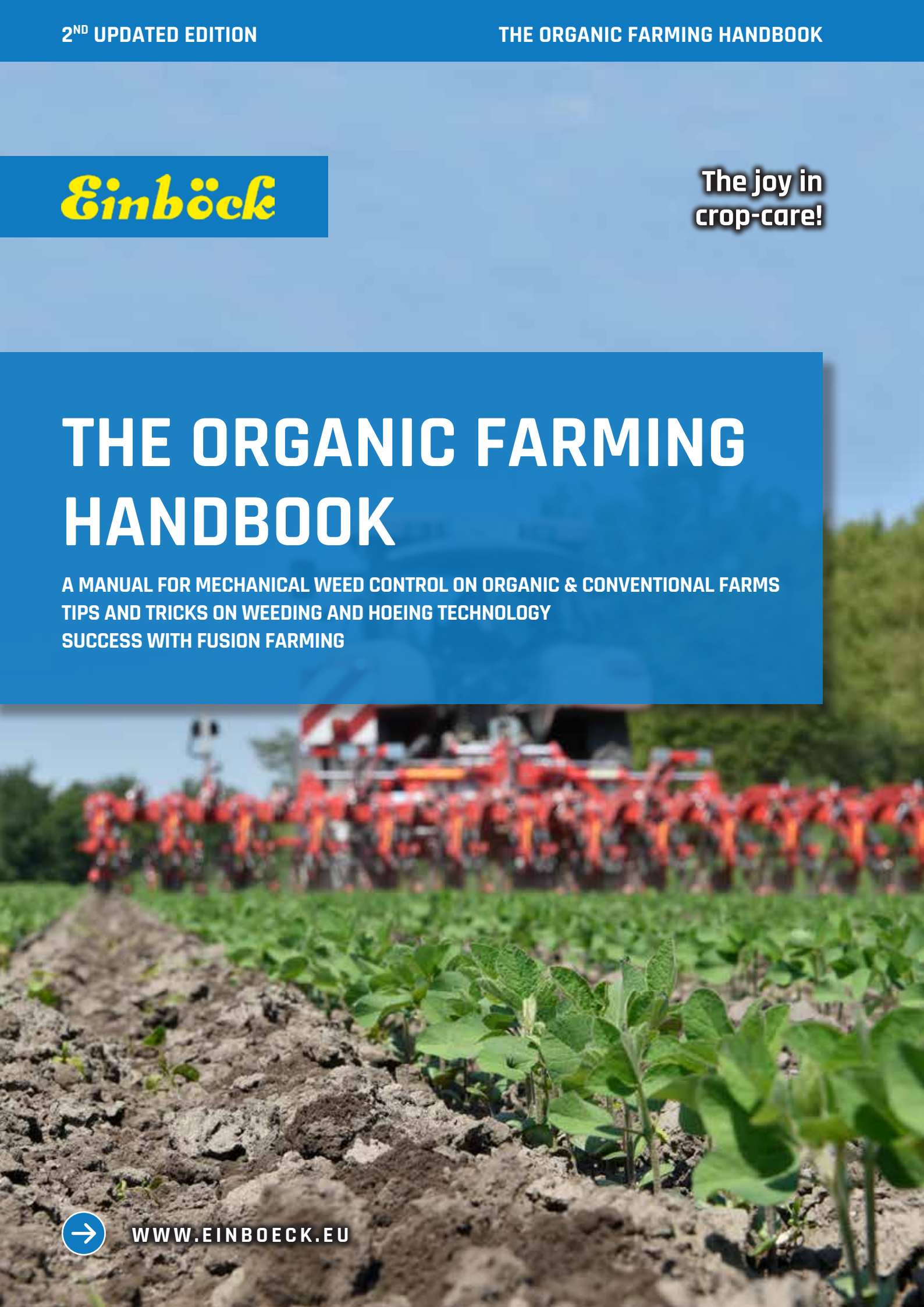
Einböck

The joy in crop-care!

THE ORGANIC FARMING HANDBOOK

A MANUAL FOR MECHANICAL WEED CONTROL ON ORGANIC & CONVENTIONAL FARMS
TIPS AND TRICKS ON WEEDING AND HOEING TECHNOLOGY
SUCCESS WITH FUSION FARMING



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PREFACE

Organic farming requires precision and a great deal of experience – both of which we have been building on for decades. We have been blazing the trail for organic farming for over 40 years, not least as a result of running our own organic farm, which provides us with valuable insights on a regular basis. We are constantly testing new approaches, machinery and farming methods on our testing fields, and our organic farming advisers have been farming organically for decades too.

In the future, farming will need to cleverly combine chemical, mechanical and organic measures. Plant protection, whether chemical or mechanical, is a significant part of farming. A truly forward-thinking approach is to apply less chemicals as part of an integrated plant protection strategy, since the goal is to farm profitably while integrating high environmental standards as a basis for top-quality, regional food production.

With "Fusion Farming", we are advocating for conventional and organic farming methodologies to be combined. Fusion farming takes the best solutions from both farming practises and delivers increased efficiency and value creation to farmers worldwide.

As experts in organic farming, the future of our soils is something that lies close to our hearts. With many years of practical experience behind us, we want to change the structure of farming for the better, so that future generations can enjoy the diverse bounties nature has to offer.

The Einböck Family
Managed by the 3rd and 4th generations.

CONTENTS

This handbook is a guide, not a guarantee for success.
Farmers should gain their own practical experience in order to achieve the optimum result for their specific conditions.

If you have any tips and examples from your own experience that you'd like to discuss, please contact us via info@einboeck.at.

1. ADVANTAGES OF SUSTAINABLE FARMING

Advantages of hoeing and weeding

For the cultivated crop:

» Weeds are removed mechanically, which enables the crop to grow better
» Looser, damper soil promotes root growth in the cultivated crop
» Water is conserved through breaking up capillary action, which means more water for the cultivated crop
» Strain and leaf damage in the cultivated crop due to herbicide use is avoided
» Weeds in the row are covered in soil and the cultivated crop is earthed up

For the soil:

» Aerating the soil and breaking up crusting after heavy rainfall boosts soil moisture
» Mobilisation of nutrients and promotion of mineralisation, thus greater microorganism activity
» Gentle humus cultivation – shallow cultivation of the upper soil layer
» Incorporation of (organic) fertiliser – fertiliser mineralisation e.g. incorporation of slurry, mineral fertilisers and urea
» Release of nutrients: "Twice weeded/hoed = once fertilised"

For the environment:

» Avoidance/reduction of herbicides and active substances
» Reduced usage of active substances and removal of resistant weeds
» Improved soil fertility and healthier, more resilient soils
» Protection of waters
» Safeguarding of biodiversity

Agriculture is the root of all education in the world.

Berthold Auerbach, politician/author

2. SOIL LIFE

Natural soil fertility is the key success factor in farming.

2.1 Boosting soil fertility

Cultivated crops are not fertilised on demand as in conventional arable farming. Instead, plants should have access to sufficient nutrients based on the high fertility of the soil. The plant shows exactly what it needs from the supply of nutrients. For this reason, in changing the farming methodology, the soil fertility should be at least maintained or ideally increased.

The following aspects promote soil fertility:

- Regular supplies of large amounts of rotted organic matter, especially crop residues
- Green fallow land
- Avoidance of bare fallow land
- Increased organic fertilisation, particularly using well rotted manure or compost
- Switching between shallow root and deep root crops as a main or catch crop
- Varied and appropriate crop rotation for the location with as many different well-matched crops and varieties as possible
- Multi-year fodder production using a mixture of legumes and grasses
- Undersown crops
- Ground cover for as long as possible through catch crop and second crop cultivation
- Soil-protecting cultivation systems
- Minimal cultivation intensity
- Lighter harvesting and transport vehicles
- Avoidance of driving and working on soil when it is too wet
- Use of (alkaline) rock dust
- Application of lime as required

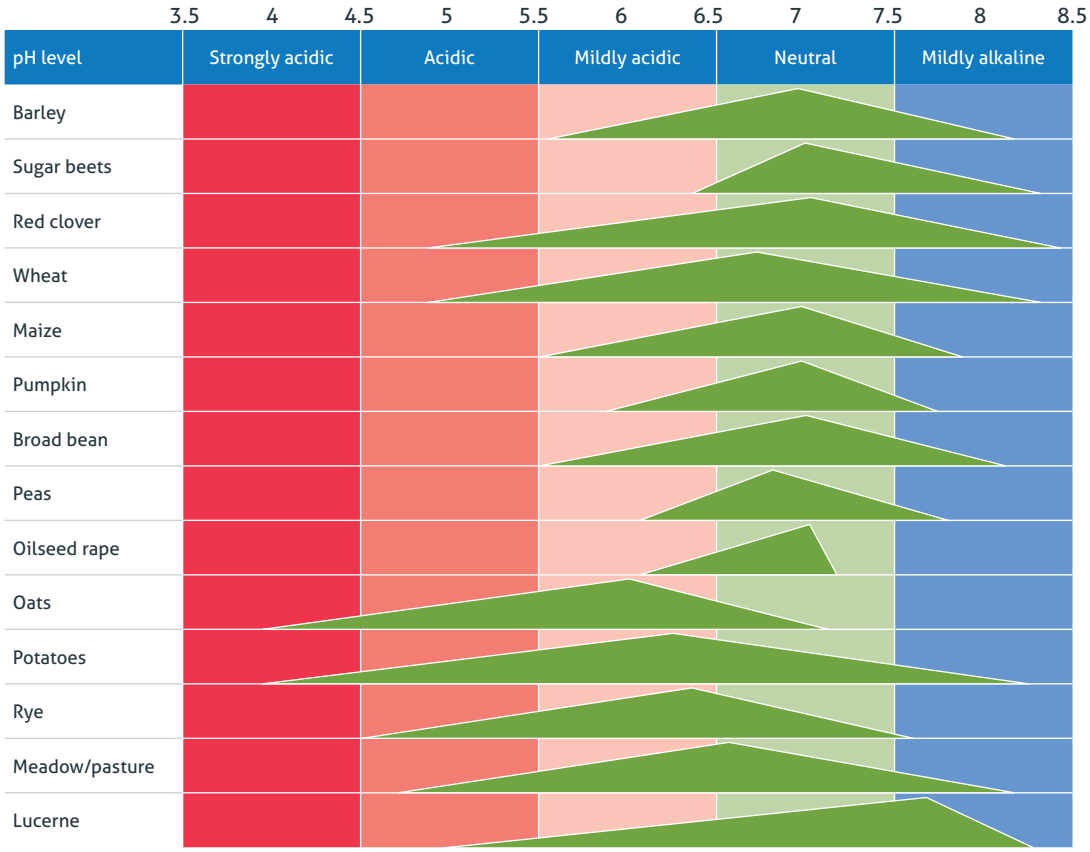
A varied and appropriate crop rotation for the location results in healthy soils.

2.2 Lime for soil stability*

In principle, the appropriate amount of lime should be applied regularly to arable land every two to four years in order to maintain a stable pH level.

» Calcium – the main component of lime – ensures a stable soil fabric, particularly in heavy, clayey soils. This is because lime forms connections between clay and humus particles, i.e. the clay-humus complexes.
» Rain washes carbon dioxide into the soil and calcium out. This effects sandy soils especially (up to 300 kg/ha/year). The consequence: pH levels sink and the soil acidifies.
» Plants need calcium as a nutrient, but it is more important that the pH level in the soil is correct so that other nutrients remain available, and harmful substances are not able to damage the plants.
» pH level under 5: Aluminium is released (damaging to plant roots and microorganisms).
» pH level 6–7: Phosphorus and boron are most readily available at this level.
» pH level above 7: Availability of most trace elements drops, with the exception of molybdenum. (Iron, manganese, boron.)

Lime = "feed lime" for soil organisms



Cultivated crops each have their own optimum pH level (according to Klapp)

*Source: "Von Analyse bis Zeigerpflanze" (Manuel Böhm, Landwirt Bio plus Edition 3) and "Kalk für den Acker - Sauer ist nicht lustig" (Stefan Simon, Landwirt Bio plus Edition 4), Landwirt Agrarmedien GmbH, www.landwirt.com

Summary:

Each crop has its own optimum pH level. Legumes benefit especially from an application of lime before cultivation. Lime should therefore be spread within the crop rotation before peas, beans, soybeans, clover or lucerne. Since these plants develop protein, it also makes sense to pay attention to their supply of sulphur.
To maintain adequate levels of lime, a spreading quantity of two to three tonnes every two to four years is recommended. When using calcium carbonate, the finer it is grounded, the more effective it is.

It is better to spread smaller amounts each year than larger amounts every 3–4 years.

2.3 Soil testing and spade testing*

The aim of soil testing is to gain an overview of the nutrient levels in cultivated land. In additional to conventional laboratory analyses, in which actual soil values are compared against target values or content classes, there are a number of simple options for assessing soils either directly or indirectly via the plants. These methods do not provide the most clear-cut results, but are usually adequate.

Field-based methods

» Spade test or soil classification
» Optical assessment of main and catch crop
» Earthworm assessment
» Analysis of indicator plant functions

Spade test or soil classification

In this context, a soil classification simply means assessing the soil using your senses. The best way to do this is to dig out a slab of soil using a spade and to examine it in relation to the following points:

» Soil structure (crumbly or rigid structure)
» Smell
» Soil layers (smear layer, plough pan, seed layer)
» Roots (whether nodule bacteria are present in legumes)
» Presence of a wide variety of living organisms
» Decomposition of organic material (rotting or decay)

Optical assessment of main and catch crop

You can learn a lot about soil conditions by assessing the crop at different locations throughout the fields. In addition to combine harvester tracks, problematic growing conditions as well as differences in the soil structure and characteristics become apparent. Paleness in the leaves, stunted or intensified growth, or the complete absence of cultivated plants are all indicators.
There are often several reasons for the cultivated plants having stunted growth or being completely absent. One reason could be that the seedbed was not sufficiently reconsolidated. In the case of a very dry autumn, for example, only the plants that were sown on the tracks (i.e. on reconsolidated soil) will grow.

*Source: "Von Analyse bis Zeigerpflanze" (Manuel Böhm, Landwirt Bio plus Edition 3) and "Kalk für den Acker - Sauer ist nicht lustig" (Stefan Simon, Landwirt Bio plus Edition 4), Landwirt Agrarmedien GmbH, www.landwirt.com

Earthworm examination

Earthworms are indicators of an active soil life because their presence and actions are visible to the naked eye. Their burrows, dung piles and casts are a clear sign of their activity and, accordingly, the quality of the soil structure.

Earthworms keep the soil in good shape and ensure that the water in saturated soils can seep downwards. This prevents waterlogging. Furthermore, the channels made by earthworms aerate the soil and are used by plants for root growth.

Stable clay-humus complexes occur within earthworms, which contribute greatly to the formation of stable soils.

Worms are the only creatures on this Earth that have the unique ability to create soil.

2.4 Analysis of indicator plant functions*

Indicator plants can provide reliable information on the soil's pH level as well as its structure (mud silting, compaction, smearing) and moisture levels. If crops are demonstrating irregular growth, the effect of wet harvests, wet tillage conditions and their associated consequences such as compaction, acidification, and nutrient and oxygen deficiencies can be felt for years. Furthermore, discolouration in the crop can suggest a lack of various nutrients.

1. **Wet tillage**
2. **Surplus of nitrogen (nitrates) on the surface**
3. **Surplus of nitrogen (nitrates) in deeper soil layers**
4. **Smear layer with accumulating catchment water**
5. **Compaction on the headland and superficial structural damage**
6. **Soil acidification**
7. **Lime deficiency**
8. **Gaps (sparse crops or temporary gaps)**
9. **Gaps (sparse crops or isolated gaps/damage to sward)**
10. **Dry, light, warm soils**
11. **Wet, heavy, cold soils**
12. **Deep soil compression**
13. **Good tilth**
14. **High nutrient levels**

The image shows the limitations of mechanical weed control on heavily weed-infested fields when they are weeded and/or hoed too late or not at all.

*Source: "Von Analyse bis Zeigerpflanze" (Manuel Böhm, Landwirt Bio plus Edition 3) and "Kalk für den Acker - Sauer ist nicht lustig" (Stefan Simon, Landwirt Bio plus Edition 4), Landwirt Agrarmedien GmbH, www.landwirt.com

Corn chamomile

Key indicator of **7**
Otherwise **5, 6**

Buttercup

Key indicator of **7**
Otherwise **6, 2**

Dandelion

Key indicator of **7**
Otherwise **2, 3, 6, 12, 14**

Creeping thistle

Key indicator of **3** and **4** through to **1**, otherwise **11**

Wild radish

Key indicator of **7**
Otherwise usually **2, 6, 14**

Orache

Key indicator of **2**
Otherwise **14**

Amaranth

Key indicator of **2**
Otherwise usually **6**, sometimes **10**

Barnyard grass

Key indicator of **2**
Otherwise **14**

Couch grass

Key indicator of **8**
Otherwise usually **2, 4, 14** or often **5**

Dock

Key indicator of **7**
Otherwise **3, 4 or 12**

Gallant soldier

Key indicator of **2**
Otherwise **13, 14**

Horsetail

Key indicator of **4**
Otherwise **7, 11 or 12**

Symphytum

Key indicator of **4**
Otherwise **1, 11 or 12**

Cleavers

Key indicator of **2**
Otherwise **4, 14**

Common chichweed

Key indicator of **2**
Otherwise **9, 13, 14**

Lamb's quarter

Key indicator of **2**
Otherwise **13, 14**

Cornflower

Key indicator of **6**
Otherwise **7, 10**

Silky bent grass

Key indicator of **1**
Otherwise **11**

TIP:
Download a "weed-indication" App on your phone to quickly identify your weeds.

3. CROP ROTATION

In essence, understanding the context of crop rotation is crucial. Individual crop types should be selected based on their cultivation benefits rather than on pure economic or commercial aspects.

As such, the crop rotation plan should be designed so that the available nitrogen can largely be reutilised by the subsequent crops. Crop rotation elements should be arranged as follows:

Nitrogen accumulating – Heavily nitrogen draining – Low nitrogen draining

A certain amount of overlap is needed, however, to increase the humus content (a humus increase of 1% requires 1200 kg nitrogen/ha)

CR planning essentials

» Legume proportion between 20–25%
» Cereal proportion maximum 50–60%
» Root crop proportion maximum 5–25%
» Switch between:
- Deep root and shallow root plants
- Nitrogen increasing – Nitrogen draining
- Winter crops – Spring crops
- Leafy crops – Cereals
- Catch crops and undersown crops

Goals of crop rotation

» Maintain soil fertility
» Maximum nitrogen fixation
» Weed control
e.g. Grass-clover ley – controlling thistles
» Disease prevention and pest defence
» Nutrient mobilisation
» Year-round ground cover (only possible with catch crops)

Market-orientated crop rotation

1st year: Grass-clover
2nd year: Forage wheat
- Catch crop with legumes (vetches, vetchlings)

3rd year: Grain maize
4th year: Broad beans/soybeans
- Catch crop, e.g. mustard as N storage

5th year: Triticale
- Catch crop without legumes

6th year: Spring cereal (oats)
- with clover sown in

Forage crop rotation

1st year: Grass-clover
2nd year: Grass-clover
3rd year: Winter triticale
- Catch crop (oats, phacelia...)

4th year: Forage peas
- CC: Spring vetch, spring oilseed rape and sunflowers

5th year: Winter triticale
- CC: Spring vetch, phacelia, oilseed rape and sunflowers

6th year: Spring barley
- with clover sown in

SECOND CROP

FIRST CROP	Rye	Wheat	Winter barley	Spring barley	Oats	Maize	Pota-toes	Beets	Oilseed rape	Peas	Broad bean	Soy beans	Sun-flower	Clover
Rye	S	P_D	P_D	P	N	P	P	P	P	P	P	P	P	P
Wheat	P	N_E	P_D	P	P	P	P	P	P	P	P	P	P	P
Winter barley	P_D	N_E	N_E	N_E	P	P	P	P	F	P	P	P	P	P
Spring barley	P	N_E	N_E	N_E	N_C	P	P	P	P	P	P	P	P	P
Oats	N	F	P	P	N	N	N	N	P	P	P	P	P	P
Maize	(P)	P-F	(P)	P	N	P	P	N	N	P	P	P	P	P
Pota-toes	F	F	F	P	P	P	N	N	P	P	P	P	P	P
Beets	(P)	P-F	(P)	P	P	P	N	N	N_2	P	P	P	P	P
Oilseed rape	F	F	F	P	P	N	P	N	N_4	P	P	(P)	N_4	N
Peas	F	F	F	P_L	P_L	P_L	P_L	P_L	(F)	N_4	N_4	N_4	P_L	N_{3-4}
Broad bean	F	F	F	P_L	P_L	P_L	P_L	P_L	(F)	N_4	N_4	N_4	P_L	N_{3-4}
Soy beans	(P)	F	(P)	P_L	P_L	P_L	P_L	P_L	N	N_4	N_4	S	(P)	N_{3-4}
Sun-flowers	(P)	F	(P)	P	P	P	P	P	N	(P)	(P)	(N)	N_4	N_{3-4}
Clover	P	F	F	F	F	F	F	N	N	N	N	N	N	N

F	Favourable
S	Self-compatible
P	Possible
D	Danger of self-seeding when propagated
N	Not favourable/possible
E	Danger of eyespot
C	Danger of stem eelworm
2/3/4	Necessary growing interval in years
L	Danger of N leaching

4. TILLAGE

Post-harvest is pre-harvest

Each round of tillage releases nutrients and breaks down humus. In that sense, the ground should be tilled "as much as necessary and as little as possible". A spade test should be carried out before each round of tillage to provide clarity on the soil condition. Tillage has a significant effect on the soil and soil life. Arable farmers may pursue very different goals with their tillage. Depending on the measure and the implement used, various goals can be achieved to a greater or lesser extent. Therefore, arable farmers must be very clear about their goals and priorities before selecting implements and tillage measures.

Basic goal of stubble cultivation:

Loosening the soil

» Breaking up crusting, mud silting
» Breaking up compressed areas
» Repairing compression from tractor tyres
» Increasing the pore volume (aerating the soil, increasing the water storage capacity)

Mixing in organic matter (harvest residues, compost, farmyard manure, etc.)

» "Injection" of soil life
» Promotion of rotting in organic matter (disease and pest prevention)
» Efficient transformation of organic matter into humus

Weed control

» Pulling weeds out, cutting them off, burying them or covering them with soil
» Stimulating germination in weed seeds and volunteer seeds from the harvested crop
» Exposure and drying out the roots of root-propagated weeds (couch grass, thistles, etc.)

Seedbed preparation

» Preparing the seedbed for drilling
» Preparing the seed layer for the next crop

Regulating the water balance

» Avoiding unproductive evaporation in dry conditions
» Encouraging evaporation/drying out in soils that are too moist

Active soil is a prerequisite for healthy crops and consistent yields.

4.1 Stubble cultivation with a focus on weed control

After harvesting cereals, oilseed rape and peas, etc. in summer, there is often quite a long gap before growing the next main crop (soybeans, maize, broad bean, etc.). This gap is generally used for growing an early catch crop to cover/shade the ground, feed the soil life and promote the active formation of humus and soil. When an early catch crop is grown under good conditions, it quickly establishes dense growth and effectively suppresses any weeds or volunteer cereals that may germinate. More detail on growing catch crops can be found in chapter 5. On fields with high levels of weed pressure, and especially those with acute root-propagated weed problems, this gap between main crops can also be used to treat weeds. At this point, it should also be mentioned that it is important to analyse and eliminate the causes of a widespread occurrence of weeds. A weed treatment is more or less extent an acute measure, which primarily combats symptoms without eliminating the actual causes in the long term. (E.g. nitrate leaching in the subsoil, compressed areas of soil, unbalanced levels of nutrients)

With a focus on weed control, the first pass of stubble cultivation should be as shallow as possible (approx. 4–5 cm / 1.6-2") – using a shallow cultivator, for example – to encourage weeds and volunteer cereals to germinate. Further, the soil should be penetrated at full width (to control root-propagated weeds). When dealing with root-propagated weeds especially, intensive reconsolidation has a negative effect because residual weeds that are pressed down can often sprout up again and even propagate.

For this reason, a lightweight trailed implement such as a cage roller should be used in combination with a harrow. A harrow brings weeds up to the surface and loosens the residual soil from the roots. As a result, weeds dry out faster. To successfully treat root-propagated weeds, a few days of dry weather (hot, dry air, wind) are required.

On the second pass of cultivation (usually two weeks later), the working depth should be increased to approx. 10 cm / 4" to destroy any weed seeds that have already germinated and volunteer cereals that have started to germinate, and to achieve the optimum conditions for straw rotting. In doing so, it is important that only the dry soil horizon is cultivated. Patches of smearing or slades should always be avoided, otherwise the pores in the soil close up, which interrupts ground water movement (capillarity).

When laying the roots of root-propagated weeds out on the surface, a few days of subsequent dry weather are also required to permanently damage them. In dry weather conditions, the process of laying root-propagated weeds out on the surface to dry out can be repeated a second time. After treating the weeds, a dense catch crop should be established immediately in order to bind the nutrients released through intensive cultivation and to stabilise the soil structure. (See Chapter 5 on growing catch crops.)

Duckfoot sweeps mounted on spring tines

Wing shares mounted on rigid shafts in addition to double-heart shares

Both systems enable full-width soil penetration.

4.2 Primary tillage

Primary tillage involves loosening the entire layer of topsoil to create favourable growth conditions for the following crop. Various implements can be used for this. Choosing primary tillage implement requires careful consideration. Arable farmers must determine their goals before primary tillage and weigh up the pros and cons of each measure.

Ploughs

Ploughs are the classic implement used for primary tillage. They cultivate the topsoil with maximum intensity, turn it over completely and have the most impact on soil life.

Advantages of ploughing

- The soil is intensively aerated, which mobilises a large number of nutrients (nitrogen).
- "Clean sweep" – weeds are buried or destroyed
- The working depth and quality of work (smearing) are immediately visible
- Bare surface = very good conditions for frost
- Subsequent seedbed preparation using simple machinery without blockages (even with towed machines)
- Sowing using simple sowing equipment (Suffolk coulter)
- Cultivation impossible even under moist conditions
- Moist soils dry out quicker
- Weeding and hoeing is possible using simple equipment without the risk of blockages

Disadvantages of ploughing

- Nutrient mobilisation = break-down of humus
- High energy consumption, low acreage performance, thus high costs
- Harvest residues and farmyard manure are buried, rotting is poor – thick layers of straw are formed underground rather than humus – non-root-friendly/impenetrable areas
- Frequent ploughing reduces the earthworm population due to a lack of food on the surface and their habitat being damaged
- Soil layers reversed – unstable aggregates (soil particles) rise to the surface and smear easily.
- Nitrogen mobilisation is not desirable in autumn because it easily leaches away;
- Lack of ground cover from organic material leads to a high risk of erosion
- High levels of unproductive water loss are detrimental during droughts and in dry areas
- Too much aeration on light soils – short-term overheating of soil life – "flash in the pan" effect

Using a plough is as popular as ever in organic farming due to it being so good at suppressing weeds. Nevertheless, ploughing has a big impact on soil life and should therefore be given careful consideration before each use. In particular, the presence of soil fungi (mycorrhiza fungi) and earthworms can be bolstered when farmers abstain from ploughing.

Cultivators

Rigid cultivators are very well suited to primary tillage and have their pros and cons in comparison to ploughs. Using a cultivator for primary tillage has gained significant traction over the past few years (new developments in cultivators, increased acreage performance, water savings, erosion reduction, soil protection, etc.). Many arable farmers use both a plough and a cultivator for primary tillage depending on the situation.

Advantages of using a cultivator

- Soil layers are not reversed – stable soil aggregates are created in the upper soil layer; soil life is protected
- Earthworm population is boosted
- Organic matter is mixed into the entire humus – favourable conditions for rotting; efficient transformation of organic matter into humus; no straw matting; protective mulch layer
- Increase in number of medium pores – improved water holding capacity in soil
- Increased acreage performance
- Lower diesel consumption
- No plough pan formation
- Less unproductive evaporation
- Good erosion protection

Disadvantages of using a cultivator

- No "clean sweep" (mulch layer stays on the surface)
- Higher requirements on seedbed preparation
- Higher requirements on sowing equipment (disc coulters)
- Fewer large pores than with ploughing
- Does not work well in wet conditions
- Limited use in very heavy and compact soils
- Higher demands on weeding and hoeing technology
- Difficult to use and provides poor results on very moist soils

Shallow ploughs

Shallow ploughs combine the advantages of traditional ploughing with a minimal amount of cultivation. Their mode of operation consists in using a minimal working depth to turn and mix the soil, then re-cover the surface. In addition to being a good preparatory tool for controlling weeds, shallow ploughs ensure a rapid rotting process due to their shallow mode of operation. Problems with fungal infestation and other diseases are also reduced as a result.

Advantages of shallow ploughs over conventional ploughs

- Harvest residues are only incorporated superficially. This enables them to remain in contact with oxygen, which accelerates the decay process.
- Besides the top few centimetres, the soil is left uncultivated. As a result, its holding capacity and structure are retained, which are necessary for maintaining optimum gas and water balances.
- Weeds and volunteer cereals are controlled mechanically even at a shallow depth (up to 20 cm / 8" deep)
- Shallow ploughs are pulled along outside of the furrow ("on land"), which enables plough pan compaction to be completely avoided
- With each centimetre of working depth, 150 tons of earth are to be moved per hectare, which takes a lot of power. Shallow cultivation can therefore reduce diesel consumption
- By reducing the performance output, the working width can be increased by up to 40% compared to regular ploughing

Less is more.

4.4 Seedbed preparation

A perfectly levelled, shallow-cultivated seedbed is characterised by a medium to coarse tilth with an open structure. The seed itself is deposited into a fine-tilth soil horizon with a compacted, water-bearing layer underneath. To avoid damaging the soil through compression, seedbed preparation should be carried out in as few passes as possible. To the extent possible, the land should not be driven over when saturated. The resulting compressed areas and mud silting delay the development of plants.

If the conditions in spring permit, a "false seedbed" can also be prepared. Weed seeds can germinate and start to grow in a seedbed that is already prepared 2 to 4 weeks before sowing is planned. This population of weeds can then be tackled relatively easily and effectively during actual seedbed preparation before sowing. To intensify this effect, the "false seedbed" can also be cultivated once or twice in between using a seedbed combination or potentially also a tined weeder. This enables weed pressure to be distinctly reduced, particularly during the early stages of the main crop.

To the extent possible, PTO-driven implements such as rotary harrows and spike drums should be avoided, since they can smear the soil in wet conditions.
There is also the danger of breaking up the different soil components too intensively when using these implements. When they are used in spring, after the field has been ploughed in autumn, the seedbed can quickly become too fine, which tends to cause mud silting or erosion.

Seedbed preparation using a classic seedbed combination
- Very high impact (large working width + high speed)
- Very good levelling from the levelling bar (= important for precise sowing)
- Good reconsolidation
- Protects soil structure (= prevents erosion)

As rough as possible and as fine crumbly as necessary.

5. GROWING CATCH CROPS

Catch crops are a sensible and important solution for drawing solar energy into the ground between main crops (particularly during the summer months of July, August and September), feeding soil-dwelling organisms and fixing N.

Fundamental goals of catch crops:

» Ground cover (preventing soil from drying out)
» Root penetration
» Increased soil fertility
» Capturing and storing nutrients
» Breaking up the main crop rotation
» Promoting straw rot

Catch crops should complement the main crop rotation and reduce infection crossover. The following aspects should therefore be considered when growing catch crops:

» If a crop rotation includes growing peas, then peas, lupins, vetches and broad beans should be avoided as catch crops because peas are especially sensitive to rotation-contingent diseases. The same applies to a lesser degree when lupins or broad beans are the main crop.
» Mustard and fodder radish should be avoided in oilseed rape crop rotations due to the risk of finger-and-toe disease.
» Phacelia and mustard are taboo in potato crop rotations because they transfer rattle virus (internal rust spot).

The more species (ideally 8–10) in the catch crop the better, but at least 5 partners.

5.1 Undersowing catch crops

The following are particularly suitable: short grasses, white clover, black medic, mustard, camelina, perko or grass-clover, red clover, lucerne.

Recommendation: Sow the undersown crop with the second weeding pass between tillering and shooting

Advantages:

- Fixes additional nitrogen, helps to control weeds and reduces erosion
- Once the main crop has been harvested, the undersown crop is exposed to light and gets growing. No cultivation is necessary/possible
- Cost-effective since no cultivation is necessary

Disadvantages:

- Undersown crops can be too highly suppressed by the main crop and grow poorly
- Undersown crops can grow too aggressively and overwhelm the main crop or deprive it of water and nutrients
- No cultivation is possible after harvesting

5.2 Seed sowing after and/or during stubble cultivation

Once a cereal crop has been harvested, the ground should be tilled as soon as possible and as shallow as possible to encourage volunteer cereals and weed seeds to germinate. Multiple passes with a cultivator at various depths and at intervals of several days reduces the prevalence of weeds. However, this is in conflict with the early sowing of a catch crop, and ensuring the ground is covered quickly. Depending on the summer and the weed pressure, either a weed treatment should be carried out or a catch crop should be sown as early as possible. Volunteer cereals can usually be suppressed fairly reliably by using a bulky green manure mix. Otherwise, they make a perfectly good enhancement to a green manure mix once they have germinated.

Shallow stubble cultivation (working depth approx. 5 cm / 2")

2nd pass stubble cultivation (working depth up to approx. 10 cm / 4") in combination with sowing green manure

A pneumatic seed drill should be used for sowing, especially for expensive, small-grained catch crop seeds. They ensure precise seed placement and a nice even crop emergence. If a catch crop is spread using a classic disc spreader, the seed can end up being unevenly distributed due to the implement's susceptibility to wind.

The aim is to sow a catch crop as soon as possible after harvesting.

5.3 Incorporation of green manure

In nature, green plant matter does not normally end up underground, so it follows that only rotted matter should be incorporated into the soil. Furthermore, earthworms can only utilise the plant matter that is on the soil's surface as actual food.

The following principles should be considered in addition:

- Tall crops should be chopped at the right time (in the case of flowering crops, protect insects by chopping green manure in the evening, morning or generally during cooler weather)
- The initial composting that follows reduces the risk of anaerobic digestion
- Chop approx. 2 weeks before incorporating the green manure
- Do not let the growth lignify, otherwise nitrogen is only slowly released and this can lead to shortfalls in yield
- Therefore, do not plough fresh green material deep into heavy soil
- On light soils, do not incorporate too late before sowing winter crops, otherwise the emergence of the main crop may be hindered

With easily breakable crops (such as mustard, buckwheat and broad beans), a quick pass with a roller is often enough to cause the green manure to die off. Green manure that is hard to chop (such as clover or grasses) must be mulched or mown.

Caution: Incorporating green manure takes a great deal of intuition.

Incorporating frozen off green manure

Certain crops such as mustard, phacelia and Egyptian clover can be easily incorporated if they are well dried out. They break up superbly just by using a tillage implement such as a cultivator or rotary harrow. Egyptian clover and phacelia can also be "chopped" when frozen using a Cambridge roller.

Shallow incorporation of frozen catch crop in spring using the light cultivator

Shallow incorporation of frozen catch crop in spring using the universal cultivator

Incorporating green manure that has not frozen off

Careful work is required in this case to prohibit the greening crop from appearing in large quantities in the following crop. Special care must be taken with grasses, since they are especially persistent. It is important to cut into the ground at full width with either a plough, a wing share cultivator or a light cultivator with duckfoot sweeps.

When tilling without turning over the sod, the rhizomes must be separated from the earth as much as possible in order to prevent new growth. A trailed weeder has proven to work well for this. Often, a combination of multiple tillage steps at intervals of a few days are necessary to allow the strong plants to die off. Do not mow or mulch beforehand because tall plants drain the roots dry.

It is important to cut across the full working width when incorporating green manure.

6. MECHANICAL WEED CONTROL

CROP	Tined weeder	Precision tined weeder	Rotative weeder	Rotary hoe	Rollstar hoe	Hoe with sweeps
Winter cereal	✓	✓	✓	✓	–	✓
Spring cereal	✓	✓	✓	✓	–	✓
Maize	✓	✓	✓	✓	✓	✓
Soybeans	✓	✓	✓	✓	●	✓
Sugar beet	●	✓	✓	✓	●	✓
Oilseed rape	●	●	●	●	–	✓
Broad beans	✓	✓	✓	✓	●	✓
Peas	✓	✓	✓	✓	–	✓
Lupins	✓	✓	✓	✓	–	✓
Potatoes	●	✓	✓	–	✓	–
Pumpkin	✓	✓	✓	✓	●	✓
Seed flax	●	✓	✓	●	–	●
Caraway	●	✓	✓	●	–	●
Specialist crops	●	✓	✓	●	●	●
Blind weeding	●	✓	✓	–	–	–

✓ = easy to use ● = limited use (additional equipment may be needed) – = unusable

In general – do not be afraid of weeds!

For those transitioning: In the first few transitional years especially, weed pressure is generally lower because the seed potential has been heavily reduced by plant protection products.

The goal of weeding and hoeing is to support the cultivated crop and to damage and eliminate weeds. We aim to reduce the weed pressure to a minimum and to give the cultivated crop a head start. Complete eradication of weeds is not possible, nor is it the goal. Up to a certain damage threshold, weeds are even desirable because a higher density and variety of wild plants actually promotes soil stability.

Important for non-organic farms: An arable field that has been weeded or hoed will never look like one that has been treated with chemical plant protection products, and nor should it!

✓ **Healthy soil has less weed pressure.**

7. WEEDING TECHNOLOGY BASICS

Tined weeders have been a trusted implement for mechanical crop care for decades, as well as providing an alternative or addition to chemical weed control. Through their successful use with cereals, maize, beets, oilseed rape, potatoes, vegetables, peas, soybeans, broad beans, pumpkin, etc., these tined weeders provide crucial benefits when it comes to crop care.

Their thorough, effective mode of operation makes the tined weeder an essential component of a sustainable farming concept, whether conventional or organic. The benefits of weeding extend far beyond mechanical weed control. In addition to their ability to aerate the soil, regulating the water balance and promoting tillering are both significant benefits. Not to mention mobilising nitrogen, which is a major benefit in promoting a high-yielding crop. In addition to the economic benefits for farms, weeding technology also benefits the general environment as well as public perception.

7.1 Weeding fundamentals

- The correct and therefore optimal adjustment settings for a tined weeder depend on the soil and plant conditions as well as the prevailing weather conditions.
- The ideal tine pressure is achieved by correctly adjusting the tine tilt in accordance with the depth and speed settings.
- The success of a tined weeder in controlling weeds is primarily accomplished by it burying the weeds in soil at the cotyledon stage (50–70%) in addition to pulling the weeds out of the ground (30–50%).

When to use

» The best timing for weeding is around midday on a sunny, windy day, since weed seedlings dry out in the sun and this causes them to die off. It also allows you to drive more intensively because the cultivated crop is more flexible under these conditions (cell pressure in the plants diminishes).
» The optimum timing for weeding can be determined by laying a windowpane on top. The warmth makes it easier to see the first weed cotyledons, which means it is time to get the tined weeder out.
» For rye, winter barley and early-sown wheat in a cereal-rich crop rotation, the autumn-germinating weeds silky bent grass and slender foxtail often cause the most problems. In this case, success with weeding depends on starting well before winter (i.e. weeding in autumn).
» If the weeds have passed beyond the cotyledon stage, controlling them is harder. Weeding must be carried out more intensively (more tine pressure or a stiffer tine setting) because it will barely be possible to pull the weeds out and they tend to survive being buried. In this case, one or more additional passes of hoeing with the row crop cultivator can often be helpful.

Seedbed and soil

» The measures that are carried out before a crop germinates are critical. As such, a basic prerequisite for having weed-free fields is getting the seedbed right. The right seed and seed depth – aligned to both climate and soil – are also important for a high-yielding harvest.
» Whenever possible, a false seedbed should be prepared, as this causes the first wave of weed seeds to germinate, enabling them to be eradicated before seed sowing.
» In principle, the ground should be of excellent tilth, i.e. loose and crumbly (caution: not too coarse). Therefore, on clayey and silty soils, the pH level in the topsoil must be correct, otherwise crusting may occur.
» It is important to ensure that the soil is not damp, otherwise mud silting can occur, which will cause the soil to lose its crumbliness. A rotative weeder can remedy this, since it can be used sooner than a tined weeder (e.g. if the soil is still a little damp).
» When the soil is heavily frozen in spring, it is advisable to roll it first then weed it once the plants are standing.

Working speed and tine settings

» The faster you drive with the tined weeder, the greater its performance power and success in controlling weeds. Nevertheless, travelling at higher speeds poses a greater risk for the crop. It is important to find the right balance here.
» The speed of travel can be between 1.5 (young crops) and 12 km/h / 7 mph depending on the conditions.
» **Tines on grip:** Less soil deposited on crop – speed under 6 km/h / 3.7 mph
» **Tines dragging:** More earth movement – higher risk of covering crop
» **Tines at 90°:** Weeds are covered – choose faster working speed – only use this setting once the crop is bigger

5 km/h / 3 mph

9 km/h / 5.6 mph

Source: Diagrams – Naturland.de, Becherer & Hänsel 2004

Summary

Finding the right weeding settings for a specific farm and its various crops takes a lot of experience. The greater your knowledge and experience, the faster and better you become at choosing your tined weeder settings. Sadly, there is no one-size-fits-all solution because the conditions can often change even during the season or on different areas of land depending on the weather and soil. Your individual settings should be checked multiple times and adjusted if necessary. Weeding takes patience and precision – quality is more important than acreage performance.

7.2 Weeding at different growth stages

Cereals	Blind weeding	Crop emergence	1 leaf	2 leaves	3 leaves	Tillering
Spelt	-	-	-	X	XX	XXX
Wheat	-	-	-	X	XX	XXX
Rye	-	-	-	-	X	XXX
Triticale	-	-	-	X	XX	XXX
Oats	X	-	-	X	X	XX
Barley	X	-	-	-	X	XX
Additional crops	**Blind weeding**	**Crop emergence**	**5 cm / 2"**	**10 cm / 4"**	**20 cm / 8"**	**40 cm / 16"**
Broad beans	XX	X	X	XX	XX	XX
Peas	XX	-	X	XX	-	-
Vetches	X	-	X	X	-	-
Lupins	-	-	-	X	X	X
Lentils	X	-	-	X	-	-
Soybeans	X	-	X	X	X	-
Sunflowers	X	-	-	X	X	-
Maize	XX	-	-	X	X	X
Potatoes	XXX	-	-	X	XX	-
Safflower	X	-	X	X	XX	-
Flax	-	-	-	X	XX	X
Oilseed rape	-	-	-	-	X	-
Beets/buckwheat/hemp	-	-	-	-	-	-
Millet	-	-	-	-	X	-

- = Do not weed
X = Weed with care
XX = Weed as normal
XXX = Can be weeded intensively

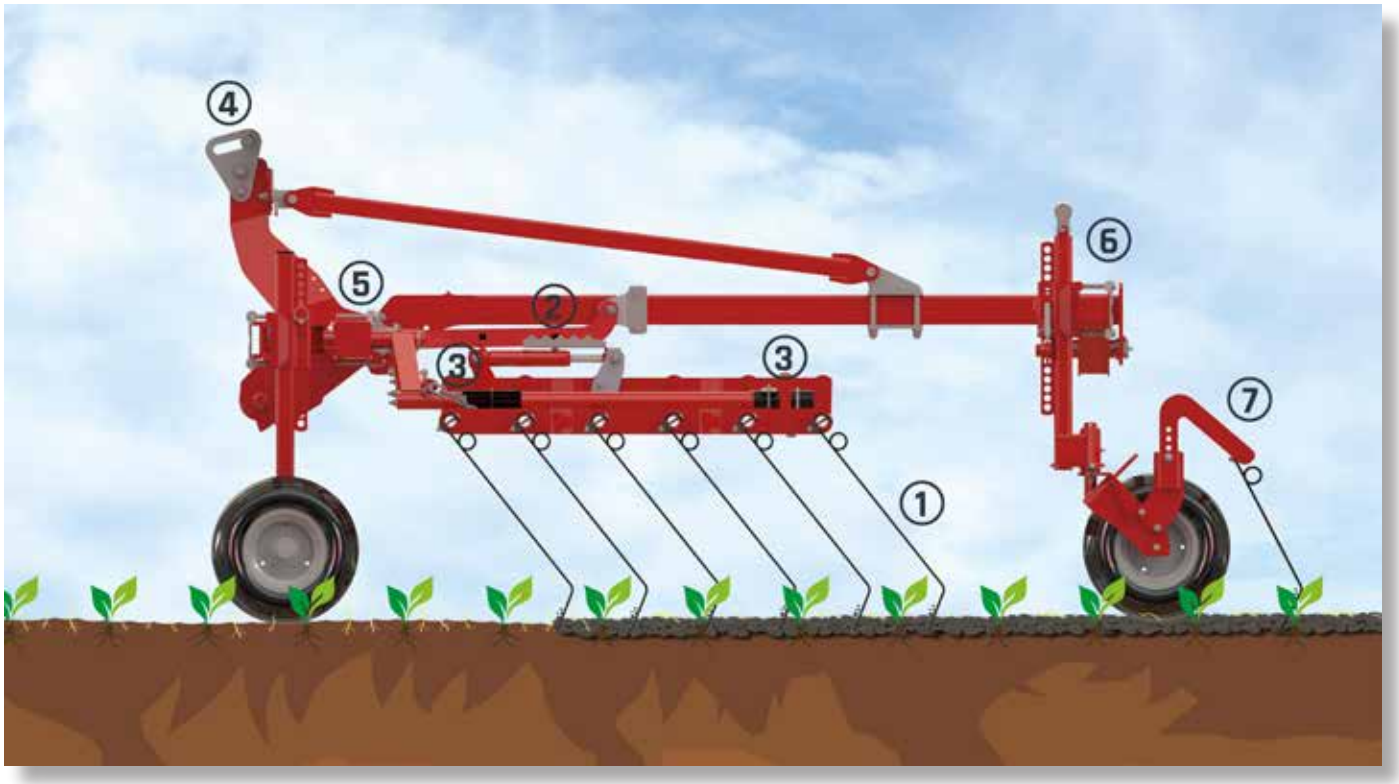
Source:
"Der fortschrittliche Landwirt"
(Dec. 2010 edition, no. 23)
Report by Franz Traudtner & Heinz Köstenbauer

No field or crop is the same, which is why the tined weeder is used differently in each case.

Basic concept for weeding:

1. Directly spring loaded tines with a high clearance and 2.5 cm / 0.9" true line spacing; tines should set on grip for best possible results
2. Constant tine pressure over the entire working width due to hydraulic tine pressure balancing
3. Constant working depth on all tine rows on the tine section due to section fixings front and back
   Working depth up to 3 cm / 1,2" – seed grain must not be touched
4. Slotted hole for optimum ground adjustment even when uneven
   Tined weeder is pulled rather than carried or lifted
5. Tined weeder runs smoothly due to compact design
6. Pendular axle to compensate for uneven ground
   The tine section rather than the fork should be set parallel to the ground
7. Loosening of wheel tracks due to extra weeder tines at the rear on the trailing wheels

The sooner you weed, the better!



7.3 Blind weeding

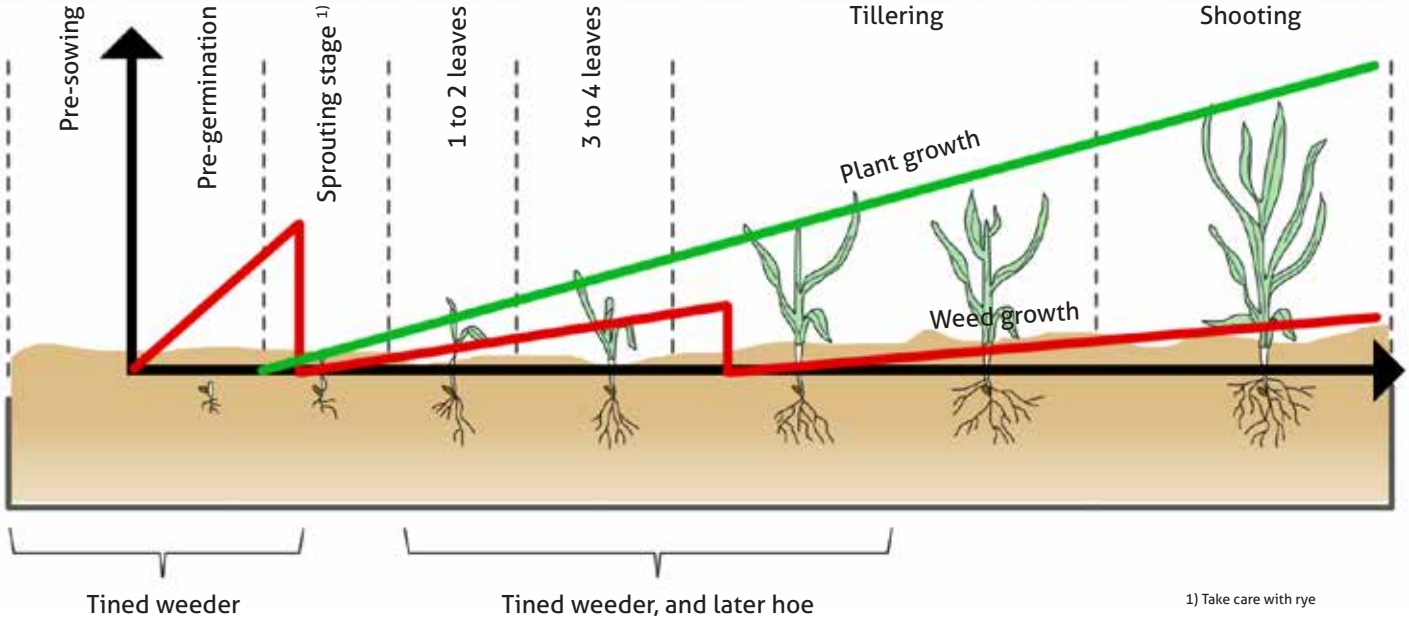
Blind weeding is carried out between seed sowing and crop emergence. A deeper seed placement ensures that the seedlings are not damaged. Blind weeding is primarily recommended for crops such as broad beans, soybeans and maize (crops that are sown later anyway). As well as helping to control weeds, blind weeding also breaks open the soil crust, enabling a better crop emergence. When blind weeding, the tined weeder must be adjusted very precisely so as not to damage the seedlings.

- Blind weeding (a few days after sowing, before the crop emerges) often produces very good results and provides another opportunity to control germ tubes from weeds before emergance. Virtually all crops should be blind weeded in this way.
- The best success with weed control is achieved in the tube stage at up to 80%.
- To avoid damaging the crop (i.e. the seedlings), the working depth must be precisely maintained when blind weeding. This should ensure that the seeds are not affected or displaced by the weeding in any way.

Plan for blind weeding during good weather and when it is safe to drive over the fields.

7.4 Weeding post-emergence

In principle, the timing of weeding cereals, grain legumes, maize and potatoes is dictated by the weed growth. Once the crop has emerged, the ground should be weeded to cover the weeds in soil as long as it is possible, i.e. when the weeds are no further than the cotyledon stage (tube stage). However, the crop's delicate growth stages (e.g. cereals at the 2-leaf stage) should be avoided.



The weeding speed is dependent on the crop, growth stage and soil characteristics.

7.5 Weeding TOP 10

1. **Weeding begins immediately after sowing**

2. Each pass with the tined weeder weakens the soil structure and encourages weed seeds to germinate – therefore, before each **pass with the weeder, careful consideration** is needed to decide whether it is necessary

3. Sowing should be timed with a view to **blind weeding** and the appropriate weather conditions

4. Adjust the **working depth** of the tined weeder based on the seed placement depth and the size of the seedlings so that they are not damaged (step off and check several times)

5. **Working speed** has a big influence on intensity – adjust this based on the conditions, crop and weed pressure.

6. Pay close attention to the appropriate **timing** (soil, weather, crop growth stage, weed size) – always check if the soil is safe to drive over

7. Set the **tines on grip** – this ensures optimum weed control and coverage (the tine section must be set parallel to the ground during travel)

8. The **weeding effectiveness and intensity** is determined via the speed, tine setting and tine pressure

9. Use a **"weeding diary"** to record as you work (usage, speed, depth, setting, etc.)

10. Trying and failing is better than studying – **success through experience**

8. HOEING TECHNOLOGY BASICS

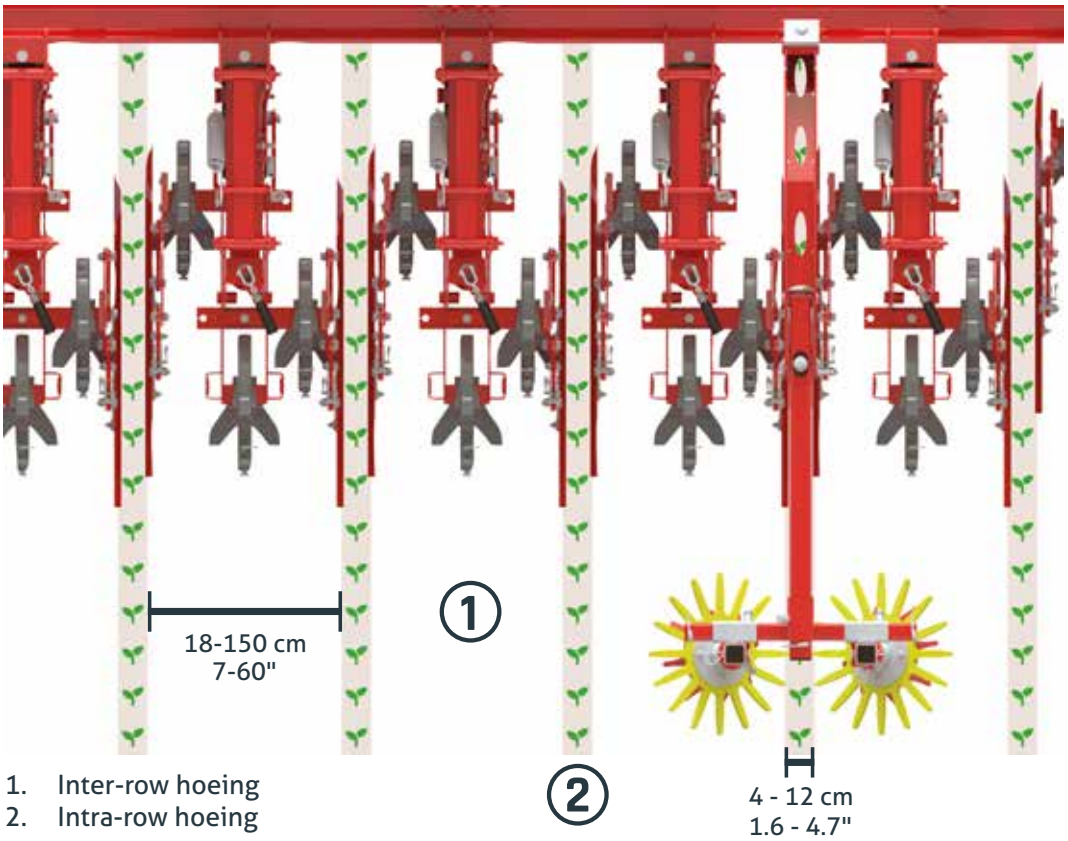
8.1 Hoeing fundamentals

Row crop cultivators can be used to protect row crops mechanically. This enables chemical plant protection to be reduced or avoided. As well as a bladed hoe mounted at the rear or front, a rotary hoe or rollstar cultivator can be used. They can be steered by either the tractor steering wheel (for front-mounted implements), via upper link steering, a hydraulic steering wheel on the cultivator or via automatic camera steering. A range of new options such as the finger hoe, trailed rotative weeder, various sweeps and vibrosprings, ridging tools, angle knives, cutting discs, etc. have been developed over the past few years.

In addition to the customary row spacings of 45/50 cm / 18/20" (in sugar beet and winter oilseed rape) and 70/75 cm / 27/30" (in maize), individual rows with a spacing of 25 cm / 10" are now common in cereals, oilseed rape, broad beans and peas. Hoeing should be considered as early on as seed sowing. Rows must be in parallel to be able to work as closely as possible to them.

Hoeing is so popular because you can see the results of your work immediately.

Albert Einstein



1. Inter-row hoeing
2. Intra-row hoeing

Front hoeing

Rear hoeing with upper link steering

Rear hoeing with camera steering

Rear hoeing with camera steering and section-controlled element lifting via GPS

Rollstar cultivator with rear upper link steering

Rotary hoe enables soil crust to be broken across the whole working width

8.2 Tips for setting up your row crop cultivator:

Setting up your row crop cultivator correctly is critical for success with hoeing, and therefore with your harvest. We are pleased to share our knowledge gained over four decades with farmers throughout the world.
Allow yourself enough time to set up your hoeing technology correctly and professionally. If you put in adequate time and exercise patience, you will be rewarded for it later on.

As a general rule: Number of rows sown = number of rows hoed

- Your row crop cultivator must always be perfectly in tune with your seeder. The number of rows on the seed drill dictates the number of rows on the row crop cultivator (half widths are also possible).
- In addition, the row spacing on the row crop cultivator must be identical to that of the sowing machine. Sowing your seed precisely and accurately sets you up for success later on when hoeing. If the row spacing varies at this stage, it is difficult if not impossible to work with any precision at the hoeing stage.
- The headland is always hoed first, otherwise the weeds are run over when turning, which makes them harder to hoe later.
- The best time to hoe is late morning (or even better, early afternoon). There should ideally be no rain forecast after hoeing.

Adjustments for mounting a row crop cultivator onto a tractor:

- Regardless of whether you are using camera steering (diagram 6) or upper link steering (diagram 5), the height compensation should always be made available to the lower links in order to achieve better ground adjustment.
- In addition, the lower link brace should always be the same length.
- When mounting a row crop cultivator with upper link steering (without camera steering), the side lower link stabilisers must be opened so that they can move side to side. Otherwise, the row crop cultivator cannot follow the tractor properly and you quickly end up alongside the track.
- When mounting the row crop cultivator without upper link steering but with camera steering, it is important that the lower links are locked so that they cannot move side to side. In addition, the ball in the lower link bracket must be mounted "free from play". Distances may help in this situation. If the sideshift frame is not mounted rigidly onto the tractor, it creates a lot of play. Then there is a danger of the row crop cultivator not moving in line with the crop rows, since it can move in another direction on the lower links at the front (it oversteers). Due to the large amount of play, the sideshift movement cannot be directly transferred to the row crop cultivator, which delays course correction and greatly impairs precision.
- The upper link should be set up so that the machine is level during operation. A hydraulic upper link is best suited to this. If the machine is not set up level, not all of the sweeps work at the same working depth. This can lead to the machine not operating at full width. The hoeing sections should be set up parallel to the ground (or slightly sloping to the rear (diagram 1).

Diagram 1

Diagram 2

Working depth and tool adjustments:

- As a general rule: As deep as necessary and as shallow as possible (diagram 3) in order to cut down all the weeds at full width and let them dry out on the surface. To guarantee that the implement is working at full width, the sweeps must overlap slightly. Using the scale provided, all of the hoeing sections can be set to the correct working depth (generally 2–4 cm / 1-1.6") via the spindle (diagram 2).
- If the working depth is too shallow, it will not be possible to operate at full width.
- If the hoe is set too deep, a lot of damp earth will be brought up to the surface. Too much soil movement increases the risk of erosion and water loss (diagram 3). Furthermore, a large quantity of new weed seeds are brought to the surface with the potential to germinate. This can cause weeds to regerminate faster and cultivated plants to lose out on vital moisture.
- Depending on the soil type and conditions (e.g. presence of stones, organic matter, etc.), sweeps of different widths can be fitted in alignment with the row spacing. Furthermore, depending on the crop and purpose of use, various hilling sweeps, angle knives, ultraflat duckfoot sweeps and rear rollers can be used. This is where it is important to choose the right tools, adapted to the conditions. The row crop cultivator can be adapted to the future crop as early as winter.
- The working depth and cutting setting should be checked multiple times while working.

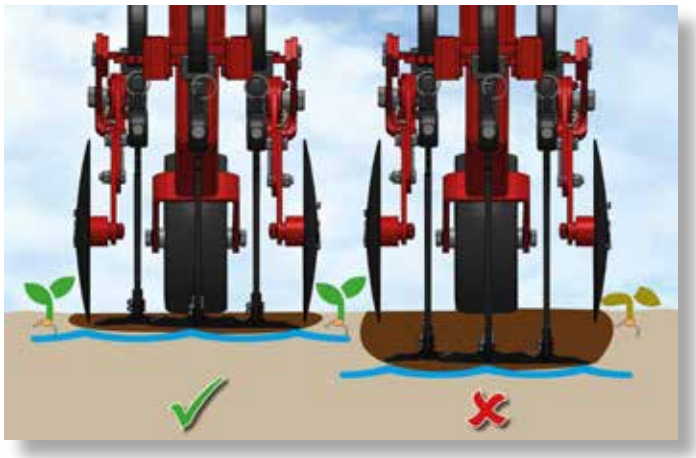


Diagram 3

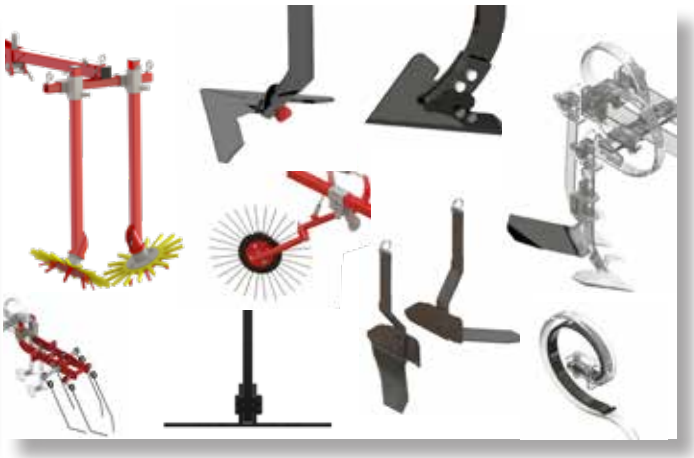


Diagram 4

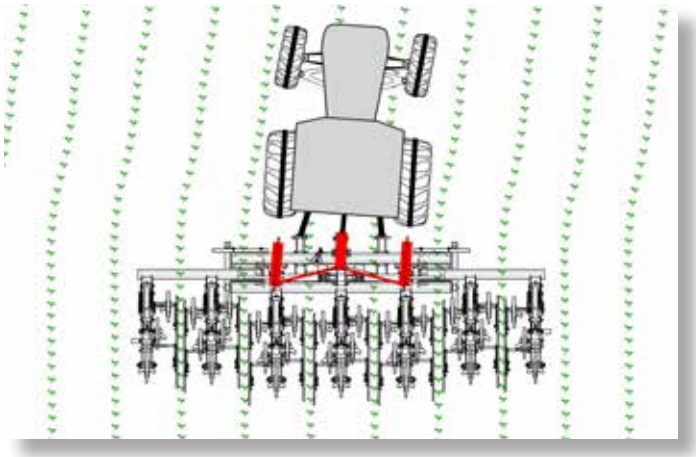


Diagram 5

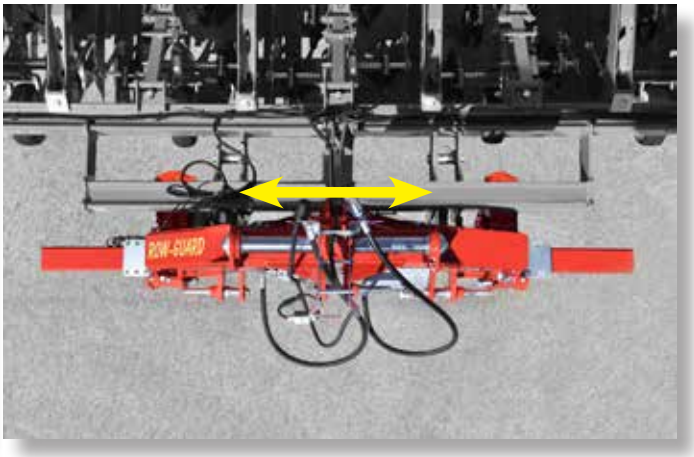


Diagram 6

Parallelogram and hoeing section adjustments

» The smaller the plants, the closer they should be hoed. The aim is to get the sweeps as close as possible to the crop without covering it with soil.
» The larger the plants, the farther away the sweeps must be fitted so as not to damage the roots and or assimilation surfaces.
» The parallelogram should be in the working position, parallel to or slightly sloping (diagram 1) towards the ground
» This enables the retraction spring of the hoeing parallelogram to be preloaded and guarantees penetration by the hoe sweeps, even on heavily crusted soils. In this position, the parallelogram also has the largest amount of scope to adjust upwards and downwards.
» In addition, a 3-stage adjustable retraction spring ensures that the parallelogram does not put increased pressure on the ground.
» On ground that is prone to erosion, a small trench with larger clods can be formed in the middle of the row by setting the last tine on each element lower. This should prevent shallow undercut earth from being washed away from hillside fields.

Protection element adjustments

» The smaller the plants (diagram 8), the deeper the protection elements must be set so that the plants are not buried or damaged. Nonetheless, most legumes such as soybeans or broad beans are not weakened by being covered with soil while the plants are small.
» Once a crop is well established, protection elements are no longer needed at all. Faster working speeds (diagram 7) and various ridging tools are used at later stages to shift some of the earth into the row. This encourages the soil over the plant roots to warm up by creating a larger surface area, thus guaranteeing faster growth. Furthermore, small weeds within the row are covered with soil, thus alleviating some of the weed pressure.
» Shortly before row closing, the protection elements are rendered unnecessary again and can simply be lifted up out of the way.
» The type of protection element that should be used, i.e. crop deflector disc or plate, depends once again on the crop type and soil conditions (e.g. organic matter or large amounts of stones).

Diagram 7

Diagram 8

Finger hoe adjustments

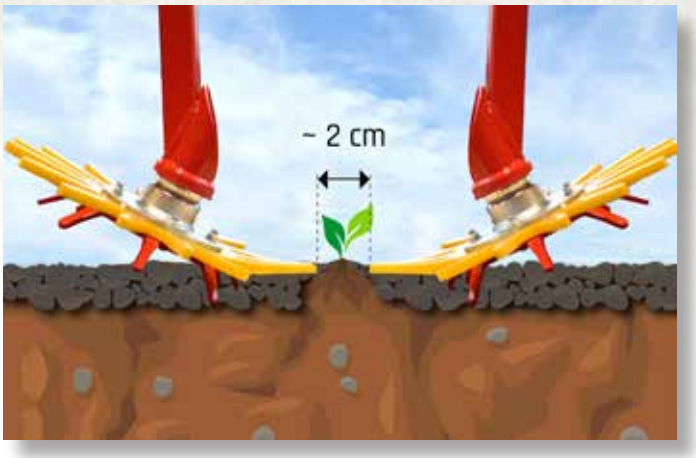


Diagram 9

» The fingers hoes should be set approx. 2 cm / 1" apart (diagram 9). If the cultivated crop is a little taller, the finger hoes should be set slightly further apart due to the plants being wider. A setting of 2 cm / 1" is only possible in practice, however, when camera steering is fitted at the rear. If the implement does not have front or rear camera steering, it is virtually impossible to detect 2 cm / 1" with the naked eye, so this setting is pretty much infeasible.

» The finger stars should always be slightly bent to exert a small amount of pressure. In doing so, it is crucial that the spring is preloaded on the holder (diagram 10).

» It is also important that only one spring-mounted holder is used for each crop row, and that it is mounted on the frame of the row crop cultivator itself rather than the hoeing section (diagram 11). This is because the hoeing element would pass on height adjustments to the finger hoes, which would then no longer be able to work precisely and in parallel with one another (diagram 12). Finger hoes that are not positioned in parallel shift the rows sideways, causing them to be damaged by the finger hoe behind (diagram 13).

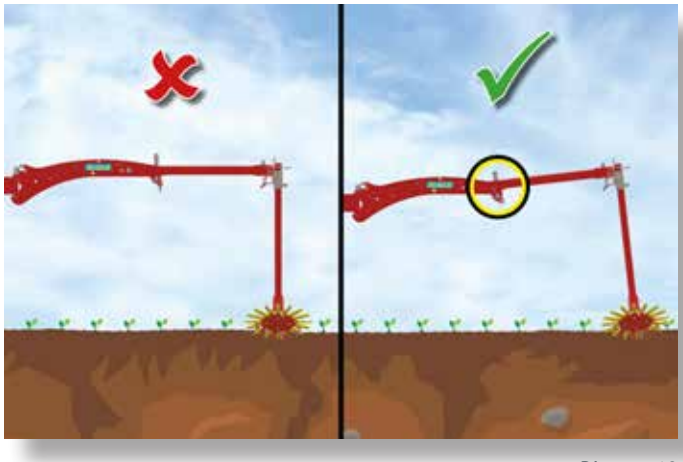


Diagram 10

Diagram 11

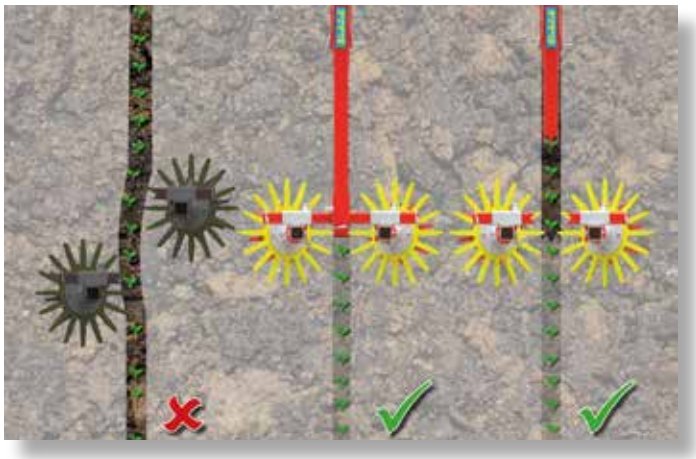


Diagram 12

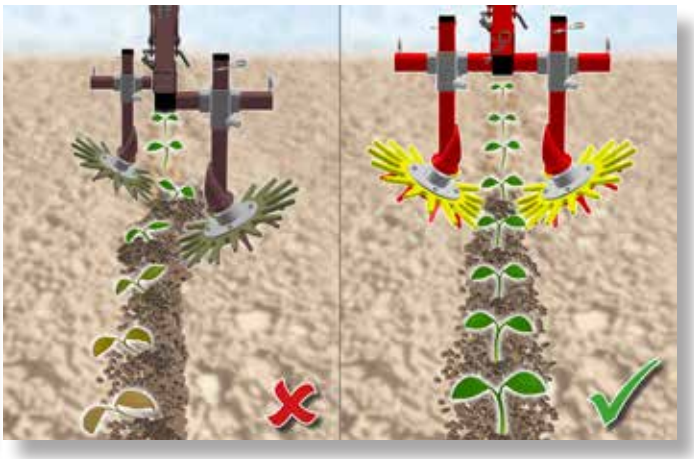


Diagram 13

Trailed rotative weeder adjustments

Speed of travel, and the down pressure and angle of the star tines are all levers for adjusting the intensity.

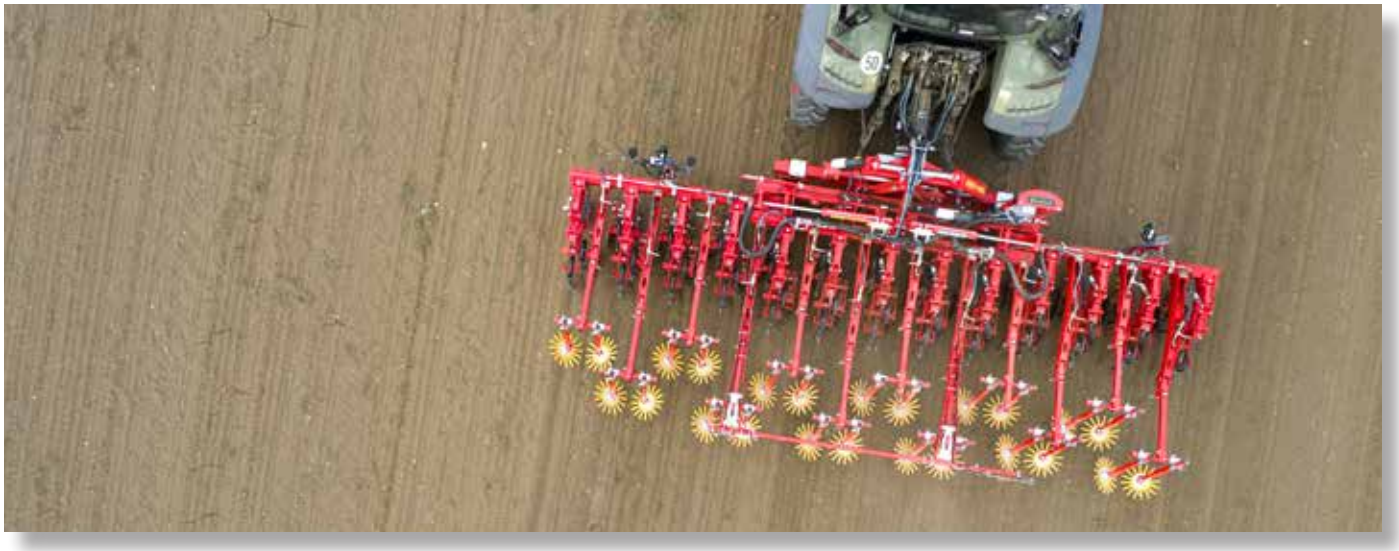
- Speed of travel – the greater the speed, the more intensive the mode of operation.
- Down pressure – can be set from "floating" to "heavily spring-loaded". The higher the down pressure, the more intensive the mode of operation.
- Angle of stars – please be very careful here! Do not go over the top because the plants can easily be chopped off.

It is important to find a blend of these three parameters that enables the maximum impact on weed control without damaging the crop (diagram 14).

Diagram 14

Summary

As a general rule based on the above: There is no one setting to match all conditions and crops. A row crop cultivator must be adapted to the crop (including its size) as well as the soil and weather conditions. Hoeing only becomes easier and more precise with experience. Calmness and patience are required, because using a row crop cultivator correctly contributes significantly to the success of the harvest.



TIP:
Keep a "hoeing diary" to capture your experiences.

8.3 Tips for setting up your rotary hoe

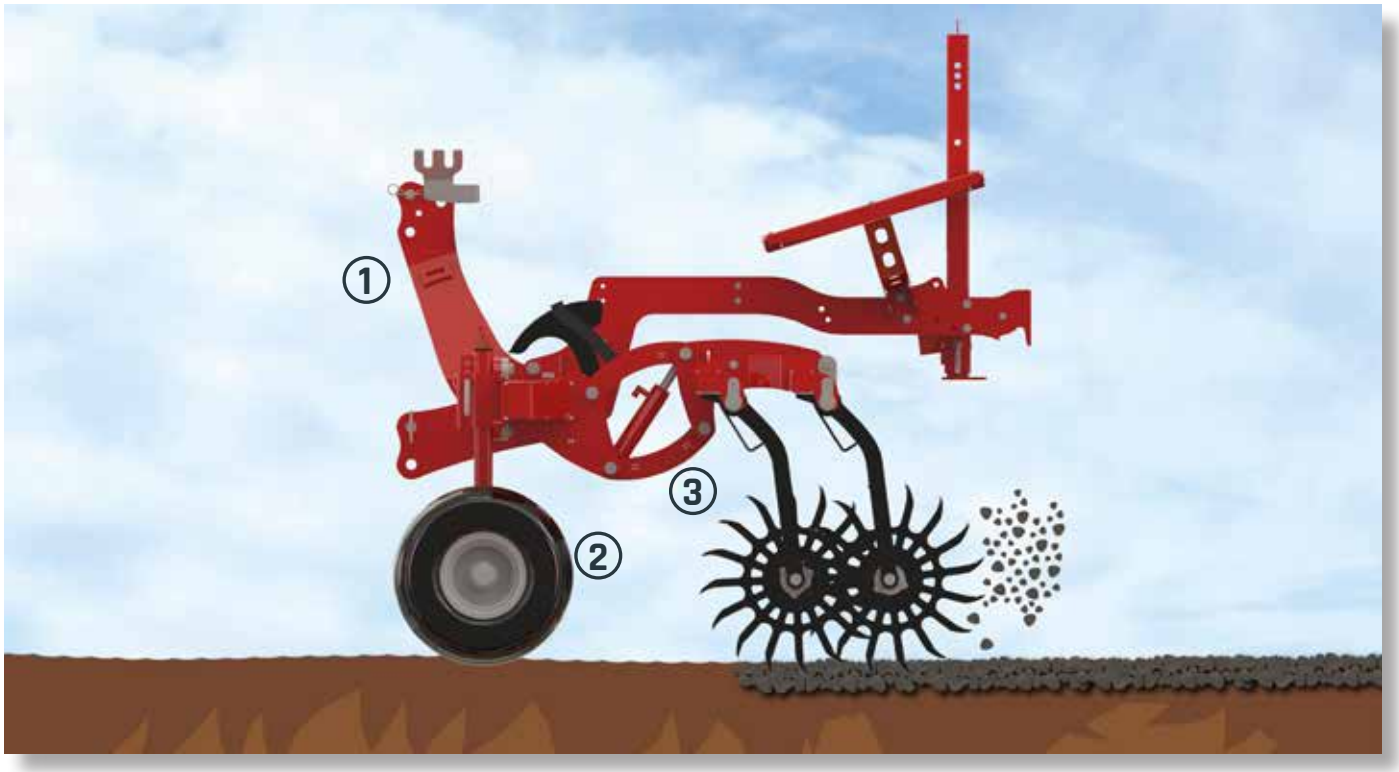
Rotary hoes break up crusting and allow air and water to penetrate the soil. Particularly in regions with heavy rainfall, rotary hoes ensure plants are encouraged to grow. In addition to breaking up crusting, they also control weeds during the same work step. The working depth is between 2 and 4 cm / 0.8-1.6". The speed of travel is fast, between 12 and 25 km/h / 7-16 mph. If a rotary hoe does not adequately control the weeds, the loosened ground is best cultivated using a tined weeder 1–2 days after the rotary hoe.

Rotary hoe adjustments

1. Mount the implement horizontally onto the tractor
2. Adjust the depth via the depth control wheels
3. Set the pretension of the rotary stars via the hydraulic level regulation

Machine applications

» Soybeans, broad beans – blind weeding and/or from first set of true leaves
» Maize – blind weeding until maize plants sprout and/or from two-leaf stage
» Winter cereals – in spring, after the last frost
» Spring cereals – from three-leaf stage



9. CEREALS: WEEDING AND HOEING

Overview Winter and spring cereals	Frequency	Timing	Working depth	Setting
Blind weeding	Once	Provided the seed shoot remains 3 cm / 1.2" below the surface	Max. 2 cm / 1" (pay attention to seed depth and shoot)	Tines dragging and/or set lightly on grip
Weeding	1st pass	2nd and 3rd leaf stage	2 to 3 cm 0.8-1.2"	Tines set lightly on grip
	2nd pass and potentially next	Until row covers, depending on weed growth	2 to 3 cm 0.8-1.2"	Tines set on grip
Mechanical hoeing (provided the cereal was sown in rows)	As required during post-emergence	Until row covers, depending on weed growth	2 to 4 cm 0.8-1.6"	Parallel and/or slightly heaped

Source: Allgäuer Bauernblatt 25/2020

9.1 Weeding spring cereals

Spring cereals such as oats, spring barley and spring wheat are usually the last crop in the rotation after winter cereals, maize or potatoes. If a crop is too heavily fertilised, it has a risk of lodging. In principle, spring cereals should be sown as soon as possible. However, any type of cereal will struggle to tolerate compressed or waterlogged areas of soil.

Mechanical weed control

1. When the seed placement is a little deeper, blind weeding is possible 2–5 days after sowing.
2. After germination, weeding can be carried out after the 2-leaf stage using medium (to intensive) tine positioning. In addition to controlling weeds, this process also stimulates tillering.
3. The final pass with the tined weeder takes place before crop covering. At this point you can work fairly intensively with high pressure on the tined section. This brings the high weed pressure in spring under control.

The image shows spring wheat being weeded for the second time (intensive weeding mid-tillering, before crop covering)

9.2 Weeding winter cereals

Sequence based on demands of the previous crop:
Winter barley – winter wheat – triticale – spelt – rye

Winter cereals must be sown at the right time. Winter barley, triticale and rye should tiller before the end of the growing season. Winter wheat and spelt should overwinter in the 3-leaf stage.
Caution: If the crop rotation has too high a proportion of winter cereals, this encourages cereal diseases as well as weeds that germinate during autumn such as cleavers, silky bent grass and root-propagated weeds (docks and thistles) due to the long growing period.

Mechanical weed control in autumn (depending on climate, soil moisture, weather, etc.)

1. When the seed placement is a little deeper, blind weeding is possible approx. 2–5 days after sowing. Goal: Aerate the soil, destroy any germinating weeds, break up soil crust.
2. After germination, weeding can be carried out after the 2-leaf stage using medium to intensive tine positioning. This pass is usually impossible in autumn due to the wet weather. Caution: Ensure the risk of overnight frost has passed before weeding. In addition to controlling weeds, this also encourages tillering and the humus is loosened and aerated.

Mechanical weed control in spring

3. Weeding (medium intensity); Goal: Strengthen stalks, encourage tillering, loosen and aerate soil. Timing: As soon as it is safe to drive on the field.
4. Weeding at approx. 30–40 cm / 12-16" plant height:
   To mobilise nutrients, control late-germinating weeds and prevent diseases, as well as to create well-balanced growth conditions for plants and microorganisms.

Before:
Intensively weeded winter barley (it looks as though the crop would be damaged)

After:
The same crop of winter barley at the end of May

Weeding in autumn

Weeding in spring using rotative weeder

9.3 Combing out cleavers in cereals

This weed has a significant impact on crops and thus on yield, particularly in wheat and oilseed rape. It can reduce yields by 30–60%. The damage caused by cleavers relates primarily to the competition it creates for soil nitrogen and light by overwhelming the crop.

Cleavers can be controlled rather effectively through weeding (without the weeder tines touching the ground), because the tined weeder is able to damage it during the growth stage and comb it out before the cereal has formed ears.

9.4 Hoeing cereals using a row crop cultivator

The first pass of hoeing should be carried out from the 4-leaf stage. Therefore, it is advisable to weed the cereal first (blind, if necessary) to capture weeds that are present in the rows. The second and third passes with the hoe (if necessary) can be carried out until the row is covered or ears emerge.

Common row widths:

Drill seeding: 12.5–18 cm / 5-7"
Row seeding: 25– 37.5 cm / 10-14.7"

To avoid earthing up the cereal crop too much and/or moving too much earth in narrower row spacings, you should aim to use the shallowest sweeps possible (see diagram on next page).

Using a hoe, weeds can be removed from between and, in some cases (using a finger hoe), amongst the rows.

A 25–30 cm / 10-12" row spacing is ideal for row seeded cereals.

Advantages of growing cereals in wide rows

- Improved weed control (combination of weeding and hoeing) because only a hoe works on root-propagated weeds. As such, problem areas can be sown in rows in order to deal with root-propagated weeds.
- With winter cereals, it is often too late to try and break up heavily crusted soils in the spring using a tined weeder. By breaking up the crust in the spring, the soil is aerated and warms up faster. As a result, the crop can start growing faster. Caution: Of course, everything is possible with a tined weeder, however, if the crust happens to be extremely hard, multiple passes would likely be required to achieve the same effect, or a rotary hoe would need to be used.
- Breaking up the soil prevents unproductive evaporation.
- Seed costs are reduced by up to 30%.
- Tillering is markedly improved since each individual plant is exposed to more light.
- Improved tillering means that each plant forms more leaves. This can lead to the crop assimilating for longer. As a result of extended growing, the grains generally grow bigger and the protein content is increased. In addition, the protein content is increased as a result of soil mineralisation during hoeing. (Image adjacent)

Drill seeding (normal row) Row seeding (wide row)

Cereal should be hoed using the shallowest sweeps possible.

Recommendation:

A 25–30 cm / 10-12" row spacing is ideal for row seeding cereals. If the spacing is narrower, only a short application with camera steering is possible due to the row covering sooner. If the spacing is wider, e.g. 37.5 cm / 14.8" or above, the row does not cover by the end of growing. Later weed infestations are possible. This would require further weed control even in the late stage. At 25-30 cm / 10-12", you have the advantage of increased tillering and lighter weed control, yet the row spacing is still narrow enough to allow the row to cover.

10. MAIZE: WEEDING AND HOEING

As a row crop, maize provides a welcome break amongst a cereal-heavy crop rotation, as well as a simple solution to controlling root-propagated weeds. Maize consumes nutrients and later provides good ground cover. It should therefore be kept weed-free up until the 6-leaf stage. To ensure young plants develop quickly, the soil temperature during seed sowing should be at least 8°C.

Maize overview	Frequency	Timing	Working depth	Setting
Blind weeding	Once	Provided the seed shoot remains 3 cm / 1.2" below the surface	Max. 2 cm / 0.8" (pay attention to seed depth and shoot)	Tines set to dragging
Weeding	1st pass	From 2 to 4-leaf stage (approx. 5 cm / 2" tall)	2 to 3 cm 0.8" to 1.2"	Tines set lightly on grip
	2nd pass and potentially next	Until row covers, depending on weed growth	2 to 3 cm 0.8" to 1.2"	Tines on grip dragging
Mechanical hoeing	1st pass	From view of the rows	2 to 4 cm 0.8" to 1.6"	With crop protection
	2nd pass	Depending on weeds	3 to 5 cm 1.2" to 2"	Lightly earth up rows
	3rd pass	Until row covers, depending on weeds	4 to 5 cm 1.6" to 2"	Heavy earthing up possible

Source: Allgäuer Bauernblatt 25/2020

Mechanical weed control

1. Blind weeding (approx. 3–5 days after sowing). The timing of sowing should be arranged based on the timing of blind weeding (weather conditions).
2. As required: Gentle weeding at the 2–3-leaf stage at 2–3 / 1.2-1.8 mph
   Caution: The plants may bend slightly!
   At this growth stage the crop should be weeded on warm days when the maize plants become more flexible under the heat of the sun and as such do not bend over.

3. As required: Break up soil crust to aerate the soil and disrupt capillary action.

4. Hoe from the 2-leaf stage: Hoe as closely to the row as possible. Camera steering on the row crop cultivator assists the tractor driver and compensates for any mistakes. Depending on the maize crop and weed pressure, carry out 2–3 passes of hoeing after this. To control weeds between plants in the row, finger hoes or rotative weeder elements can be fitted.

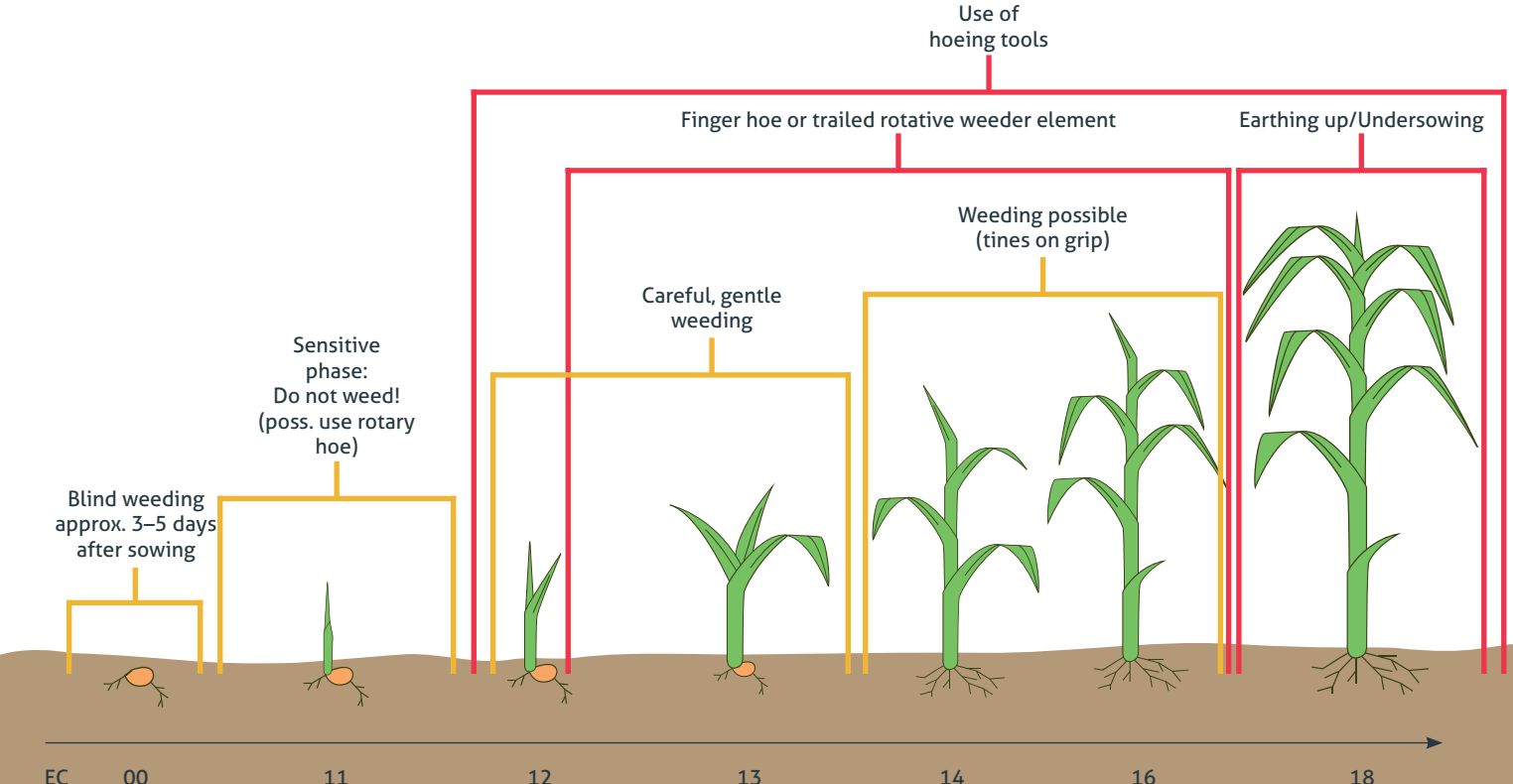
5. Last pass of hoeing just before row covers: set the tines on a narrow setting to avoid damaging the roots. It is further recommended to earth up the rows using hilling sweeps or hilling discs, etc. Once the row is covered, no further crop care measures are required/possible.

Undersowing maize

Undersown crops can be sown into the maize crop using a drill on the row crop cultivator. This is predominantly an option for the final pass of hoeing. Clovers and grasses are the best for undersowing. Undersown crops can also be sown using a tined weeder that is equipped with a drill. The main advantage of undersown crops is that they suppress weeds, reduce erosion and provide excellent soil conditions. On the one hand, undersowing supports soil life, and on the other, it makes the ground better to drive over during harvesting due to the widespread growth.



Mechanical weed control in maize



11. SOYBEAN: WEEDING AND HOEING

Soybeans grow best on a deep, well-settled seedbed that is not too fine, on medium-heavy soils in warm, damp climates (soybeans needs a lot of heat and water).

» It is important that the soil warms up slightly and that it is neither too heavy nor too light.
» The pH level should be between 6.0 and 7.0. Fields with root-propagated weeds should be avoided.
» In addition, soils with a stronger subsequent delivery of nitrogen prevent nodule formation.
» Compressed areas of soil are not able to compensate soybeans plants well.
» To develop young plants quickly, the soil temperature during sowing should be at least 10°C.

Minimal previous crop requirements: Cereals (C/N ratio) are good previous and following crops; maize and beets are sometimes an option (legumes, sunflowers and potatoes are not suitable).

Caution: To ensure good development of nodule bacteria, soybean seeds should be inoculated with a rhizobial inoculant shortly before sowing.

Mechanical weed control

1. Blind weeding (approx. 3–4 days after seed sowing). The timing of seed sowing should be arranged based on the appropriate weather for blind weeding. Caution: Pay attention to the sowing depth of 3–5 cm / 1-2".

2. Hoeing (row crop cultivator or rotary hoe) as soon as the cotyledons have fully unfurled. Soybean plants can even be slightly covered with soil.

3. Gentle (crossways) weeding 1–2 days after hoeing – soil is weeded away from the soybean plants again.

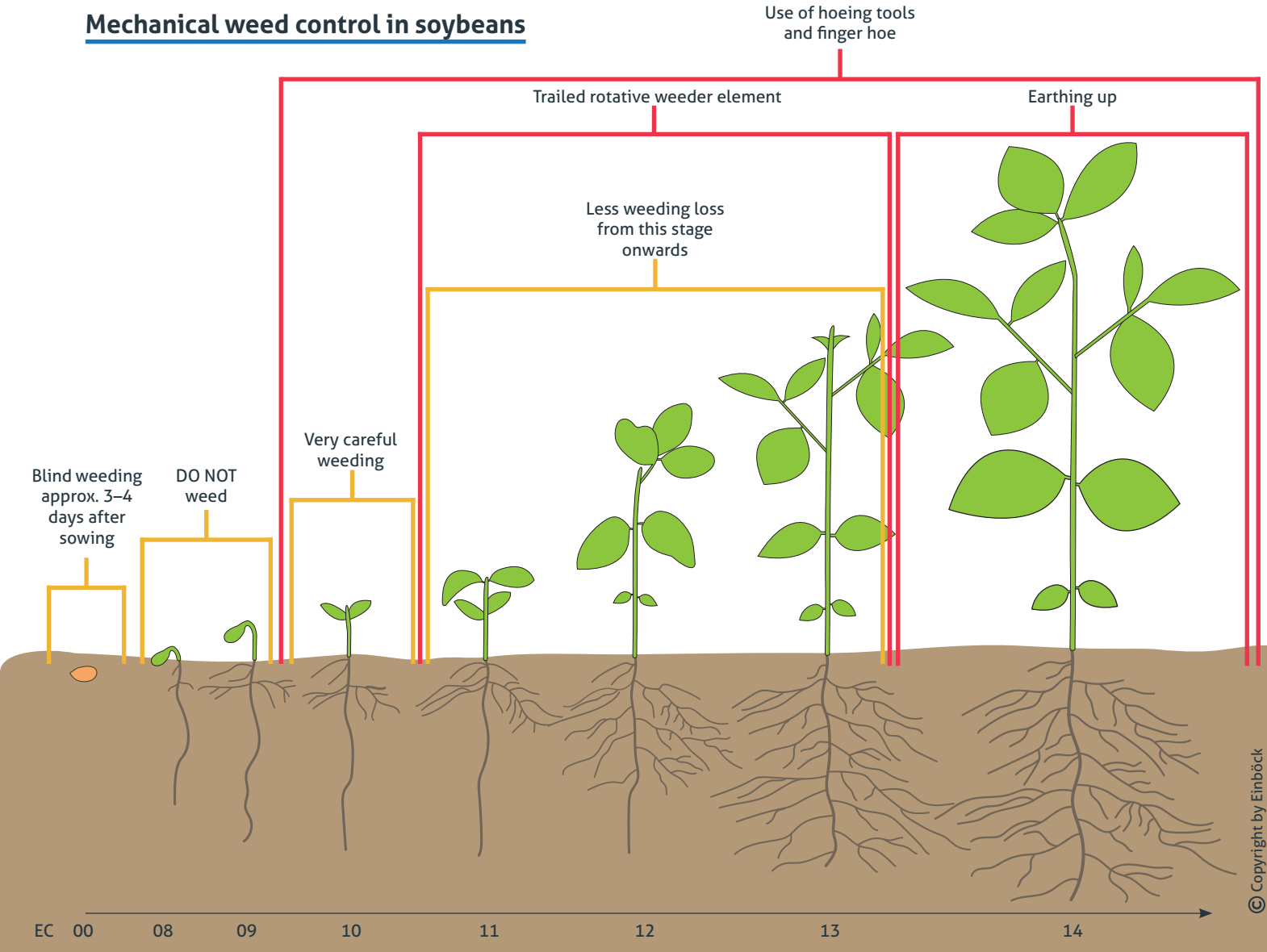
4. 3–4-leaf stage: Hoeing and crust breaking using a row crop cultivator plus finger hoe or rotative weeder, or using a rotary hoe.

5. 1–2 weeks after hoeing, the ground is weeded once again.

Weed and hoe as much as possible and as necessary, but not so much that excessive N is released.

6. Just before flowering: Final pass of hoeing using a finger hoe. This enables weeds in the row to be captured and the row to be earthed up. Additional earthing up using hilling sweeps or hilling discs is optional.

Mechanical weed control in soybeans



12. BROAD BEAN: WEEDING AND HOEING

Broad beans store nitrogen and provide good root penetration. Cultivation is suited to deep, heavy, lime-rich soils. A break of at least 5–6 years should be maintained between crops. The seedbed should not be too fine. The ideal time for sowing is the beginning of March – essentially as soon as possible. The seed should be placed at approx. 6–10 cm / 2.4-4". Broad beans can be either drill seeded or sown in wide rows.

Mechanical weed control – drill seeding

1. Blind weeding (approx. 6–10 days after sowing) Intensive weeding is an option if the seed has been placed deeply.

2. Weeding (approx. 10 days after blind weeding, growth height approx. 5 cm / 2") – broad beans can be covered by soil.

3. Weeding (approx. 10 days after the second pass with tined weeder) – afterwards no further weeding is necessary.

Mechanical weed control at a row spacing of 25 cm / 10" or more

1. Blind weeding (approx. 6–10 days after sowing) Intensive weeding is an option if the seed has been placed deeply.

2. First pass of weeding at a growth height of 5 cm / 2" (approx. 10 days after blind weeding).

3. First pass of hoeing at a growth height of 5 to 10 cm / 2-4". Use of finger hoes (see image to right).

4. Second pass of weeding at 15–20 cm / 6-8" growth height.
Goal: Loosening and aeration of soil before row covering.

5. Second (and last) pass of hoeing based on weed pressure or before row covering – fairly fast speed to earth up rows.

Weed-free broad bean field, all from weeding

13. SUGAR BEET: WEEDING AND HOEING

Sugar beet consumes nutrients but is also valuable as a previous crop, particularly when the leaves are incorporated. It is important to prepare the ground well with a well-rooted green manure that will freeze off. The time required for weeding by hand is a decisive factor in determining the profitability of organic sugar beet. For this reason, any measures to reduce the amount of manual work are extremely important.
Higher ground temperatures substantially promote an even crop emergence.

Mechanical weed control

1. Blind weeding approx. 2–3 days after sowing

2. First pass of hoeing only possible from the cotyledon stage onwards. Sugar beet is especially poor at competing with weeds at this stage. Therefore, hoeing should be very shallow and crop deflector discs should be used.
Caution: Do not use finger hoes.

3. The next pass of hoeing is possible from the 1st pair of true leaves using camera steering. The row crop cultivator leaves behind just a slim uncultivated strip.

4. Careful weeding is possible from the 4-leaf stage, between two passes of hoeing.

5. Depending on the weed pressure, additional hoeing is possible until row covering. At the last pass of hoeing before row covering, it can be earthed up a little.

Frequent hoeing encourages more weeds to germinate and damages the crop.

14. PUMPKIN: WEEDING AND HOEING

A row crop of pumpkins is not only a good way to loosen up the crop rotation, but is also one which requires a lot of nitrogen. This means that surplus nitrogen in the deeper soil layers can be put to good use. Although pumpkins are nitrogen drainers, they leave behind well-balanced soil conditions for the following crops (e.g. cereals). Pumpkins turn out best on warm, good-quality soils. The soil should have good water-bearing qualities and above all be well-draining. A slightly acidic to neutral pH level is also important for the soil.

Mechanical weed control – Pumpkins:

1. Blind weeding approx. 2–6 days after sowing.
   Caution: Pumpkin seeds are placed at a shallow depth – do not blind weed too deep.
2. As soon as the plants are visible, 2–4 passes of hoeing depending on the weed pressure. Use finger hoes for as long as possible. Pay attention to the width of the hoeing bands.

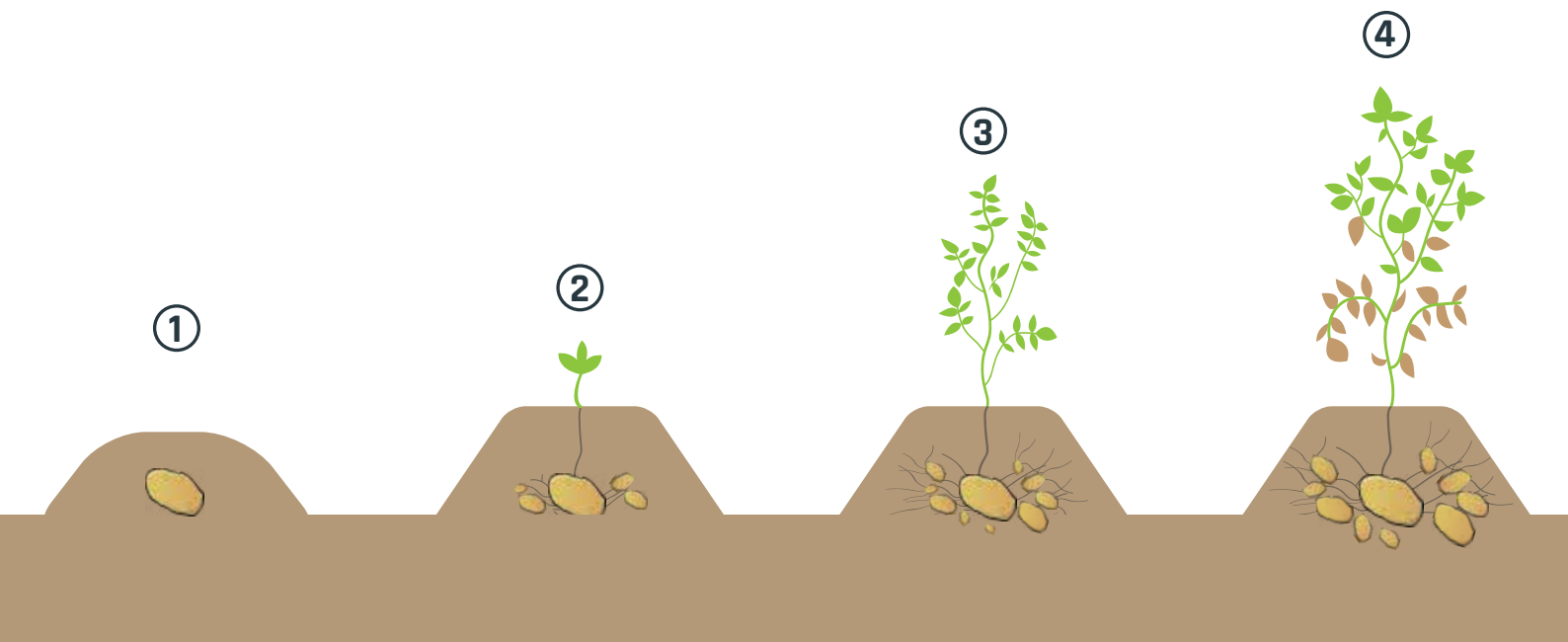
15. POTATO: WEEDING AND HOEING

A ridged crop of potatoes has its merits in terms of preparing a good summer tilth and drawing lots of air into the soil, which leads to the perfect soil for arable farming. In this sense, it creates the ideal conditions for e.g. wheat as a following crop.

The plants prefer slightly acidic, well-draining, fertile soils. Potatoes are sensitive to frost so can only be planted in spring once the danger of frost has passed. Caution: The tubers must not be exposed to light, otherwise they become green (similar to the shoots) and poisonous.

Mechanical weed control – Potatoes:

1. Blind weeding approx. 2–5 days after sowing. Important: "Weeding off" the ridge – the ridge bottom does not necessarily need to be weeded/ cultivated.
2. First pass of hoeing using the rollstar cultivator to earth up the ridges again and to cultivate the sides of the ridges.
3. Second pass of hoeing using the rollstar cultivator with guided hill-weeder element. The ridge is hoed and the plants are weeded in one pass.
4. Third pass of hoeing using the ridger. To ensure the ridge sides are not cultivated too intensively, which would damage the potato roots, the ridges should only be earthed up lightly, i.e. the sides should only be cultivated lightly. The plants themselves should be weeded off using a guided hill-weeder.



16. TEST: WIDE VS. DRILL-SEEDED ROW

IN ORGANIC SOYBEANS)

In spring 2017, soybeans were sown in parcels (each 4000 m²) as part of a purely organic test. Each crop was sown once using drill seeding (row spacing 13 cm / 5.1") and once in wide rows (row spacing 37.5 cm / 14.8").

Location

The test fields were located in Dorf an der Pram, 4751 Austria, at an altitude of 460 m above sea level. The average annual temperature is 11 degrees and the average rainfall is 900 litres/m² (spread over 80 rainy days).
The soil type there is silty loam (tight, lacking in air, easily waterlogged, often lacking in structure, nutrient poor, easily eroded).

Previous crop: Lucerne

Sowing

For the soybeans, 70 grains/m² were sown on both parcels.

Calculation basis

» Machinery costs without driver (ÖKL values 2017 = Austrian standard machine costs)
» Costs for primary tillage, seedbed preparation, seed sowing and harvest were not taken into consideration, since they were identical in both systems.

Mechanical weed control

(Due to the weather, it was not possible to keep to the optimum timing as described earlier to control weeds in each crop.)

» Drill seeded soybeans
– Blind weeding: 4 days after sowing
– Weeding: In 2nd cotyledon stage
– Weeding: Plant growth height approx. 10 cm / 4"

» Wide row soybeans
– Blind weeding: 4 days after sowing
– Hoeing: In 2nd cotyledon stage
– Weeding: Plant growth height approx. 10 cm / 4"
– Hoeing: Just before flowering

Soybeans

Soybean results (drill seeded – wide rows)

Soybeans	Drill seeded	Wide rows (37.5 cm / 14.8")	
Yield	1230 kg (24% moisture)	1580 kg (17 % moisture)	
Yield (13% moisture)	1075 kg	1505 kg	
Yield/ha	2687.50 kg	3762.50 kg	**40% Additional yield**

As a result of the row crop cultivator breaking up the soil crust, the gas substitution and consequently the nodule bacteria activity is increased. This enables the wide row seeded soybeans to achieve an additional 40% in yield compared to the drill seeded crop. The hoed, weed-free soybean crop had less competition for light, water and nutrients, which enabled better growth in the crop.

Test parcel, drill seeded

Test parcel, wide rows

Revenue calculation	Drill seeded	Wide rows (37.5 cm / 14.8")	Excess profit
Seed costs	€ 323.35	€ 323.35	
Maintenance costs	€ 55.50	€ 93.00	
Revenue*	€ 754.57	€ 1,056.40	
Gross profit – parcel	€ 375.72	€ 640.05	
Gross profit/ha	€ 939.31	€ 1,600.14	**70% Excess profit**

*Revenue: Price of soybeans for food production for 2016/17 per Agrar Markt Austria €701.93 per tonne ex. VAT.

Despite the higher maintenance costs, a significant excess profit increase of 70% was achieved.

17. TEST: SOYBEANS

(COMPARISON OF ORGANIC AND CONVENTIONAL FARMING)

In conjunction with a seed producer, a soybean test was arranged in 2017. This involved soybeans being farmed both conventionally and organically (previous crop = maize). An organically farmed testing parcel was established within a conventionally farmed soybean field in Dorf an der Pram, Upper Austria. The test results where the following:

Cultivation steps for the organically farmed soybeans:
» 2x weeding (1x blind weeding)
» 2x hoeing

Cultivation steps for the conventionally farmed soybeans:
» 1x pre-emergence plant protection measure
» 1x post-emergence plant protection measure

LIVIUS	Maturity group	Maturity per AGES	Cropping density plants/m²	Crop moisture at harvest %	Raw protein content %	Oil content %	Yield at 14% H_2O	Yield rel. %
With hoeing	000	4	53	16.9	41.4	21.4	3,528	119
With chem. plant prot.	000	4	69	17.0	40.3	21.9	2,954	100

Test farmer: Gerold Zellinger, Mitterjebing 1, 4751 Dorf an der Pram, Austria

The figures clearly substantiate that at 19%, the yield achieved through organic farming was higher than that achieved through conventional farming.
This may be due to the fact that the herbicides permitted for use on soybeans not only control weeds but also impair the growth of the soybean plants.

The raw protein content at 41.4% is a little higher in comparison to the 40.3% in the conventionally grown crop.

Something which must be highlighted, however, is that the cropping density in conventional farming is at approx. 69 plants/m². When this figure is compared with growing in rows and cultivating using a row crop cultivator, it equates to 53 plants/m². This means that the smaller number of organically farmed plants branched more, which produced a higher yield per plant.

NOTES

WWW.EINBOECK.EU

Additional brochures related to ORGANIC FARMING and MECHANICAL WEED CONTROL:

HOEING TECHNOLOGY

- **Row-crop cultivator** CHOPSTAR
- **Rollstar cultivator** ROLLSTAR
- **Camera steering system** ROW-GUARD
- **Rotary hoe** ROTARYSTAR

TILLAGE TECHNOLOGY

- **Seedbed cultivator** VIBROSTAR
- **Blade cultivator** TAIFUN
- **Universal cultivator** HURRICANE
- **Seedbed combination** EXTREM

WEEDING TECHNOLOGY

- **Tined weeder** AEROSTAR
- **Precision tined weeder** AEROSTAR-EXACT
- **Rotative weeder** AEROSTAR-ROTATION

PRODUCT RANGE

- Crop care
- Tillage
- Grassland care
- Seeding & fertilising

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