15 cm diameter	70% soil cover
Weed			White filaments			Cotyledon to 2-leaf	2 - 4 leaves	Flowering and seed-bearing
Machinery			**Clay** Rotary cultivator Ridgers	**Sand** Harrow Ridgers		Harrow Angle hoe Finger weeder	Angle hoe Ridgers	Hand weeding
Setting			On clay soils, ridge when plants emerge	Harrow tines, angle forward		Harrow tines, angle forward	Ridge up to cover weeds on the ridge	
				Alternating smooth harrowing and ridging, repeat with newly emerged weeds		Weeder elements against each other (overlap)		

Table 7| Mechanical weeding in cereals (winter and spring) and grass seed.

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