Einböck

When crop-care is joy!

The ORGANIC FARMING Handbook

A GUIDE TO MECHANICAL WEED CONTROL
SOIL LIFE | CROP ROTATION | CATCH CROPS | TILLAGE
WEEDING & HOEING IN THEORY AND IN PRACTICE
10 CULTIVATION GUIDELINES

WWW.EINBOECK.EU

This handbook is a guide, not a guarantee for success.
Farmers should gain their own practical experience to achieve the optimum result for their unique conditions.
Do you have any practical tips and experience? Send us an email to info@einboeck.at, so that we can share experience and ideas.

Summary of symbols:


General tip


Settings


Practical tip


Technical tip


Caution


Example

PREFACE

Organic farming requires precision and a great deal of experience. This is how we've been operating for decades. We have been deeply involved in organic farming and mechanical weed control for more than 40 years. In addition, our own organic farm continues to provide us with valuable insights. We continually test out new approaches, new machinery and new cultivation methods on our trial plots and maintain a close dialogue with industry experts and consultants. This is why we are proud to call ourselves pioneers and trailblazers where agricultural technology for organic farming is concerned.

In the future, farming will need to cleverly combine chemical, mechanical and biological measures. Targeted weed control, whether chemical or mechanical, is crucial for successful farming and high yields. Integrated pest control that requires fewer resources constitutes a forward-focused approach. Our aim is to achieve economical and sustainable agriculture that complies with high environmental standards and forms the foundation for high-quality, healthy food.

As experts in organic farming, our soil's future 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.

Not all of our recommendations, tips or tricks can or should be implemented on your own farm. The practical instructions, recommendations and examples we have brought together in this handbook will not always be applicable, relevant or even appropriate for all farms.

Instead, this handbook is intended to inspire farmers, drive innovation and help establish the foundation for successful organic farming.

Best wishes from Austria!

The Einböck Family
Management in the 3rd and 4th generation

CONTENTS

1. THE CHALLENGES OF ORGANIC FARMING

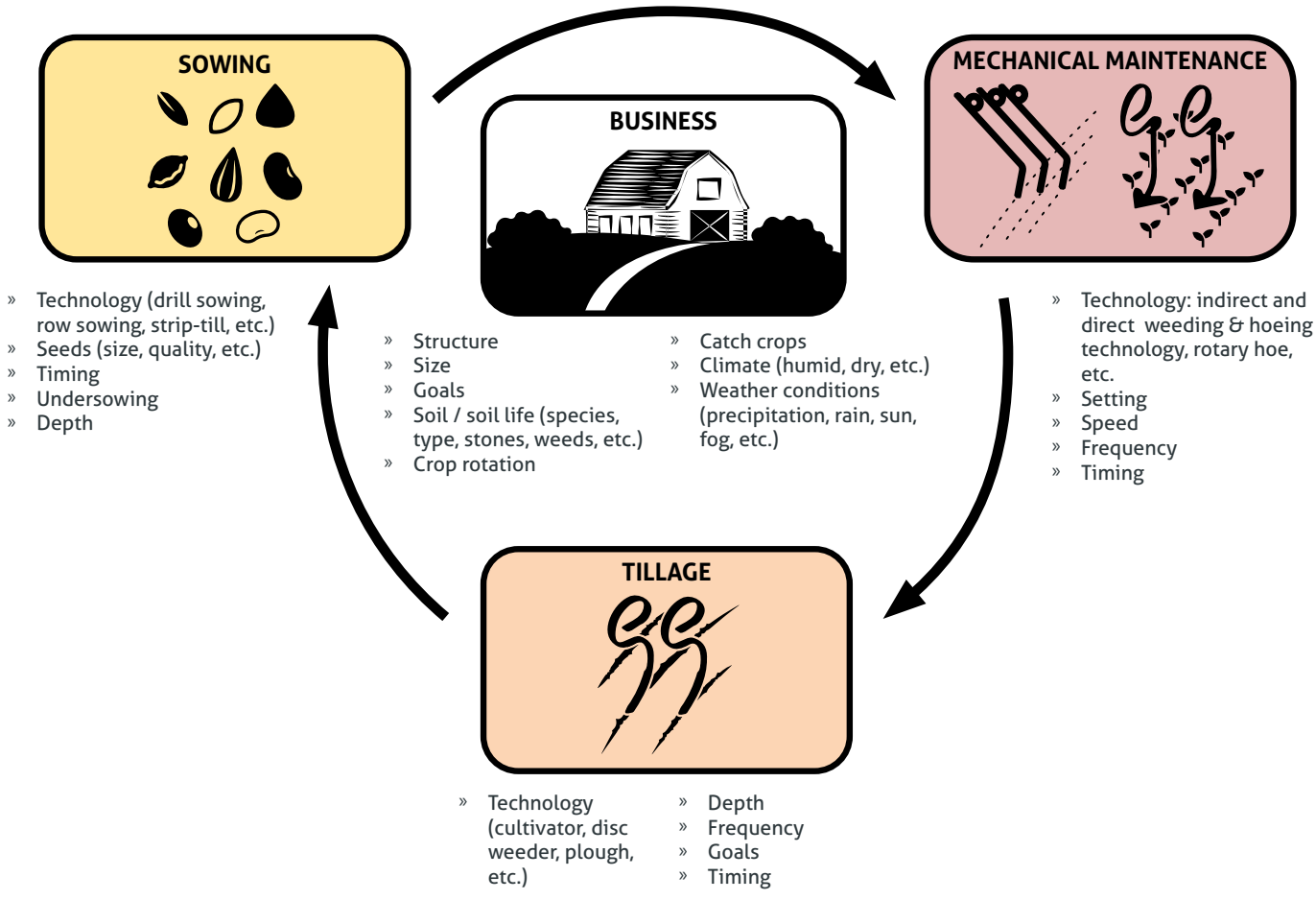
Switching to organic farming or adopting organic farming techniques and practices on a conventional farm takes time and planning. It is not merely a case of hoeing, weeding or using a rotary hoe instead of spraying. Rather, the entire farming approach must be adapted to the new method, including crop rotation, tillage, seedbed preparation, catch crops, undersowing, etc. Choosing the perfect moment and being highly precise is vital when it comes to using machinery for mechanical weed control, especially when compared to conventional areas where such techniques are not used.

Simply replacing spraying with a hoe or a weeder is not enough.

Why adopt mechanical soil cultivation?

- Organic/eco-agriculture
- Legal reduction (quantity restrictions) or bans on pesticides
- Reduction/loss of active ingredients or resistance
- Minimum distances to bodies of water
- Social acceptance of pesticides
- Market requirements / demand
- Soil improvement
- etc.

Organic farming challenges and parameters - the cycle:



2. ADVANTAGES OF SUSTAINABLE ARABLE FARMING

For the cultivated crop:

- Mechanical removal of weeds and weed grasses for improved crop development
- Weeds in the row are covered by soil and the cultivated crop is hilled
- Promotion of plant & root development thanks to humus-rich soil
- Reduction in water usage thanks to interrupting the capillary effect, more water is available to the crops
- Avoidance of unnecessary stress on the crop because of the use of herbicides

For the soil:

- Increase in soil moisture and aeration, incrustations broken up after heavy rainfall
- Nutrient mobilisation - resulting in increased microorganism activity
- Gentle humus tillage – shallow cultivation of the top soil layer
- Incorporation of (organic) fertiliser - fertiliser mineralisation
- e.g. incorporation of liquid manure, mineral fertiliser or urea
- Increased nutrient release: "twice weeded/hoed = once fertilised"

For the environment:

- Avoidance of pesticides
- Less need for additional active substances
- Weed resistance development prevented
- Improvement of soil fertility, a more resistant and healthy soil is promoted
- Protection of waters
- Conservation of species diversity, biodiversity supported

3. HEALTHY SOIL LIFE

Each farm must adopt a custom tillage strategy or philosophy. This is because every soil is different due to its unique soil types and species. There are light and heavy soils, nutrient-poor and extremely fertile soils, for example. Different soil conditions, climate conditions, legal requirements, and farming methods and objectives make every farm one-of-a-kind. A wide range of measures are therefore required, and it is extremely difficult to compare soils and farms with one another.

Decades of cultivation of the Einböck trial fields and the results thereof are included as guidance within this handbook. We have also collated and included many strategies from customers around the world.

Healthy soil constitutes the foundation for healthy plants, and in turn, healthy animals and humans. This is because healthier plants ensure the best feed quality and stable yields.

The goal must be: to keep soils healthy and productive through environmentally friendly cultivation.

Soil improvement begins with soil analysis.

3.1 Soil analysis

The aim of soil analysis is to gain an overview of the nutrient levels in cultivated land. Conventional laboratory analysis assesses the levels in the soil and compares these to target values or content grades. The latest studies also recommend paying attention to the bacterial and fungal population as well as the nutrient content.

In addition to laboratory analysis, soil can be assessed directly or indirectly using plants by way of a range of simple methods. We advise carrying out comprehensive laboratory analysis at regular intervals. A recurring independent field check can provide sufficient information. This can be done using the following techniques.

Spade test or soil classification

Soil classification is a soil assessment you can carry out yourself. A slab of soil is cut out with a spade and examined in relation to the following points:

- Soil structure (crumbly or rigid structure)
- Odour (typically earthy or foul)
- Soil layers (smear layer, plough pan, seed layer)
- Roots (presence of nodule bacteria in legumes)
- Presence and condition of various living organisms
- Decomposition of organic material (rotting or decay)

Organic farms should carry out field spade tests several times a year.

Visual assessment of main and cover crop

The growth of main and catch crops in fields can tell you a great deal about soil condition. In addition to soil compaction, which is commonly caused by combine harvester tracks, there are also tricky cultivation conditions and differences in soil structure and composition. This can lead to a range of issues, such as bleaching, reduced or increased growth or even the total absence of a crop. There are often several reasons for this, however sometimes insufficient reconsolidation after sowing can be the cause.

Earthworm population

Earthworms are good indicators of active soil life. The healthier the soil, the more active the earthworms. Their burrows, faeces piles and star-shaped heaps of litter are a clear sign of worm activity.

Spade samples can provide quick verification of earthworm activity and numbers.

Healthy soil is rich in nutrients, absorbs water and breaks down plant residues thanks to the presence of earthworms, plus numerous other soil organisms. Studies by the Research Institute of Organic Agriculture (FiBL) have shown that soil fertility is higher in organically farmed soils than in conventional soils. They contain 30 to 60 per cent more soil organisms. The biological activity on these farms is higher and the soil structure present is more stable. This acts as very effective protection against erosion.
Depending on the location and climate, there are on average 140 earthworms per square metre. This includes different species such as litter-dwelling, shallow-digging and deep-digging worms. Mechanical tillage involves turning over approx. 2,800 tonnes of soil per hectare down to a depth of 20 cm / 7.90". In contrast, earthworms can move more than 100 tonnes of soil per hectare to the surface. In addition, they leave behind stable cavities resulting in a solid and porous crumb structure.
For more information on earthworms, read the "Soil improvement" section.

Earthworms can eat as much as half their own weight every day!

Interpretation of indicator plants and their functions *

Decisive factors which determine which plants will do well: pH value, nutrient content, nitrogen content, soil structure (including incrustation, compaction) and moisture conditions. Each plant species has a different habitat requirement. This can be referred to as its optimum ecological habitat and represents the ideal conditions for plant growth. Each plant species is a reflection of the habitat that best suits its requirements. These specific requirements can be determined with the help of indicator plants. When crops grow unevenly, this can be caused by harvesting in excessively wet conditions or inappropriate tillage. The results of this may still be felt years later in developments such as soil compaction, acidification, nutrient and oxygen deficiency. Crop discolouration may indicate nutrient deficiencies.

When used as indicator plants, weeds can provide valuable information about the soil.

Below are some of the soil conditions indicator plants can indicate:

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. **Headland compaction 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. **Nutrient supply**

*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**

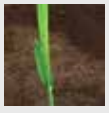
Amaranth

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 chickweed

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**

There are many good apps (which are often free) that can help when identifying plants and weeds.

3.2 Fertilisation

Harvesting removes nutrients from the soil. Fertilisation should compensate for this loss of nutrients. Plants cannot grow in the absence of nutrients, therefore the question is not whether you need nutrients, but how you should add them to soil.

High soil fertility is a prerequisite for optimum crop development and soil must have sufficient nutrient levels, because plants obtain the substances they need from the soil's nutrient pool. Maintaining and increasing soil fertility is therefore high on the list of priorities. Humus - i.e. organic matter - is essential, not just for plant nourishment, but also for the activity of soil organisms and microorganisms. Humus keeps soil moist for longer and ensures it has a loose structure.

Field characteristics, the climate, soil organism activity and soil structure are predetermined. Sometimes, however, these conditions are not favourable when it comes to profitable and economical cultivation. The soil therefore needs to be improved. In contrast to conventional farming, crops grown organically cannot be fertilised with fast-acting synthetic fertilisers. In principle, a small selection of fertiliser variants can be used in organic arable farming. Some of these fertiliser variants are described in more detail below.

Crop rotations which contain a high proportion of legumes can also provide valuable nitrogen. In organic farming, natural processes and soil-plant interactions are also considered and supported during fertilisation, however, a holistic approach must also include durable cover crops and reduced tillage. For more detail on this, head to the sections "Crop rotation" and "Catch crops".

In organic farming, the principle is:
"We fertilise the soil, rather than the plant."

Possible fertiliser options

- Lime
- Manure and slurry from own livestock farming
- Feed and manure mixes
- Compost
- Catch crops and/or legume cultivation
- Authorised organic fertilisers

Fertilisation with lime for more soil stability*

Each crop has its own optimum pH level. If the pH value lies outside the optimum range (i.e. it is too low), lime is advisable. Liming before peas, beans, soy, clover and alfalfa is advisable. Legumes especially benefit from an application of lime before cultivation. Please note, care must be taken to ensure the correct crop rotation. To maintain adequate levels, applications of two to three tonnes of lime every two to four years is recommended. When using calcium carbonate, the finer it is, the quicker it yields results.
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). As a result, pH levels reduce and the soil acidifies.

Lime promotes:
- Soil structure (physical)
- Fertiliser efficacy
- Nutrient mobilisation
- Soil biological activity

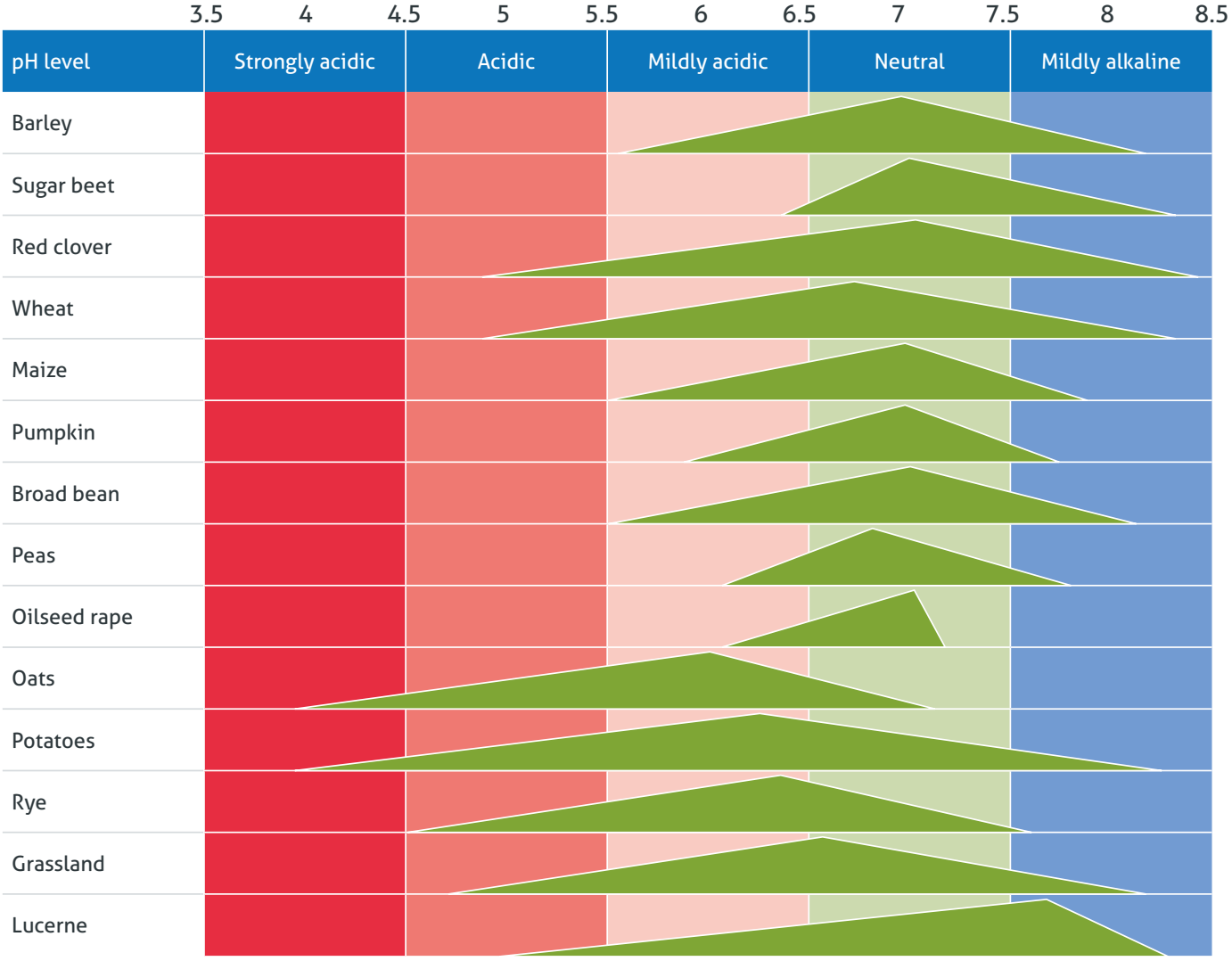
Lime prevents:
- Soil acidification (chemical)
- Discharge of harmful heavy metals

*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

The right pH value

Plants need calcium as a nutrient, but it is more important that the soil's pH level is correct so that other nutrients remain available, and harmful substances are not able to damage the plants.

- pH level < 5: Aluminium is released (damaging to plant roots and microorganisms).
- pH level 6–7: Phosphorus and boron are most readily available at this level (this is beneficial for plants).
- pH level > 7: Most trace elements decrease, except molybdenum (e.g. phosphorus, magnesium, iron, manganese and boron).



Cultivated crops each have their own optimum pH level*

It is advisable to apply lime in small yearly increments rather than using larger amounts at less frequent intervals.

* Source: Klapp

Farmyard/industrial fertiliser (manure)

Properly prepared manure (well-rotted, not foul-smelling) constitutes a nutrient-rich organic fertiliser. The bound nitrogen present promotes the development of microorganisms and mycorrhizal fungi (which live in symbiosis with the root system) in the soil and their activity. This soil life significantly promotes plant growth and health. In the absence of active soil life, crops can have too little energy and may grow sparsely or not at all.

Fertilisation using rotted manure can enhance the humus. High humus content in the soil acts like a sponge during rainfall. For every 1% of humus present, an extra 40 litres of water can be stored per 1m3 of soil. Humus-rich soil therefore stays moist for longer, even during dry periods. Naturally, this significantly affects whether plants can "hold out" until the next rains or not. Negative growing conditions can also be better mitigated (e.g. dry weather phases, heavy rainfall, weed growth, soil erosion, etc.).

If no manure is available, large quantities of plant biomass should be regularly distributed across fields (preferably in the form of catch crops and harvest residues).

3.3 Soil improvement

Cultivation of undersown crops

Undersown crops promote biodiversity. Permanent ground cover and root penetration reduces the risk of soil erosion and also prevents excessive moisture loss. These crops are often used to build up biomass through photosynthesis, while increasing the roots growing in the soil.

Undersown crops are suitable for a wide variety of crops, and the aim is to achieve a permanently closed plant cover. When there is insufficient time between two main crops to establish a catch crop, these crops can offer a suitable alternative. Undersown crops increase soil shading and therefore help to suppress weeds and retain more moisture in the soil. Particularly when the main crop is in the mature stage, undersown crops can prevent late weed infestations. Clover and clover grass is well-suited to being an undersown crop as it develops slowly in the early stages.
Additional details are available in the section "Undersowing & mixed crops".

Soil is best when continually covered and rooted.

Growing catch crops

Catch crops are grown between two main crops. They promote good root penetration and improve soil fertility. Catch crops feed soil life, mop up nitrogen and are easily degraded by micro-organisms. Popular crops used in this way are legumes, mustard and clover grass mixtures, however, similar main crops and catch crops should be avoided.

Additional details are available in the section "Catch crops".

Duration of catch crops

In organic farming, crops are not artificially fertilised, meaning that any missing nutrients cannot be instantly added to the soil. It is therefore vital to establish a soil rich in humus and nutrients to create the perfect foundation for an active soil life. Continuous vegetation is the key to healthy soil life. Any periods of time without vegetation must be kept to a minimum to prevent soil erosion and drying and to maintain soil biodiversity. Permanent catch crops support the development of mycorrhizal fungi, microorganisms and bacteria that mop up nitrogen and release phosphorus. This process closes the loop and promotes humus formation.

Reduced tillage

Attentive tillage is an essential measure in maintaining soil fertility. Tilling the soil too intensively carries negative consequences such as impairing soil structure and disrupting mycorrhizal fungi networks. It also disrupts microorganism and soil organism activity. Soil that has been heavily compacted causes lasting damage that prevents the soil from absorbing air and water efficiently. This lowers the oxygen content and reduces the number of soil organisms, resulting in a reduction in soil fertility. To avoid these negative effects, we should avoid deep and intensive tillage.

Only healthy soil can offer us the results we seek.

The earthworm

Earthworms move plant material through their tubes and are undoubtedly one of the most efficient enhancers of soil. Their actions drain the soil, allow water to be absorbed when soil is saturated and prevent waterlogging, and promote aeration. Plants use the tunnels they create to penetrate deeper into the soil's layers.

Earthworm faeces contain abundant organo-mineral clay-humus complexes, which are a product of the decomposing and mixing activity (bioturbation) of soil organisms. These clay-humus compounds promote a stable soil structure. Worm faeces is an excellent plant fertiliser, as it contains roughly 5 times more nitrogen, 7 times more phosphorus and 11 times more potassium than the surrounding soil.

In organic farming, earthworms are considered miniature nutrient processors.

Interesting facts about earthworms:

- Earthworms have survived form around 200 million years on planet earth
- Earthworms can grow up to 30 cm (11.80") long
- 2 to 4 million earthworms can live in a single hectare of healthy grassland and arable soil
- Earthworms eat dead plant residues For earthworms to consume these residues, their food needs to be located on the soil surface between 0-5 cm (0-2") down
- Earthworms are most active in spring and autumn. They enjoy "periods of rest" in summer and winter, when it gets too hot and dry or when the ground is frozen
- Earthworms love to eat Fusarium fungi which can be found on cereals and maize stubble, for example

How to increase or maintain your earthworm population:

- To establish or increase your earthworm population, you must distribute organic fertiliser regularly.
- The less intensively the soil is tilled, the better it is for earthworms. In practice, this can be a balancing act, and it is important to find a suitable compromise - "less is often more". Ploughless cultivation is particularly beneficial to the earthworm.
- To increase your earthworm population, it also needs sufficient fresh food on the soil surface. In one night, earthworms can direct up to 20 leaves into their mouths, where they then coat them with saliva. Year-round vegetation supports earthworms.
- Avoid soil compaction:: Heavy machinery compresses the soil pores which conduct air and drain soil.
- Grow "humus enhancers" such as grass-legume mixtures (e.g. Clover grass) and catch crops

Earthworms are the only creatures on this Earth that have the unique ability to produce soil.

Post-harvest is pre-sowing

After crop harvesting, plant residue usually remains in the field. This is also the case after catch crops. After drying out, these residues are worked into the soil. The next step is spreading manure, closely followed by seedbed preparation and sowing. The seeds should be superficially mixed with the manure. This allows the young plants that will grow to reach the nutrients. In dry years, loose soil should be compacted with a roller.

Healthy soil produces stable yields

Observing these basic principles is essential for biodiversity and can prevent poor or highly variable yields and soil erosion. These principles also apply to conventional farming and even to simple private vegetable gardens.

Measures you can take to promote healthy soil

» Permanent catch crops - keep periods of zero vegetation to a minimum
» Grow catch crops
» Tend to soil "gently" and use common sense
» Assess and measure your soil (take soil samples/spade samples)
» Only adopt measures that have been well thought out in advance. Do not continue to follow senseless measures purely for the sake of tradition.
» Fertilise as and when required

Soil naturally wants to grow plants - if you don't sow crops, it will come up with its own solutions!

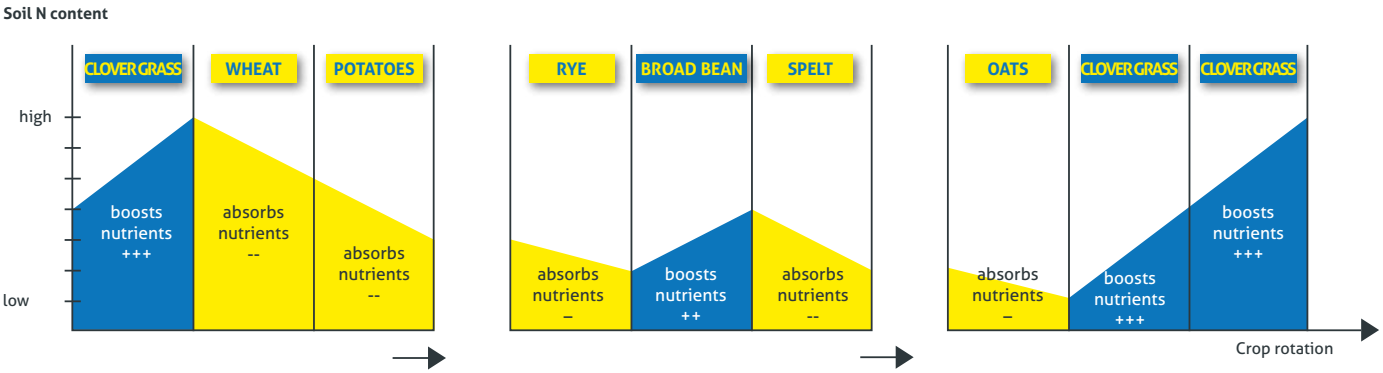
Every measure you take has an effect on soil. Therefore think through each decision and use "common sense".

4. CROP ROTATION

The interrelation between plants promotes diversity, good soil fertility, "independent" weed control and an optimum supply of nutrients. In arable farming, this symbiosis is achieved by growing plants in succession. Each plant needs a different mix of nutrients to grow. Well-planned crop rotation is therefore central to economic success. Crop rotation enhances soil fertility, thereby supporting positive yields long term. In organic farming, there is little sense in growing crops without suitable crop rotations, as the harvests you would achieve, would not be good enough.

Cultivation breaks must also be adhered to. There are many different parameters to take into account, such as location, soil condition, plant cultivation factors (nutrient supply, soil fertility, etc.), as well as operational and market factors. Each crop must fulfil its respective task within the crop rotation, and crops cannot be simply swapped about. In organic farming, mistakes made in crop rotations are difficult to correct due to the lack of chemical pesticides and nitrogen fertilisation. It can be extremely complex to achieve long-term farming goals, such as increasing the humus, controlling weeds, preventing disease and pest infestations.

Examples of crop rotations, which highlight nitrogen-boosting and nitrogen-absorbing crops.



Aligned crop rotations minimise weed pressure!

4.1 Crop rotation planning basics

Good crop rotation planning is essential for a farm to be economically successful. The following principles must be applied:

» Legume proportion (soy): 20–25%
» Cereal proportion: max 50–60%
» Max root crop proportion: 5–25%
» Rotations between:
Deep rooting and shallow rooting plants
Nitrogen increasing – Nitrogen draining
Winter crops – Spring crops
Leafy crops – Cereals

4.2 Crop rotation objectives

» Preservation/improvement of soil fertility
» "Balanced" N content
» Weed control e.g. Clover grass – Thistle control
» Prevention of disease and pest control
» Optimum nutrient mobilisation

Nature is our guide

In areas where humans leave nature alone, you will see a wide range of plant species growing side by side. They are mutually beneficial to each other and provide food and shelter for a wide variety of animals. They live in a permanent, optimal symbiosis. These interactions between plants and animals for the foundation a healthy and natural environment. Nature is our guide: A wide range of species, closed nutrient cycles and year-round ground cover are the basis for a good harvest. Soil that is continually covered is home to a myriad of important soil organisms, bacteria and fungi. High colonisation is synonymous with good nutrient and water supply for the plants. Plants that grow in soil that has an active soil life are less susceptible to diseases, while problematic weeds find it harder to take root.

Evergreen areas

In the short periods when fields lay bare, under-sown crops can offer a good solution to bridge the gap, so long as they are well-suited to the main crop and the weather permits. Undersown crops are sown at the same time as the main crop. The valuable weeks during spring should be used to enhance soil structure before a late-sown crop, such as maize, is planted. After the harvest, we advise sowing winter-hardy catch crops.

Fields adapted to climate change

Climate change is already having a major impact on agricultures so it is important we adapt to these changing conditions. The range of climate-friendly seeds and weather-resistant varieties is constantly increasing. Choosing the right variety and the optimum cultivation sequence is decisive when it comes to the yield, and you should also select drought and heat-tolerant varieties of main and catch crops. Crops that love higher temperatures include hemp, soy, sorghum millet, maize, sunflower and pumpkin.

Crop rotation is an essential part of successful organic farming!

The many advantages of well-organised crop rotation:

Good crop rotation planning is essential for a farm to be economically successful. The following principles must be applied:

» Diverse and varied crop rotation promotes the soil's natural abilities and enhances soil fertility.
» Year-round ground cover facilitates permanent rooting.
» Large quantities of organic substances from root masses and crop residues promote soil life and humus formation. This creates soil that is resistant to silting and erosion.
» Soil structure is stable, loosened and "full of life".
» The supply of nitrogen can be improved by nitrogen-consuming plants with nitrogen-collecting legumes.

Varied crop rotations promote soil fertility.

SECOND CROP

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

The key crops in various crop rotation positions

A survey of the key crops in various crop rotation positions. From 1 to 5 (1 = very good; 5 = not suitable):

CROP	Soil structure	after several years Legumes	after grain legumes	after cereals	on light soil	at high altitudes	with a lot of fertiliser	after late sowing	good root development	rapid juvenile development	good weed suppression	on the ideal soil	crop break in years
Broad bean	1	5	5	1	3	3	5	3	1	1	2	1	4–5
Malting barley	3	4	3	2	3	2	5	3	3	2	4	3	3
Buckwheat	2	5	4	1	2	1	4	1	2	1	2	1	3
Spelt	3	4	3	2	1	2	4	2	2	3	2	3	0-3
Elmer/Einböck	3	4	3	3	2	2	3	1	2	3	2	4	2-3
Peas	1	5	5	1	1	2	5	2	2	2	3	4	6
Feed barley	3	3	4	2	3	1	2	3	3	2	3	3	2-3
Forage oats	2	4–2	4	2	1	1	2	3	2	1	2	3	5
Perennial rye	2	4	4	2	1	1	2	3	1	1	1	3	0-3
Forage wheat	3	2	3	2	4	4	1	1	2	3	3	2	2-3
Hemp	1	4	3	1	2	3	3	3	2	3	1	2	3-4
Potatoes	2	2	2	1	1	3	3	1	1	3	5	1	4–5
Grain maize	3	2	1	2	4	1	1	3	2	4	4	1	0-6
Caraway	2		1	1	3	2	2	2	1	4	4	1	3-5
Pumpkin	2	2	2	1	3	3	3	1	2	3	4	1	2-5
Camellia	2	5	4	1	1	3	3	1	2	1	1	2	4–5
Lupins	1	5	5	1	1	5	5	3	1	4	4	3	6
Poppy	2	1	1	3	3	1	1	3	2	3	4	1	4–5
Seed flax	3	4	4	3	1	4	4	3	2	4	4	3	7-8
Phacelia	2	5	4	1	3	4	4	2	1	1	1	1	2-3
Oilseed rape	3	1	1	3	4	1	1	4	1	1	2	1	6
Silage maize	5	1	1	2	3	1	1	2	2	4	4	1	0-6
Soy	2	5	4	1	4	5	5	2	2	3	4	1	4–5
Spring wheat	3	2	1	4	4	2	2	4	2	3	3	1	2-3
Sunflower	4	5	4	1	3	4	4	3	3	4	4	2	4–5
Oats for human consumption	2	2	3	2	1	3	3	3	2	1	2	2	5
Rye for human consumption	2	3	2	2	1	3	3	3	1	1	1	3	0-3
Wheat for human consumption	3	1	1	5	3	1	1	1	2	3	3	1	2-3
Triticale	3	1	1	3	1	1	1	3	1	2	2	2	2-3
Sweet pea, vetch	1	5	5	1	1	5	5	3	2	1	2	3	5
Winter barley	3	1	1	4	3	1	1	5	2	2	3	1	3-4

* Source: Maillard Kundler et. al. 1998 revised Freyer 2003

Crop rotation examples *

Example 1: Cereal-orientated crop rotation with clover-grass for soil structure and thistle management

1. Clover grass
2. Winter wheat + catch crop (if req.)
3. Winter rye + catch crop
4. Field bean + catch crop (if req.)
5. Winter wheat or spelt + catch crop
6. Oats or spring barley with clover-grass undersown

Example 2: Forage producing crop rotation, commonly used for cattle farms, especially during changeover

1. Clover grass
2. Clover grass
3. Winter triticale + catch crop with sudan grass, oats, alexandrine clover or incarnate clover, possibly two-stage with Wick-Rye catch crop or Landsberg mixture
4. Silage maize
5. Grain pea/field bean + catch crop with spring vetch, oilseed rape and sunflower
6. Winter triticale + catch crop with spring vetch, phacelia, oilseed rape and sunflower
7. Spring barley with clover-grass seed

Example 3: Finishing crop rotation, common for pig/ poultry farms, also cash crop farms in changeover periods

1. Clover grass
2. Winter triticale + catch crop with sudan grass, oats, alexandrine clover or incarnate clover, possibly two-stage with Wick-Rye catch crop or Landsberg mixture
3. Grain maize
4. Grain pea/field bean + catch crop with mustard and sudan grass
5. Winter barley/feed wheat + catch crop with sudan grass and GS rye
6. Soy with Perko catch crop or winter pea-cereal mixture with catch crop
7. Oats with clover grass seed

Example 4: Market-orientated crop rotation for wetlands

1. Clover grass
2. Winter wheat + legume-focused catch crop
3. Grain maize
4. Field bean
5. Winter barley + catch crop with legumes
6. Oil pumpkin with W turnip rape undersown as catch crop
7. Soy or hemp or oil flax
8. Spelt with clover-grass undersown in spring

Example 5: Specialised crop rotation

1. Clover grass
2. Winter wheat + legume-focused catch crop. Oil pumpkin
3. Spelt + catch crop with winter-hardy components.
4. Hemp
5. Field bean
6. Winter rapeseed + summer catch crop
7. Winter barley + catch crop with legumes
8. Oil flax/potato + catch crop
9. Malting barley

Example 6: Crop rotation for dry lands (1)

1. Lucerne
2. Lucerne
3. Winter wheat + catch crop
4. Sugar beet
5. Oil pumpkin
6. W-vetch-cereal mixture with summer catch crop
7. Winter wheat + catch crop
8. Sunflower

Example 7: Crop rotation for drylands (2)

1. Lucerne
2. Lucerne
3. Winter wheat + catch crop
4. Grain maize
5. Spring barley+ catch crop
6. Grain legumes (grain pea, field bean, soy bean)
7. Winter wheat
8. Winter rye

Example 8: Market-orientated crop rotation

1. Clover grass
2. Forage wheat
   catch crop with legumes
   (sweet pea-vetch)
3. Grain maize
4. Field bean/soy bean
   catch crop possibly mustard as N storer
5. Triticale
   catch crop without legumes
6. Summer cereals (oats) with clover seed

Example 9: Forage crop rotation

1. Clover grass
2. Clover grass
3. Winter triticale,
   catch crop (oats, phacelia, etc.)
4. Grain pea,
   catch crop summer vetch, summer rape and sunflower
5. Winter triticale
   catch crop summer vetch, phacelia, rape and sunflower
6. Spring barley with clover seed

*Source: Einböck & Bio Austria, Bio Forschung Austria, chapter on soil and plants, crop rotation p. 123, "Unser Boden, Boden-Handbuch für den Ackerbau!"

5. GROWING CATCH CROPS

Planned crop rotations that feature the correct catch crops are often the key to success in organic arable farming.

Catch crops, green fallow, undersowing and mixed crops maintain the soil cover year-round, protecting soil life. Similar to appropriate crop rotation, catch crops can be an effective method to suppress weeds. Catch crops have the ability to suppress weeds, just like crop rotations do. Diverse, year-round rooting and continuous, vigorous growth.

5.1 Catch crop basics

Catch crops are used for the following objectives:

- To feed soil life
- To promote root exudation, which is responsible for soil organism nutrient supply. Sugars, vitamins, acids and other elements are released from the catch crop roots into the soil.
- For the formation of soil crumbs thanks to living organisms (earthworms)
- As ground cover that acts as protection against extreme weather conditions, silting and drying out of the soil
- For rooting (better absorption of water and nutrients from the soil)
- To improve soil fertility
- Humus formation
- As "nutrient replenishment" thanks to the catch crop
- Breaking up the main crop rotation
- To promote the proliferation and activity of mycorrhiza and microorganisms
- To promote straw rot
- As protection against erosion, particularly in hillside locations

Prevention of diseases

The right choice and sequence of crops reduces the risk of infection bridges, crop rotation diseases, pest infestations and weed pressure. The correct mix is crucial. To achieve the best results, avoid using catch crops, green fallow and undersown crops that are from the same plant family as the main crop.

Here are a few practical examples:

- After a crop of peas, avoid sowing more peas, lupins, vetches or field beans. Peas are particularly sensitive to diseases caused by crop rotation.
- The same applies (although to a lesser degree) to lupins and field beans. After a main crop of field beans, do not use (grain) legumes as the catch crop. Mustard and oil radish are cruciferous plants. They should therefore not be sown after oilseed rape due to the risk of cabbage hernia, Verticillium rape wilt and Sclerotinia white stem disease.
- Sugar beet can be decimated by nematode-resistant mustard and oil radish varieties.
- Oil radish is a deep-rooting crop, which makes it ideal for loosening the soil for cereal crop rotations. Phacelia and mustard must not be included in potato crop rotations because they pass on Rattle Virus (a pathogenic plant virus).

Catch crops maintain the soil cover year round promoting soil life!

Weed control

Catch crops can provide effective weed control for late weed crops. These are often otherwise difficult to manage (e.g. thistle, dock). Plants compete for sunlight, meaning light deprivation can be more effective than tillage. This makes this method preferable. A minimum of one catch crop element should feature rapid juvenile development, e.g. oats, buckwheat, camelina, mongoose, etc.

Nitrogen extraction

Legumes have the ability to bind atmospheric nitrogen. The wide range of types of legume are ideal for loosening the soil thanks to their different root systems. Large-grain legumes include peas, lupins and vetches, while small-grain legumes include red clover and sweet clover.

Use a wide variety of mixtures

The more species you include in a catch crop mixture, the more positive effect this will have on the soil. Ideally, include at least 8 different crops in the mixture as this will ensure greater biodiversity. To cope with adverse and changeable weather conditions, add dry-resistant and moisture-loving or reliable frost-resistant crops (e.g. ryegrass and cultivated millet) and hardy crops to the mixture.

Due to their vigorous root formation, grasses should be included in every mix. Sweet grasses specifically offer considerable advantages: Their robust root formation and significant ability to release liquids (root exudate) are beneficial to humus enrichment and improvement of soil regeneration. Once again, the interaction between mycorrhiza and microorganisms is significant.

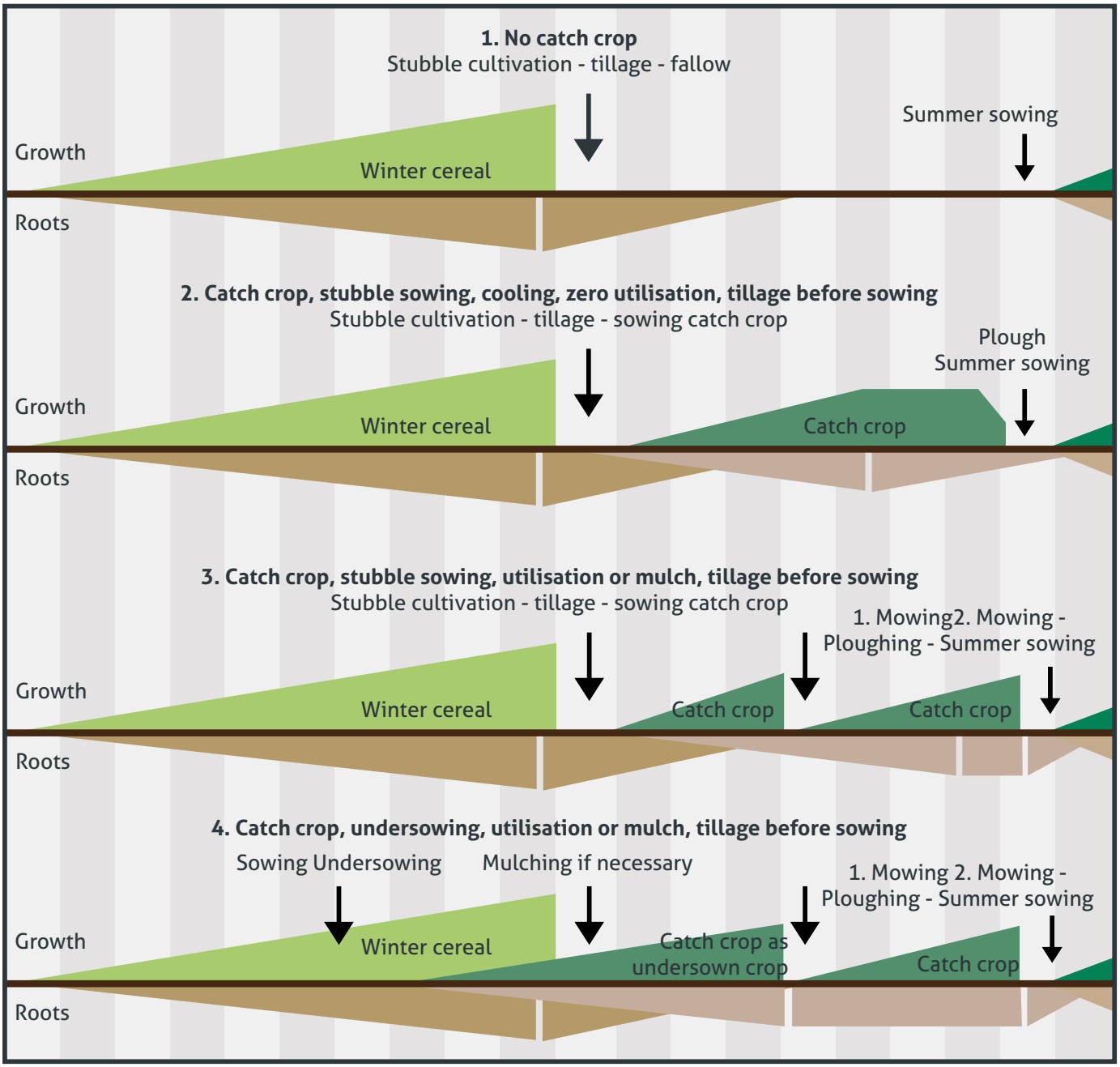
The right mix is key! Rooting abilities, germination conditions, N-fixation, etc.

Many plant species align with naturally occurring conditions, and offer the following advantages:

- Certain plant species are more tolerant of adverse weather conditions than others. They germinate easily and this results in a more rapid and dense plant cover. For example, in dry years, sunflowers (which love dry conditions) germinate faster than phacelia. This is because phacelia needs moist soil to germinate, whereas sunflowers do not.
- Plants feed on different bacteria and fungi groups. Diverse mixtures therefore promote a range of different bacteria and fungi in the soil to meet this need. Always include mycorrhizal plants (e.g. grasses, oats, lucerne, clover)
- The more plant species, the more stable the agro-ecosystem. This is because there are more beneficial organisms present in the soil.
- Different plant families break the soil down in different layers, supporting better nutrient mobilisation.
- Deeper soil layers are created thanks to the range of root types (taproot, shallow root, deep root, etc.)

Catch crops must always be adapted to suit the site and unique conditions they will be grown in, e.g. dry land, wetland, etc.

Catch crop strategies *



The period between the cereal harvest and summer harvest lends itself well to opportunities for catch crop strategies *

It's all about the right mix. The more species in the catch crop the better (ideally 8-10). Include a minimum of 5!

*Source: Top Agrar; Alexander Watzka, Bioland Consultancy

In a nutshell:

- Balanced catch crop mixes reduce the risk of crop rotation diseases and interrupt chains of infection.
- Stubborn weeds such as thistle and dock can therefore be reduced.
- Particularly on organic farms, legumes are ideal when it comes to binding nitrogen for the next crop.
- The more species the better - ideally more than 8, but 5 as a minimum. This means that there is something suitable for every weather condition and sufficient ground cover is achieved.
- Due to their root formation, grasses should be included in every mix.

Mixes should contain plants with different root penetration, N fixation, germination times, etc. Cover crop species should be put together in such a way that leaching losses are minimised, and the release of nutrients can be adapted according to the needs of the subsequent crop.

5.2 Sowing catch crops

Catch crops promote life in soil, however, suitable soil preparation and sowing are crucial when ensuring rapid emergence.

Conduct spade tests and take appropriate action.

Weed treatment or early sowing

Prepare the seedbed two to four weeks before sowing for weed treatments and repeatedly work the soil using a straw weeder or cultivator with duckfoot sweeps to a shallow depth every 7 - 10 days. Only carry out in dry conditions to ensure successful weed treatment. Each mechanical pass stimulates new seeds to germinate. Weed treatments are extremely effective and can prevent weed pressure from annual weeds. In response to summer weather conditions and the prevalence of weeds, weed treatments may be conducted or catch crops can be sown as early as possible, depending on the circumstances. Volunteer cereals can usually be suppressed fairly reliably by using a bulky green manure mix. Alternatively, they can be useful as a good enrichment for a green manure mix once germinated.

When cereals follow a catch crop, volunteer cereals should not be included in the catch crop to avoid disease transmission.

Soil cultivation before sowing

When weed treatments are not required, soil should be tilled, and the catch crop sown as early as possible after the grain harvest to cover the bare soil quickly.

Cultivation date rule of thumb

A later catch crop cultivation date means a shorter growing season, meaning the date should be as soon after the harvest as possible.

A good rule of thumb: 1 day in July = roughly 1 week in September / the whole of November during the growing season.

Sowing catch crops

The smaller the seed and the drier the soil, the higher the demands on the seedbed. For uniform and even catch crop emergence, it is essential to consider factors such as distribution across the entire area, depth of placement, reconsolidation, etc. during the sowing process. A pass with a "disc spreader" will not produce the desired result (e.g. wind drift causes uneven distribution). The most efficient and economical option is a pneumatic seed drill mounted on a soil tillage implement (cultivator, disc weeder or similar).

The aim is to plant the catch crop immediately after the harvest to make effective use of the fast-growing summer months.

A brief summary of catch crop sowing

- The correct stubble cultivation depth and sowing significantly reduces undesirable weeds.
- For the most efficient and economical use of seed, we recommend using a pneumatic seeding box mounted on a soil tillage implement or a seed drill.

Sow at the same time as stubble cultivation using a mounted pneumatic seed drill.

5.3 Einböck technology for catch crop distribution

The P-BOX-STI is a pneumatic seeder with electrical quantity dosing. The user-friendly, electric SPEED-TRONIC control unit regulates the seed quantity depending on the working speed. With the P-BOX-STI, all standard seeds and their mixtures can be sown from approx. 3 kg of seed per ha.

Advantages:

- Precise electrical application and dosing via operating monitor
- Versatile, economical seeder
- For grassland reseeding or fertiliser distribution
- Suitable for catch crops or cover crop sowing
- Distributes many different seed varieties and species of differing sizes
- Can be mounted on a wide variety of cultivators, weeders, etc.

5.4 Incorporation of cover crops & catch crops

In nature, the green sections of plants do not end up in the soil, as such, only rotted material should be worked into soil. Furthermore, earthworms can only make use of plant matter on the soil's surface as actual food.

The basics of incorporation

- Tall crops should be chopped at the right time (in the case of flowering crops, protect insects by chopping cover crops in the evening, morning or as a rule, during cooler weather).
- Chop approx. 2 weeks before incorporating cover crops.
- Subsequent pre-rotting reduces the anaerobic decomposition risk of the organic matter
- Do not let the growth lignify, otherwise nitrogen is only released slowly, and this can lead to shortfalls in yield.
- Therefore, do not plough fresh green material too deeply into heavy soil.
- Do not incorporate winter fertiliser too late on light soils, otherwise the emergence of the main crop may be hindered
- With easily breakable crops (such as mustard, buckwheat and feld beans), a quick pass with a roller is often enough to cause catch crop to die down.
- Cover crops that are hard to shred (such as clover or grasses) must be mulched or mown.

Avoid ploughing green manure too deeply into the soil.

Incorporating frozen off cover crops

Certain crops such as mustard, phacelia and Berseem clover can be easily incorporated if they are well dried out. They break up superbly just by using a tillage tool such as a cultivator or rotative/spade weeder Berseem clover and phacelia can also be "chopped" when frozen using a Cambridge roller.

Incorporating cover crops that have not frozen off

Be mindful to work carefully when incorporating unfrozen vegetation, cover crops might otherwise grow through to the subsequent 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, blade cultivator, or a light cultivator with duckfoot sweeps.

The correct tool depends on the following crop's components, the soil structure and the farm's approach to cultivation.

In cases when the soil is not turned, the roots must be separated from the earth as much as possible in order to prevent new growth. Good results can be achieved when using a weeder as a trailing unit or "beating" rollers. Often, a combination of multiple tillage steps at intervals of a few days are necessary to allow the strong plants to die off.

It is important to cut across the full working width when incorporating cover crops.

Cover crops in autumn

Cover crops that freeze off should still be able to develop sufficiently in autumn to freeze off safely in winter and enough mulch material should be left behind for the following crop. Avoid cutting in autumn due to the many negative effects. Moderate winter temperatures contribute to extended vegetation years, fostering robust root development in cover crops. This is an advantage when it comes to the build-up of humus in the soil.

Do not plough catch crops in autumn.

Ploughing in spring.

In principle, the catch crop should be left as long as possible so that it develops as much as it can. In spring, crop requirements as regards the seedbed must be the priority. These differ according to the tillage system, the type of crop and the style of management.

In general: Tillage operations should be carried out with caution and only when the field can be easily navigated. During spring, it is important to drive in a way that protects the soil and safeguards water (i.e. as shallow as possible). Tillage can only be carried out when the soil conditions are sufficiently dry. Reducing the working speed and adjusting tyre pressures means you are well equipped for the spring drought.

You need to take a soil sample before the catch crop is cultivated in spring!

It is essential you carry out a precise assessment of the catch crop's development stage. Ploughing should be carried out before seeds ripen to avoid germination of the new seeds. Ploughing after frosty nights means that cover crops can be easily mulched or flailed. Incorporating the shredded material accelerates drying, allowing for optimally preparation for subsequent cultivation. In addition, this improves weed suppression and warms the soil more quickly due to soil aeration. These measures should always be coordinated with the crop rotation in order to provide it with the best possible supply of nutrients.

If spring remains wet, do not drive onto the field.

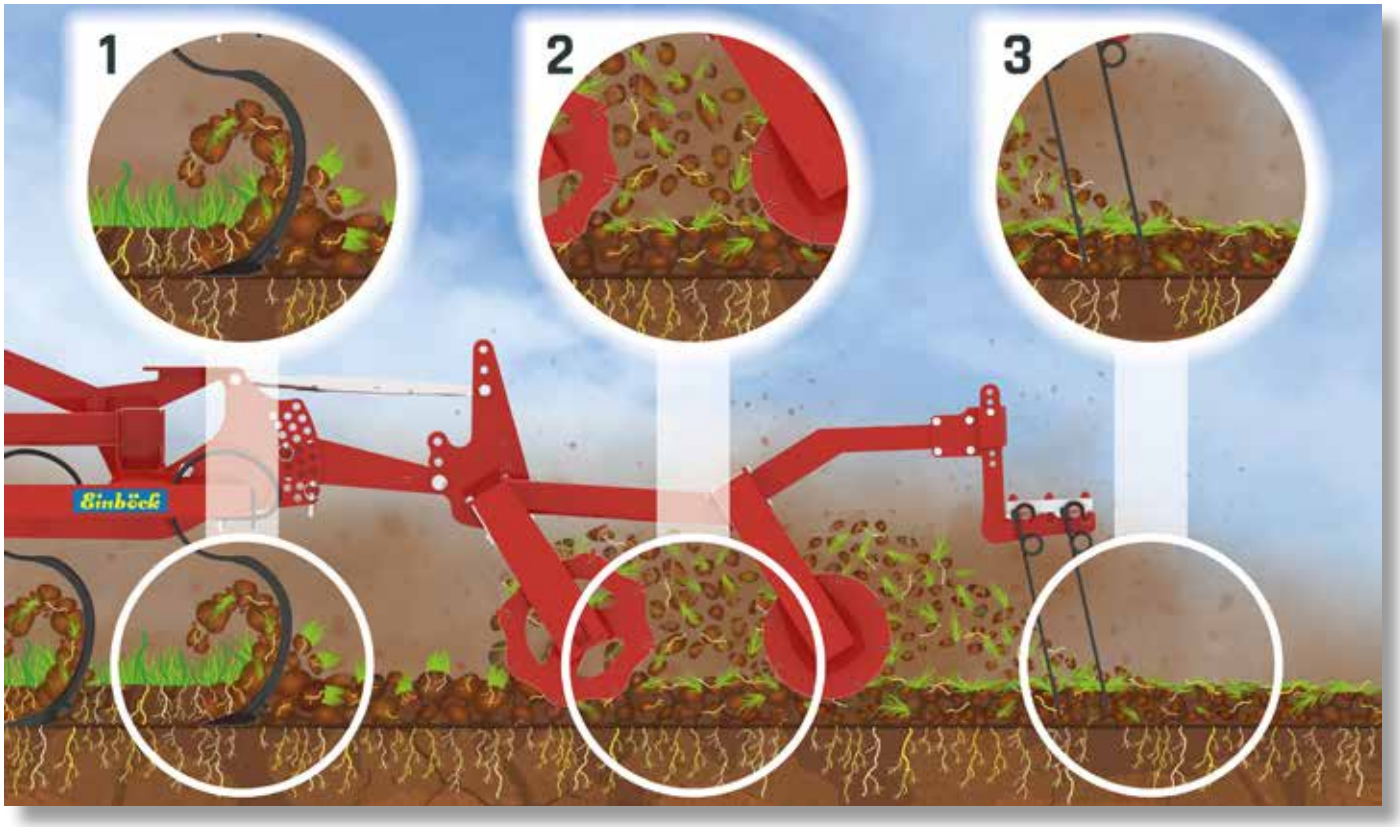
Shallow incorporation in spring

Shallow incorporation using a cultivator results in rapid decomposition. The plant material is separated from the root and incorporated into the soil allowing oxygen to enter the soil. This in turn warms up more quickly and stimulates microorganism development. Only begin tillage in dry conditions as it is essential to allow sufficient time for the soil to dry out in spring. It's useful to note, that if spring cultivation is delayed due to bad weather, it generally does not reduce the yield. Your soil will benefit in years to come from only tilling in dry conditions. In contrast, smearing of the soil surface and compaction can cause problems over several years.

Cover crop key facts in a nutshell:

- Allow soil to dry out well in spring
- Carry out a spade sample
- Till the soil gently
- Ensure a diverse organic mass
- Focus on exposing and completely cutting off at the root

5.5 An example of successful cover crop incorporation:



To ensure a good start and to provide a crop with the best possible seedbed, the cover crop must be well shredded. If the catch crops are not too vigorous during winter or if a high proportion of the cover crop is well frozen, the shredding steps may not always necessary. This means an initial shallow cultivator pass can be immediately carried out. To ensure a successful pass, take note of the following points:

1. **Full-width, clean chop:** All plants and weeds still standing should be cut off above the main root zone. A full-width cut is possible when using the correct line spacing (approx. 15 cm / 5.90") and duckfoot sweeps that are not too wide (20/22/24 cm / 7.90/8.70/9.40"). Sweeps must overlap so that vegetation cannot "slip through".

Use duckfoot sweeps made from carbide metal - they stay sharp for longer and maintain the cutting width.

Precise working depth: The device must be precisely set to the required working depth and must also maintain this depth.
Flat operation: This mode of action safeguards good capillary water connection for the seed, means that the soil crumbles well and enables optimum penetration even under hard soil conditions.

Work at a shallow depth - do not work deeper than the subsequent sowing depth.

2. **Break open clods of soil** A cultivator with rapidly rotating trailing working tools, such as flat rod crumblers and serrated crumblers, separate the soil from the roots: Clods of soil are broken at the root and crushed.
3. **Expose the roots:** A trailing weeder tine with heavy tines levels the soil and deposits the roots on the soil surface. The sun and wind will dry the roots there.
ZERO pressure: To prevent the cover crop from continuing to grow, it must not be pressed down again after it has been cut. The trailing weeder tines ensure any cut vegetation and roots are deposited on the surface. If the roots are free of soil, they will dry out quickly.

6. UNDERSOWING & MIXED CROPS

Undersown crops, i.e. an additional crop to the main crop, can be very advantageous for certain plants. Sowing undersown crops can increase plant diversity and promote rooting of the soil. They also reduce the risk of soil erosion and late weed infestations during the mature phase of the main crop.

To truly take advantage of the benefits undersown crops can offer, the right mixing partner needs to be chosen and sowing needs to be carried out in coordination. You must consider competition for space for roots, nutrients, and water.
Legumes such as clover or clover-grass are well suited to undersowing. Due to their slow juvenile development, grasses can fully develop quickly after the main crop has been harvested. Only sow undersown crops with caution when working in dry regions, as crops can often lack the necessary water in situations such as this. Drought-resistant legumes such as lucerne or kidney vetch can withstand longer periods of drought.

Particularly suitable as undersown crops: grasses such as white clover, black medic, mustard, camelina, perko or grass-clover, red clover, lucerne.

Advantages of undersown and nurse crops & mixtures

- Weed suppression
- Protection against crusting and humus erosion
- Protection due to ever-present cover crop
- Vegetation can be used as fodder
- Root penetration for better soil structure
- Incorporation of organic matter into the soil after threshing
- Fixation of extra nitrogen
- There is a developmental advantage due to the earlier sowing date than is possible for catch crops
- This approach acts as a cost-saving measure as the undersown crop benefits from the light after the main crop is harvested and grows alone. No tillage is therefore required
- Support and underpinning for the main crop

Undersown, nurse and companion crop challenges

- Competition between the main crop and the undersown crop can lead to poor development of the undersown crop
- Main crop may overrun due to being deprived of water and nutrients
- No tillage is possible after harvest
- Too much or too little seeding strength
- The right appropriate technology is required for this approach
- Incorrect timing of sowing
- Mechanical weed control difficult or not possible after sowing

6.1 Undersowing cereals

To prevent the undersown crop from overrunning, long-stalking varieties should be used at low-growing cereals such as winter barley, spring barley, etc. Choosing the right undersown mixture and time is key. After the harvest, the field is already planted. Stubble cultivation, seedbed preparation and sowing of a catch crop is not required.

6.2 Undersowing maize

A pneumatic seed drill mounted on a row-crop cultivator enables simultaneous sowing of undersown crops during the hoeing pass of the maize crop. This is usually an option for the final hoeing pass. Clover and grasses are particularly suitable for use as undersown crops. Spreading with a weeder-mounted seeder is also an option.

Under-sowing maize helps with weed suppression, erosion reduction and offers excellent shading. It also supports soil life and means the soil is more drivable during harvesting thanks to the wide-spread vegetation.

Sow the undersown crop using a row-crop cultivator with pneumatic seed drill during the last hoeing pass.

6.3 Undersowing soy*

The soy bean has slow juvenile development and ripening, which makes it susceptible to late weed infestations between the rows. Undersowing can suppress these weeds, in addition to careful weed control thanks to weeding and hoeing. Note the following key points: The sowing time of the undersown crop must be well matched to the soy bean to successfully suppress the weeds, while not impairing the soy bean yield. The undersown crop must be a good match for the main crop.

Perennial ryegrass and white clover in the undersown mixture are well suited for this purpose due to their rapid ground cover and low height. It can help to sow shallow-growing grass and clover varieties at the end of the rows as They can significantly improve field driveability when the harvest is wet. For soy, the cutter bar has to be lowered very low to the ground, therefore choosing a low but well-rooted undersown crop can make harvesting much easier.

6.4 Mixed crops

Unlike undersown crops, mixed crops are harvested at the same time as the main crop. Mixed crops support the positive interaction between the mixed plants, as well as offering the same advantages as undersown crops (i.e. soil cover, root penetration, etc.). They include plant species that promote the health and growth of other plants. Crops are chosen as mixed crops that will support other species, to make them able to be harvested.

Sow the undersown crop on the second weeding pass, between tilling and shooting.

* Source: LOP 5/2015, page 36

7. TILLAGE

7.1 Basic soil cultivation

Basic soil cultivation includes loosening and mixing the soil. The main aim of good, site-adapted soil cultivation is to achieve a healthy soil structure. Soil should have sufficient coarse pores for effective soil aeration and optimum water drainage In very dry conditions, strong reconsolidation may be desirable to save water.

It is important to ensure a high proportion of central pores for water storage and good root penetration without disturbance layers to achieve a healthy habitat that encourages an active soil life and high stability of soil aggregates. Depending on the soil conditions and moisture your field has, varying amounts of work are required.

An important aspect of basic soil cultivation is to loosen the entire surface to create the optimum conditions for plants to grow. The right approach must be selected depending on soil conditions present.

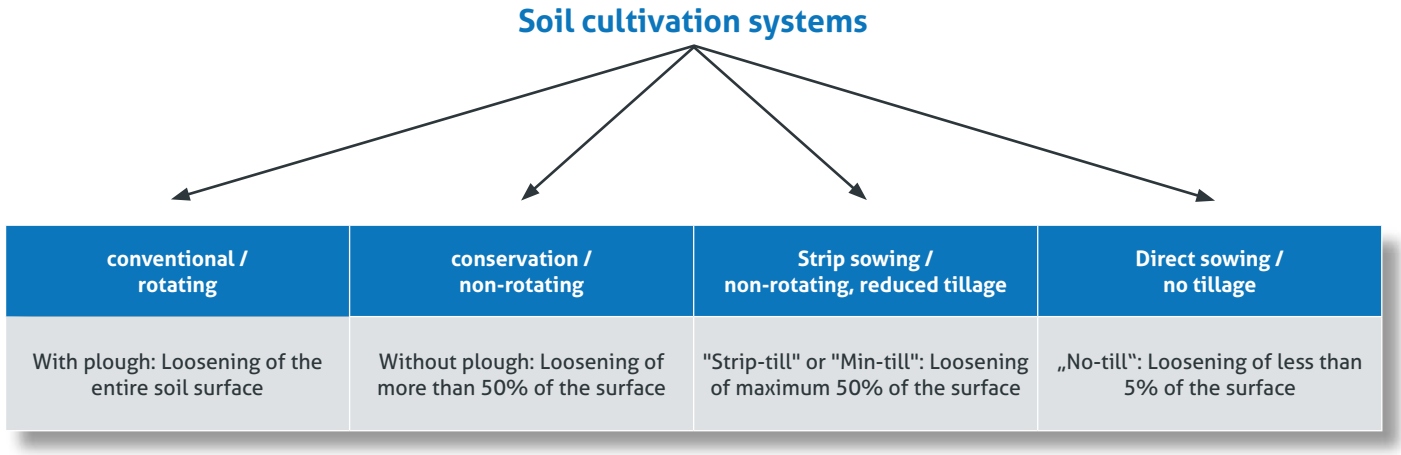
Not every tillage is the same - location is a key factor.

Tillage has a significant effect on the soil and soil life. Repeated exposure of sensitive soil to heavy machinery and agricultural tillage, compacts soil and has a negative effect on the living conditions of soil organisms. It increases the chance of erosion, nutrient leaching, and a decline in soil fertility.

Agricultural soil cultivation and usage therefore requires careful, location-specific consideration to avoid detrimental side effects, while achieving the goal of sustainable, efficient and environmentally friendly soil management.

7.2 Soil cultivation systems

Choosing the appropriate cultivation method is crucial for a farm's success. The following cultivation systems are distinguished:



Conventional / rotating

Ploughs are the classic implement used for turning in basic soil cultivation. With this method, soil is worked intensively to a depth of 30 cm (11.80") and turned across the entire surface. The plough creates a clean soil surface ("a clean table") that is well aerated and perfect for rooting. Turning allows fertiliser, crop residues and vegetation to be easily incorporated into the soil.

Using a plough is as popular as ever in organic farming due to it being so good at suppressing weeds, however, it is important to note that it significantly affects soil structure. It impacts soil life, massively disrupting the activity of earthworms and soil fungi (mycorrhizal fungi). It is important not to work the soil unnecessarily deep so that soil life is disturbed as little as possible.

Ploughs can significantly affect soil structure.

Ploughing advantages

- Effective weed control thanks to light deprivation
- Edge ingrowth effectively controlled
- Intensive soil aeration, which stimulates microorganisms and mobilises many nutrients (especially nitrogen)
- Moist soils dry out quicker
- Soil warming is sped up resulting in higher yields for heat-loving crops
- The working depth and quality of work are immediately visible
- Cultivation impossible even under damp conditions
- Reduction of disease risk for crops
- Transformation activity accelerated thanks to oxygen enrichment present in the soil
- Subsequent seedbed preparation using simple machinery without blockages (even with towed machines)
- Simpler technology for weeding and hoeing can be used without the risk of blockage, as there is less organic matter on the soil surface
- Sowing using simple sowing equipment (Suffolk coulters)
- The technology and expertise required is usually already available on the farm

Ploughing disadvantages

- Nutrient mobilisation is synonymous with humus decomposition
- High energy consumption and low acreage performance lead to high costs
- Crop residues and farm manure are buried resulting in poor rotting and leading to reduced humus build-up
- Straw mats and root-hostile or non-rootable zones are created
- 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
- Nitrogen mobilisation is not desirable in autumn because it easily leaches
- Lack of ground cover from organic material leads to a high risk of erosion
- Serious, unproductive water loss in dry periods and dry areas
- Soil organisms die in soil layers
- Too much aeration on light soils enables short-term overheating of soil life

Shallow ploughing

The shallow plough cuts roots and weeds across the entire soil surface at a shallow depth of usually 10 to sometimes 20 cm (3.90-7.90"). They combine the advantages of traditional ploughing with a minimal level of cultivation. In addition to being well-suited to controlling weeds, shallow ploughs ensure rapid rotting. Their mode of operation also reduces fungal infestations.

Advantages of shallow ploughs over conventional ploughs

- Shallow incorporation of harvest residues: Harvest residues remain in contact with oxygen, which supports the decomposition process
- Soil structure is protected and offers a high load-bearing capacity: Only the top few centimetres of soil are processed, keeping the gas and water balance at the right levels
- Preservation of the soil structure safeguards soil life
- Mechanical control of weeds and volunteer cereals happens at shallower depths than when using a conventional plough (up to 20 cm / 7.90" deep)
- Avoidance of sole compaction as a result of the plough's "Onland" driving method
- Diesel consumption is reduced, since for every centimetre of working depth, 150 tonnes of soil have to be moved per hectare
- By reducing the power output, the working width can be increased by up to 40% compared to regular ploughing

Shallow ploughing combines the advantages of traditional ploughing with those of minimum tillage!


ovlac

Conservation tillage / non-rotating

Conservation tillage is characterised by loosening of soil, rather than turning. Plant residues remain as close as possible to the soil surface (mulch). Equipment should be used for this kind of soil cultivation that transfers a great deal of power indirectly to the soil, and crushes as little as possible. Cultivators and disc weeders are some of the most important tools in non-rotating tillage.

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.).

Cultivator advantages

- Soil structure is not reversed – stable soil aggregates can develop in the upper soil layer
- Protection of soil life, which is a plus for the earthworm population and fungi
- Organic matter mixed with all topsoil: Favourable rotting conditions, efficient conversion of organic matter to humus, no straw mats, protective mulch cover
- Increase in number of medium pores – improved water holding capacity in soil
- Increased acreage performance
- Lower diesel consumption for flat work
- Less unproductive evaporation
- Good erosion protection
- No plough pan formation

Cultivator disadvantages

- Crop residues or mulch layer remains on the surface and makes mechanical weed control more difficult
- Higher demand for seedbed preparation
- Higher demands on sowing equipment (disc coulters)
- Fewer large pores than with ploughing
- Limited use in very heavy and compact soils
- Higher demands on weeding and cultivator technology due to the increased quantity of organic material on the soil surface
- This machinery is difficult to use and gives poor results on very moist soils, i.e. in wet conditions
- Weed pressure may be increased

Cultivators offer many benefits. They have therefore become increasingly important in recent years.

Strip sowing *

Strip-till sowing is a strip sowing method that cultivates only a narrow strip of soil around the sowing sweep. In essence, this is a compromise between mulch sowing (a ploughless sowing method preceded by conservation tillage) and direct sowing (sowing without any tillage, after harvesting). Roughly two thirds of the soil remain uncultivated and covered with dead or living plant material. According to the principle of first loosening and fertilising, then sowing, organic and/or mineral fertilisers are placed in a highly concentrated form in the root zone of the main crop.

"Strip-till" is generally only used for row crops (such as maize, soy, pumpkin, sugar beet, etc.) to ensure sufficient row spacings.

"Strip-Till" advantages

- The potential for erosion control is increased by the straw and mulch cover and the uncultivated sections' water infiltration. The water content in the topsoil is increased, particularly in the uncultivated sections.
- The load-bearing capacity and stability of the soil in the uncultivated sections between the rows is improved.
- Since less soil is cultivated, the loosened strips warm up and dry faster. This carries advantages for plant germination and juvenile development.
- The classic strip-till method requires less tillage leading to cost and diesel savings.

"Strip-Till" disadvantages

- Accurate and precise work is required before, during and after this method is carried out. This includes:
  - Very good straw distribution and combine harvester chop quality
  - Dry soil conditions
  - A level field without deep ruts/tracks
  - Low pressure on the area to be harvested
  - Management of volunteer grain
- Precise "strip-till technology" required for sowing. Only a few reliable and professional manufacturers exist who produce technology suitable for this method. Most options are customised solutions that suit the farm they are being used on. The output during sowing is considerably lower than "normal" precision sowing.
- Mechanical weed control is extremely challenging due to:
  - The high organic mass present
  - Difficulty identifying the main crop and choosing the appropriate intensity (especially when hoeing)
  - Strongly developed and rooted plants between rows. Weeding almost impossible

* Source: http://www.strip-till.de/verfahren_varianten.html

Direct sowing *

No tillage or loosening of the soil is required for direct sowing. With this method, the soil is only disturbed to make a slit for the seed. Since the soil is not turned, direct sowing can be regarded as a particularly extensive form of conservation tillage.

In contrast to conventional tillage, soil is not worked other than to create seed slits for sowing.

Advantages of direct sowing

- Improved water supply and good prevention of soil erosion
- Reduced horizontal displacement of nutrients and pesticides
- Good driveability
- Higher aggregate stability
- Lower energy and labour requirements
- Increased acreage performance
- Lower process costs

Disadvantages of direct sowing

- Surface drying
- Delayed surface warming in spring
- Higher requirements as regards management and plant cultivation
- Use of herbicides may be inevitable
- Direct sowing is usually only suitable for certain crops, such as winter wheat after winter oilseed rape.

Results: Direct sowing vs. tillage

Direct sowing results	Results of tillage (rotating)
Depth of operation: 2 cm / 0.79" to 5 cm / 2" (sowing depth)	Depth of operation: 15 cm / 5.90" - 35 cm / 13.80"
Frequency: low	Frequency: high
Organic material on the soil surface: high	Organic material on the soil surface: none
Mechanical loosening: none	Technical loosening: high
Biological activity: high	Biological activity: low

* Source: Direct sowing: The pros and cons | agrarheute.com https://www.agrarheute.com/pflanze/getreide/direktsaat-nachteile-442925

7.3 Stubble cultivation

After the field has been harvested, stubble cultivation is carried out. In addition to managing weeds and undersown crops, harvest residues should be incorporated and the germination of volunteer cereals or weed seeds should be encouraged. In dry areas, water evaporation should also be limited.

Stubble cultivation objectives:

- Loosening the soil
- Breaking up crusting, mud silting
- Breaking up superficial areas that are compacted
- Increasing the pore volume (soil aeration, improved gas and water transfer)
- Levelling of the field surface (tramline tracks)
- Stimulating the germination of volunteer cereals and weed seeds
- Preserving moisture to survive dry conditions

Aims of stubble cultivation:
loosen the soil, break capillaries, avoid unproductive evaporation.

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

- "Injection" of soil life
- Encouraging organic matter rotting (disease and pest prevention)
- Efficient transformation of organic matter into humus
- Straw management: When there are high quantities of straw, it should be properly chopped beforehand so that it can be properly mixed in.

Weed control

- Pulling out & cutting weeds
- Stimulate germination of weed seeds and volunteer seeds from the harvested crop
- Exposure and drying out root-propagated weed roots (couch grass, thistles, etc.)

Regulating the water balance

- Avoiding unproductive evaporation in dry conditions
- Encouraging evaporation and soil drying in areas that are too moist
- Control of animal pathogens (mice and snails)

Stubble cultivation with a focus on interrupting capillaries

To prevent moisture loss, capillary action must be interrupted during the first stubble cultivation. This stops moisture from rising through the soil and evaporating on the surface after the harvest. Volunteer cereals should also be encouraged to grow together with weed seeds so that they can be controlled in the second stubble cultivation.

Mulch sowing: Once the volunteer cereals have emerged, work deeper when sowing using the mulch method in order to reduce the topsoil's straw concentration. This improves the emergence conditions for the following crop.

Sloping or straight stubble cultivation*

Take care that crop residue (straw) is spread evenly across the field. To achieve this, we recommend travelling at an angle to the combine harvester track. A GPS steering system with lanes saved can be of great use here. CAUTION: This is not beneficial for optimum field levelling. If this is the primary goal, the second stubble cultivation should be driven crossways compared to the first pass so that section can be levelled properly.

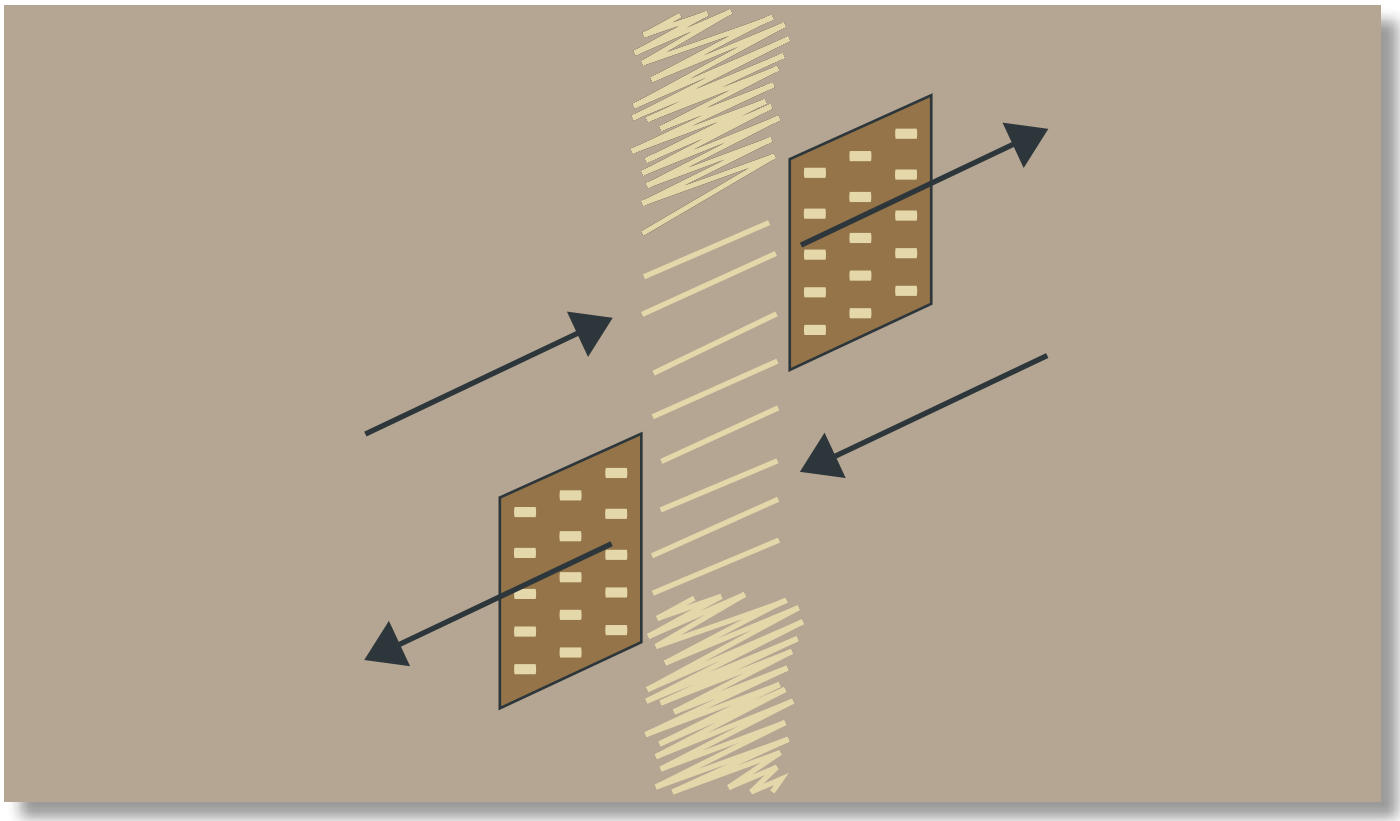
Advantages of diagonal stubble cultivation

- The risk of blockages is lower as the tractor is driven at an angle to alleys. This is where there is often (too much) straw
- Straw is distributed more effectively
- Deep tracks are levelled better
- This method results in a full-surface cut as the sweeps always hit the stubble when travelling at an angle. They cannot "cheat" their way through.
- Less tractive force required: Tractive force tests have shown that passes carried out with an inclined machining direction require up to 10 per cent less tractive force.

Disadvantages of diagonal stubble cultivation

- Instead of working two headlands, a headland must be planned in at all four field boundaries due to the diagonal tillage. This results in more wedges and tapered areas. These are time-consuming and must be worked twice. Depending on the field symmetry however, this might not be too significant.
- Field levelling may not be sufficient or suitable. This is problematic for subsequent crops and maintenance measures.

The first stubble cultivation should be done at a 10-30° angle to the main cultivation direction.



"Straw swath", unevenly distributed straw after 1st pass of straw distribution

* Source: https://www.agrarheute.com/technik/ackerbautechnik/streitthema-landwirten-stoppelsturz-schraeg-gerade-grubbern-595998 und https://www.topagrar.com/acker/news/stoppelbearbeitung-so-verteilen-sie-das-stroh-richtig-b-13434466.html

Practical example: First stubble cultivation before maize, soy, etc.

After harvesting cereals, oilseed rape and peas, etc. in summer, there is often quite a long gap before growing the next main crop (soy, maize, field bean, etc.). This gap is generally used for an early stubble cultivation and a simultaneous 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 in 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 the "Growing catch crops" section.

Practical example: Stubble cultivation with a focus on weed control

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 conflicts with early catch crop sowing and rapid soil cover. 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 cover crop mix. Otherwise, they make a perfectly good enhancement to a cover crop mix once they have germinated.

Duckfoot sweeps mounted on spring tines

Sweeps mounted on rigid shafts in addition to double-heart sweeps

Both systems enable full-width soil penetration.

"Green bridges" can present a real danger in cereal crop rotations.

Practical example: "Weed treatment" as an emergency measure

Windows of time between main crops can be used to treat weeds in fields with strong weed pressure, and especially those with acute root-propagated weed problems. At this point, we should mention that it is important to analyse and eliminate the causes of widespread weed occurrence. A weed treatment is, to a greater or lesser extent, an emergency measure, which primarily combats symptoms, without eliminating the actual causes long term (e.g. nitrate leaching into the subsoil, soil compaction, imbalance nutrient levels).

When focussing on weed control, the first stubble cultivation should be carried out as shallow as possible (approx. 4-5 cm / 1.60-2") with a flat cultivator, for example. This will encourage weed seeds 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 since residual weeds that are pressed down can often sprout again and even propagate. For this reason, a lightweight trailing unit, such as a bar roller should be used in combination with a tined weeder. The tined weeder brings the weeds 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.

"Weed treatments" only tackle the symptoms - it is therefore a reactive measure, rather than an active way to deal with weeds.

Practical example: Stubble cultivation with a focus on weed control and capillarity

On the second pass, the working depth should be increased to approx. 10 cm (3.90") to destroy any weed seeds 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 dry soil horizons are cultivated. Patches of smearing and slades should certainly be avoided, otherwise soil pores close up interrupting groundwater movement.

The roots of root weeds should be laid out in dry weather to weaken the root weeds long term. In dry weather conditions, the process of laying out root-propagated weeds to dry out can be repeated a second time. After a weed treatment, 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 section "Growing catch crops").

Overlapping of the duckfoot sweeps = full-surface cutting during stubble cultivation.

Stubble cultivation: The TOP 10

1. The primary objectives for stubble cultivation should be defined before the harvest.
2. Set the combine correctly (straw distribution, mowing height, wastage, chop length).
3. Spread stubble cultivation over 2 passes: The first pass should be as flat as possible (up to 5 cm / 2"). The working depth should be increased for the second pass.
4. Work the entire soil surface - no unworked sections (bridges) should remain.
5. Good mixing of organic matter with soil.
6. Cultivate at an angle - up to 30°.
7. Use the trailing rollers for uncovering (uprooting) roots and reconsolidation.
8. Interrupt capillaries to prevent moisture loss.
9. "Weed treatment" or timely catch crop seeding.
10. Ensure ideal weather conditions: make use of dry conditions to dry weed roots on the soil surface.

Duckfoot sweeps require a slight undercut and a clear cutting edge to work at their best.

A spade soil sample will help you decide the right tool and correct working depth.

An overview of Einböck technology for stubble cultivation: Universal cultivator HURRICANE

The extremely user-friendly universal cultivator HURRICANE combines three types of machinery in one. The HURRICANE is the ideal tool for stubble cultivation and the incorporation of cover crops. It also shows its strengths when breaking up compaction in deeper layers of the soil.

The working depth can be adjusted between 4 beams, with a 20 cm (7.90") line spacing between 4 and 25 cm (1.60 and 9.80") (depending on the sweep equipment, trailing unit and soil conditions). Operation over the full surface can be achieved by choosing the correct sweeps. After tillage, the soil surface is levelled and reconsolidated. The HURRICANE is an extremely compact and manoeuvrable tool that can be used effectively on small and large areas. A seeder for sowing catch crops can be easily mounted and adjusted.

The HURRICANE is suitable for:

» Catch crop ploughing
» Stubble cultivation
» Basic soil cultivation

The powerful all-rounder HURRICANE works down to 25 cm (9.80").

Cultivator TAIFUN

The TAIFUN light cultivator is designed for shallow cutting with duckfoot sweeps, and with a line spacing of 15 cm (5.90"). It is the perfect tool for successful first mechanical weed control. The many possible combinations (e.g. sweeps, rollers, trailing weeder tines, support wheels, etc.) mean the flat cultivator can be adapted to a wide range of conditions and applications.

A true "multi-talent":

» **Catch crop cultivation:** Full-surface, clean and shallow undercutting of winter or frozen catch crops and perfect uprooting.
» **Seedbed preparation:** A perfect structure of coarse and fine soil ensures ideal germination conditions, plus safe and even emergence.
» **Stubble cultivation:** An ultra-flat, full-surface stubble cultivation encourages volunteer grain to germinate.
» **Growing catch crops:** On the second cultivation, catch crops can be concurrently sown with the P-BOX seed drill.
» Regulation of root and seed weeds - "glyphosate replacement"
» Incorporation of liquid manure, "false" seedbed, etc.

The flexible all-rounder TAIFUN works down to 15 cm (5.90").

Techniques & settings for stubble cultivation: The TOP 10

1. Choose a suitable tractor, correct ballast (40% to 60%) and appropriate tyre pressure (change between road and field).
2. Correct coupling saves fuel: The upper link should rise slightly towards the cultivator during operation. Use the slotted hole on the upper link by using front support wheels.
3. Fit the appropriate sweeps: Duckfoot, wing share, double diamond or narrow sweeps
4. Adjust the working depth (use tape measure) and set the device parallel to the ground
5. Adjust the levelling tools to working depth
6. Set the following weeders (for active work)
7. "Work with an overlap" - preferably with GPS lane assist
8. Select the correct speed: For shallow working, 10-14 km/h - deep working up to 10 km/h
9. No working depth adjustment on the headland
10. Check the results several times - dismount and clear the working horizon using a spade

7.4 Seedbed preparation

For optimum seed placement, good conditions should encourage seed germination and, above all, ensure even emergence. Rapid water absorption is key. A soil density that steadily increases from bottom to top allows seed roots to penetrate the soil deeply and means water is easily accessible rapid seed germination.

You will require suitable technology to ensure the seedbed can be prepared for sowing up to a good standard in a single pass. The preparation of a suitable seedbed to create favourable conditions for subsequent maintenance measures is another key requirement. The main aim is to eliminate weeds.

A key consideration in seedbed preparation: creating good conditions for tined weeder and hoe usage.

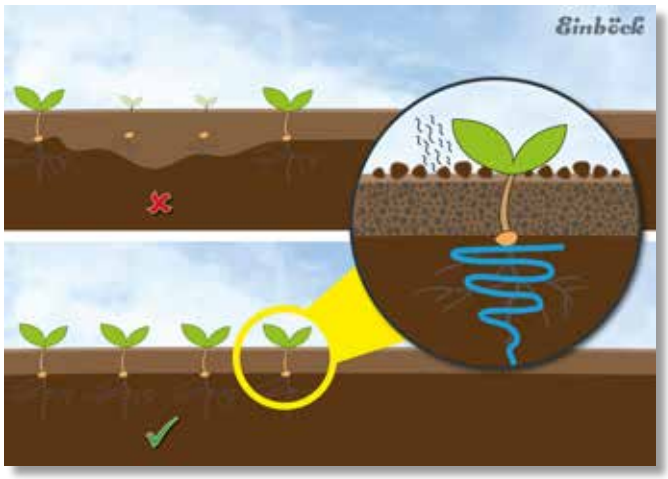
Seedbed preparation objectives

Seedbed combinations and seedbed cultivators create the right ratio between fine and coarse soil, which counteracts crusting and evaporation. It is important to disturb the soil as little as possible when preparing the seedbed to retain as much moisture as possible within the soil. Coarse soil is moved to the top, fine soil remains on the sowing horizon. The correct trailing units (rollers) and front levelling plates are particularly important.

Since every farm has a different field soil composition, the correct choice of tools is essential to achieve the best results. To enable seed to be precisely distributed at a later date, seedbed preparation requires a smooth-running tool that exactly maintains the working depth set. In organic farming, when preparing the seedbed and sowing, it is particularly important to ensure that after sowing, the surface is sufficiently even for the tools (tined weeder, hoe, etc.) to work to the same depth in all areas.

Features of an optimal seedbed

A perfectly levelled, shallow-cultivated seedbed is characterised by a medium to coarse tilth with an open structure. The seed itself is placed 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. As far as possible, the field should not be driven over when soaked. The resulting compacted areas and crusting delay the development of plants.

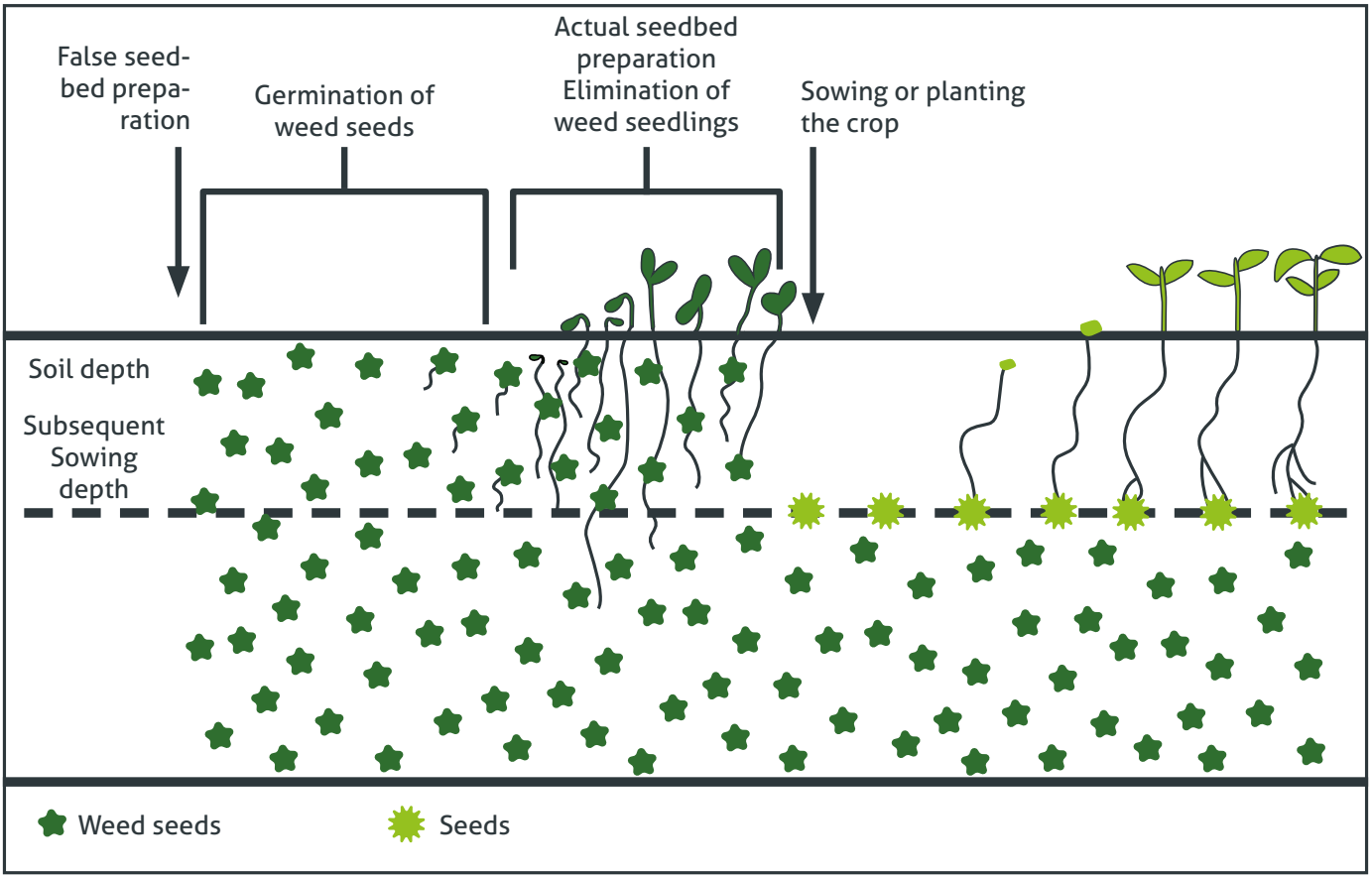


As a general rule: As rough as possible and as fine as necessary.

"False seedbed" in spring

If the conditions in spring permit, a "false seedbed" can also be prepared. Seeds from weeds can germinate and start to grow in seedbeds that have been prepared 2 to 4 weeks before sowing is planned. These 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 flat once or twice in between using a seedbed combination, or possibly also a tined weeder. This enables weed pressure to be distinctly reduced particularly during the early stages of the main crop.

False seedbeds: an effective way to reduce weed pressure



An overview of Einböck technology for seedbed preparation

EXTREM seedbed preparation

The EXTREM seedbed combination has been developed for seedbed preparation on all types of soil, especially ploughed land. The perfect combination of fine and coarse soil particles creates structures that prevent crusting. The specification of the tine sections and rear rollers, which is designed to meet the customer's soil conditions, ensures ideal depth control. This creates the perfect seed horizon, which forms the basis for optimum seed emergence. Also in heavy soil conditions, a level surface and a fine seedbed are ensured.

Fine cultivator VIBROSTAR

The VIBROSTAR seedbed cultivator is designed for professional and user-friendly seedbed preparation. It is mainly used for light to medium-heavy soils. The light cultivator creates the perfect seedbed and ensures optimum levelling on ploughed or mulch seeded fields with organic matter. The special design of the frame and the high-quality spring tines which are mounted to the frame with a line spacing of 10 cm (3.90") ensure intensive soil mixing with excellent soil flow. This ensures the machine can handle a high amount of residue without getting blocked.

Depending on the field conditions and cultivation objective, the cultivator is available with 4 or 5 row tine arrangement, tines with various different shapes and lengths as well as an alternative trailed weeder. The version with 4-row frame is also available with a front roller.

The larger the seed, the coarser the seedbed!

Avoid PTO-driven (Power Take-Off) devices

PTO-driven implements such as power harrows and rotary hillers should be avoided as much as possible since they can smear soil in wet conditions. They also run the risk of breaking up the different soil components too intensively. When they are used in spring, after the field has been ploughed in autumn, the seedbed can quickly become too fine tending to cause crusting and erosion.

Compared to actively driven seedbed preparation tools, passive tools (such as fine and universal cultivators) have a lower power requirement per metre of working width. In combination with the higher working speeds that these devices enable, the area output can be greatly increased. This can increase the economic utilisation of the machine, especially during short periods of good weather in spring, when a large area needs to be processed in a very short period of time.

Seedbed preparation: The TOP 5

1. **Prepare a precise seedbed:** The measures that are carried out before sowing are critical. A precise and, above all, even seedbed is a fundamental requirement for a weed-free field. The seed should be sown on a level soil surface with few tracks. Rolling before or after sowing can be beneficial.

2. **Pay attention to the correct working depth:** A uniform, deep seed horizon is essential for uniform emergence. During seedbed preparation, take care not to work too shallow, and certainly not too deep. A suitable ratio of fine to coarse soil is another prerequisite.

3. **Create a false seedbed:** Whenever possible, prepare a false seedbed, as this encourages the first wave of weed seeds to germinate, meaning you can eliminate them before seed sowing.

4. **Chop up organic matter & distribute evenly**

5. **Coordinate technology:** Tractor - seedbed preparation technology - seed drill

8. SOWING

In organic arable farming, correct sowing is an important component in mechanical weed control. In addition to suitable crop rotation, the right sowing rates, depth, and sowing times can also significantly influence the success of a crop and the quality of a harvest.

8.1 Sowing taking into consideration mechanical weed control

Sowing time

Better late in spring and early in autumn!
For maize or beet, sowing on sufficiently warm soil during stable, warm weather is beneficial. This allows the crop to germinate quickly, resulting in rapid juvenile development and giving the crop a significant head start on the weeds.

The sowing time should be adapted to the first weeder pass (blind weeding) - ideally, there should be 7-10 days of good weather after sowing.

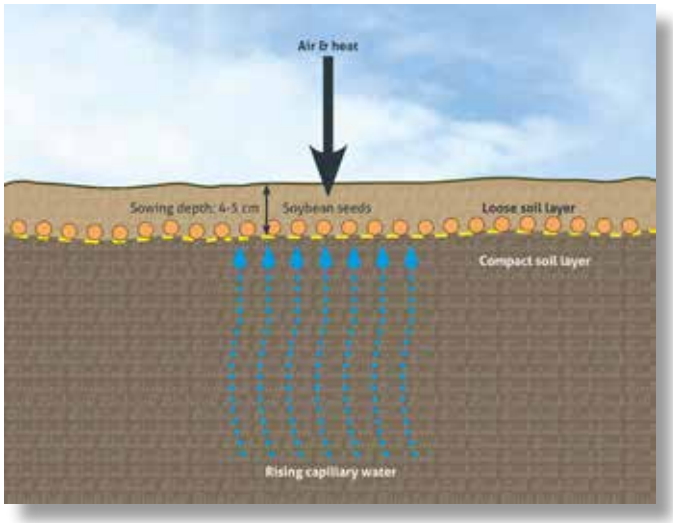
In organic farming, seeds are generally sown late in spring and early in autumn (this varies according to region).

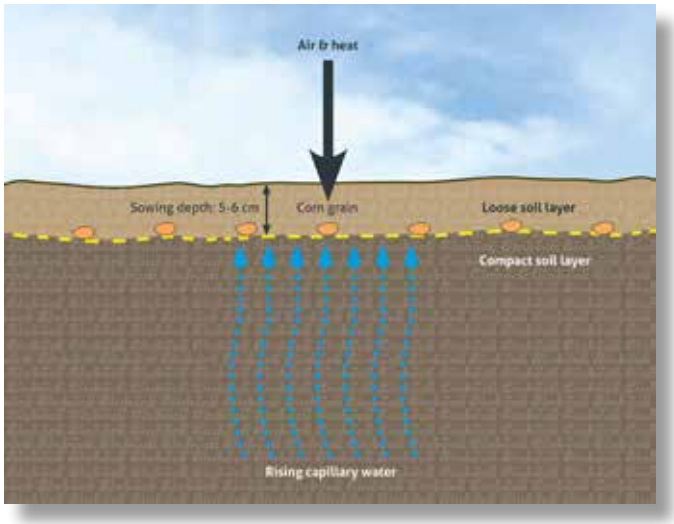
Sowing depth

To prevent germinated seeds from being pulled out during blind weeding, they should be sown a little deeper. However, this is very regionally specific and mostly depends on the soil.

In organic farming, crops are generally seeded deeper, although this does vary according to the region.

Optimising sowing in organic arable farming





Precise sowing

In general, sowing of organic crops requires great accuracy to achieve the correct sowing depth, row spacing and lines. For example, seed drills must be checked to guarantee the correct row width and passes must be carried out as accurately as possible. Accurate passes are particularly important when hoeing to ensure that the last row is not hoed out during this pass, and that no strips remain unhoed.

Sowing is best carried out with GPS assistance!

Take care when using old, worn-out sowing technology: row spacing can vary greatly!

Seeding rate

Already in advance go for a higher seed density, since some losses are unavoidable during subsequent use of a tined weeder.

If the seed rate is increased by 10-20%, later losses during weeding are compensated for.

Good reconsolidation

Additional reconsolidation with rollers can help the tined weeder and hoe perform better. Depending on the crop and cultivation method (drill sowing, row sowing, precision planting, tine sowing, etc.), rolling can also help ensure uniform emergence. Even if the seedbed has been prepared too coarsely or is very dry after sowing, rolling can ensure satisfactory emergence.

8.2 Einböck sowing technology

The row-crop drill CHOPSTAR-SEEDER has been specially designed for seeding of legumes in rows (e.g. soy), but also for other crops such as cereals and field beans, when they are sown in wide rows and hoed later. Adapted to the prevailing working conditions, this flexible system is the right solution for maintaining exactly the adjusted working depth, precise seed placement and reliable emergence of the crop. Seeding is carried out either by double-disc or Suffolk coulters. The seed depth is precisely maintained, and the seed furrow is optimally reconsolidated by means of seed downholders, feeders and double pressure rollers.

Always check physically to see whether the sowing depth and seeding rate are still suitable.

8.3 Sowing: The TOP 10

1. Uniform sowing depth: not too deep, not too shallow
2. Coordinate sowing depth and seedbed preparation
3. Seedbed should be the perfect ratio of coarse vs. fine
4. Ensure precise row spacing
5. Seeds should be distributed on a water-bearing layer
6. (Soil) temperatures are decisive when choosing a sowing date
7. Choose dry conditions when selecting a sowing date
8. Seed furrow should be closed
9. Where possible or necessary, "compact" soil with a roller
10. Take your time and sow accurately

9. INTRODUCTION TO MECHANICAL WEED CONTROL

Mechanical weed control tools bury and pull out weeds or cut them off flat: this prevents weed growth. The large-scale management of weeds using tined weeders, hoes, cultivators, etc. is referred to as "mechanical weed control".

Mechanical weed control objectives

- To ensure crops do not contain "problematic" weeds such as thistle or dock
- To impair, remove and almost completely eliminate "problematic" weeds
- To get control of weeds so that they cause as little disturbance as possible during cultivation and harvesting measures (yield reduction, contamination, difficult harvesting conditions, etc.)
- To suppress weeds so that there is as little competition with the main crop as possible (for light, water, nutrients, space)
- To reduce weed pressure to a minimum to give the crop a head start

Mechanical weed control challenges

- A 100% weed-free field is not possible using this method
- Direct comparisons of yields between chemical and mechanical weed control are not meaningful
- If too many passes are carried out, there is a risk of humus decomposition

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

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

Do not be afraid of weeds!

9.1 Indirect weed control: Measures for implementation before sowing

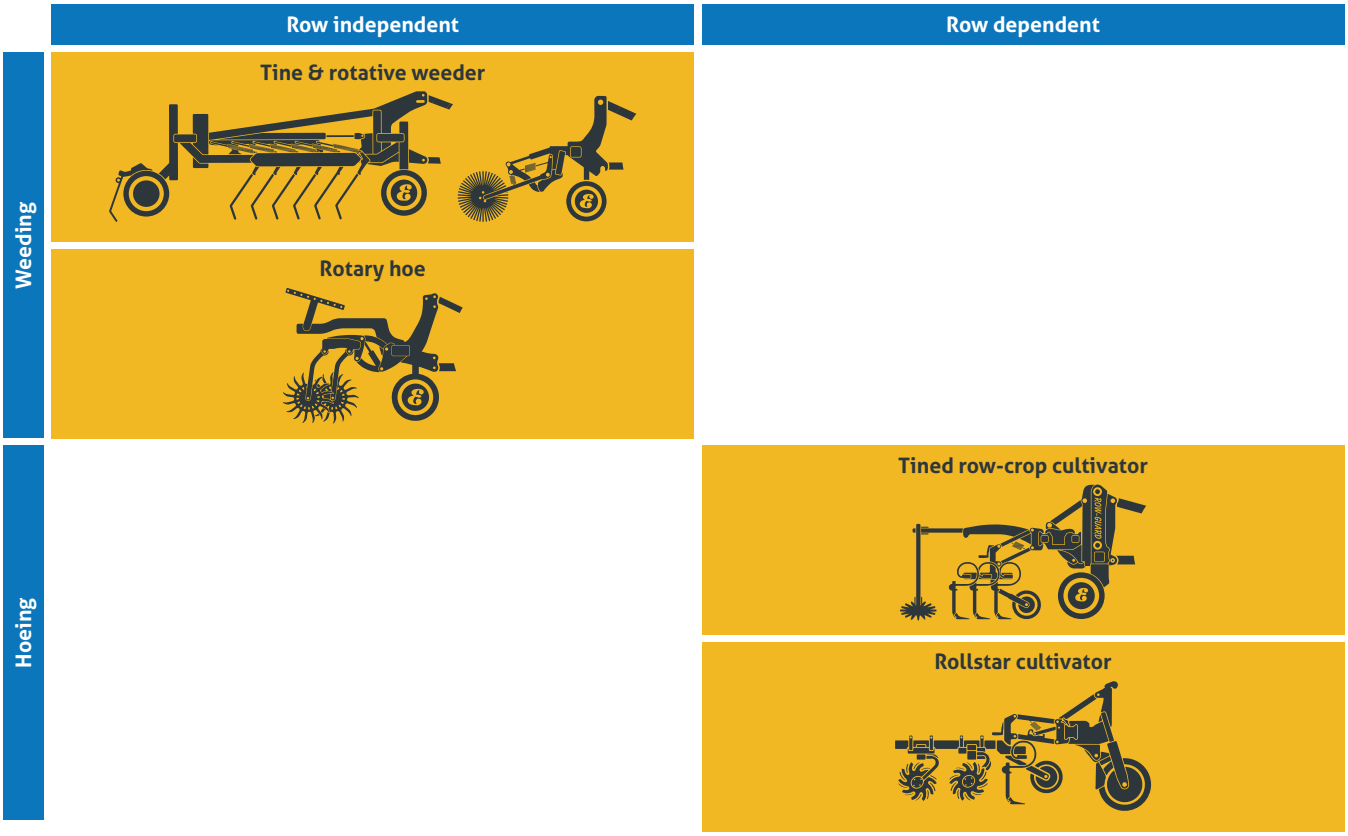
Weeds adapt to crops. Whether this is the germination time, growth rhythm or propagation - the crop will adapt to the crop. For this reason, the most effective preventive weed control measure is varied crop rotation! A mix of diverse weed species is easier to regulate mechanically and create a good soil structure. Healthy soil has less weed pressure.

If the nitrogen in the soil is also considered in the crop rotation, most weeds will be deprived of the right building blocks for growth. The appropriate tillage is another important preventive measure. This is one of the reasons why the cultivator was one of the first mechanical weed control tools. Impairment of the soil structure and soil compaction weaken the crop and encourage weeds like thistle, couch grass and windthale. However, if the soil is loose and rich in humus, the crop develops quickly and healthily.

Next year's mechanical weed control begins this year - immediately after the harvest.

9.2 Direct weed control: Weeding and hoeing after sowing

Direct weed control primarily involves weeding and hoeing. Success is influenced by many factors such as weather conditions, soil type, soil condition, weed species and their stage of development. Of similar importance is using the right technology with the right machine settings at the right time. The knowledge and experience of the farmer naturally constitutes another essential component for a successful pass.



Different techniques for different crops

CROP	Tined weeder	Precision tined weeder	Rotative weeder	Rotary hoe	Rollstar cultivator	Tined row-crop cultivator
Winter cereal	✓	✓	✓	✓	–	✓
Spring cereal	✓	✓	✓	✓	–	✓
Maize	✓	✓	✓	✓	✓	✓
Soy	✓	✓	✓	✓	●	✓
Sugar beet	●	✓	●	✓	●	✓
Oilseed rape	●	✓	●	●	–	✓
Field beans	✓	✓	✓	✓	●	✓
Peas	✓	✓	✓	✓	–	✓
Lupins	✓	✓	✓	✓	–	✓
Potatoes	●	✓	–	●	✓	–
Pumpkin	✓	✓	✓	✓	●	✓
Seed flax	●	✓	●	●	–	●
Blind weeding	●	✓	✓	●	–	–

✓ = easy to use

● = limited use (additional equipment may be needed depending on the soil)

– = unusable

10. 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. Thanks to its ability to be used row independent in almost all crops and its wide range of applications, the tined weeder offers distinct advantages in arable crop maintenance.

Their 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 advantage 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.

10.1 What to expect from the tined weeder

The success of a tined weeder in controlling weeds is primarily accomplished by burying the weeds in soil at the cotyledon stage (50–70%) in addition to pulling the weeds out of the ground (30–50%). When you increase the speed, larger weeds can be buried. However, this comes with the possible risk of harming the crop. To use the tined weeder to its full potential, you must select the right setting and the right time to use it.

Since the main goal in weeding is not to pull out, but to bury; exposing small weeds is essential. This is why the early weed filament to cotyledon stage should be targeted. For example, black grass, windthale and white goosefoot can be effectively controlled up to the cotyledon stage. Once the weeds have outgrown this stage and have grown one or two pairs of leaves, the burying effect of the weeder decreases significantly, and the tine aggressiveness must be readjusted.

When weeding, 50-70% of weeds are buried, and 30-50% are pulled out.

If the weeds are deeply rooted or are larger than the main crop, the tined weeder will not be able to remove them.

10.2 Row independent weed control = weeding technology

In weeding technology, a fundamental distinction is made between direct and indirect spring-loaded systems. The direct spring-loaded weeder tine with the spring winding is mounted on the frame. In contrast, each tine of the indirect spring-loaded tine weeder is individually connected to the rigid frame via a spring. For indirect suspension, tine aggressiveness is not set by adjusting the tilt angle, but by changing the spring pretension. This can be done from the tractor hydraulically and is infinitely variable. With the spring-loaded tine weeders, the tine aggressiveness is infinitely variable by adjusting the angle from the tractor. The rotative weeder is a special type of indirect spring-loaded tine weeder.

An overview of the Einböck weeding technology

Tined weeder			Rotative weeder
Tined weeder	Precision tined weeder	Premium tined weeder	Rotative weeder
Direct spring-loaded tines		Indirect spring-loaded tines	Indirect spring-loaded rotative stars
AEROSTAR-CLASSIC	**AEROSTAR-EXACT**	**AEROSTAR-FUSION**	**AEROSTAR-ROTATION**
The all-rounder	The arable farming expert	The total pro	The specialist
			
» 2.5 cm (1") line spacing, direct spring-loaded » For cereals, soy, maize, grassland... → Mixed farms » "Simple", economical, efficient, often "sufficient", etc.	» 2.5 cm (1") line spacing, direct spring-loaded » For cereals, soy, maize, beet, beans, special crops, etc. » Blind weeding » Quick and easy adjustment, precise, aggressive, etc.	» 2.8 cm (1.10") line spacing, indirect spring-loaded » For arable and special crops, hillcrops, vegetables, herbs, etc. » Up to 6 kg contact pressure/ tine » Customisable, quickly adjustable, precise, aggressive, accurate, etc.	» Inclined rotative stars with 6.5 mm (0.26") tines » Line spacing 15 cm (5.90") » For cereals, soy, maize, special crops, etc. » Weeding organic matter → No clogging → Suitable for mulch sowing » Early weeding on moist soil

A tined weeder only works on the surface and does not loosen soil deep down. It therefore needs to be used cautiously, using common sense.

10.3 Direct vs. indirect spring-loaded tines

Direct spring-loaded tines

- Weeder tines are mounted directly on the frame
- A spring coil on the tine "takes over" tine suspension
- Tine aggressiveness is set by adjusting the angle - this is infinitely variable and hydraulically adjustable from the tractor
- Able to be easily adapted to changing soil conditions thanks to hydraulically connected tine sections

The advantages of direct spring-loaded tines

- Shaking/swivelling of the tines (lateral movements) = crop-friendly cultivation in the row, e.g. for cereals
- Broad spectrum of tine pressure possible - enables gentle blind weeding and aggressive crust breaking
- Vibration promotes tine self-cleaning - which means weeding is even possible in fields containing organic matter
- Weeds are uprooted from soil and dirt - rapid drying prevents regrowth
- State-of-the-art tine guidance system - ensures full-surface weed control

Indirect spring-loaded tines

- Tines are freely suspended in the direction of travel on a rigid frame
- Each tine is connected to the frame through its own tension/compression spring
- Tine aggressiveness is set by adjusting the spring load - this is infinitely variable and hydraulically adjustable from the tractor
- Equal tine pressure across tines (regardless of position) even at different tine positions
- Adapts perfectly to the soil surface, e.g. potato ridges are also suitable for tined weeding

The advantages of indirect spring-loaded tines

- Superior accuracy - zero tine rotation
- Precise operation during gentle weeding
- Simpler and more precise weeding of hills & bedding crops

For both tine weeders (direct & indirect spring-loaded), set the tine angle using the feeler wheels.

10.4 Tined weeder setting

Basic configuration and useful facts about tine weeders

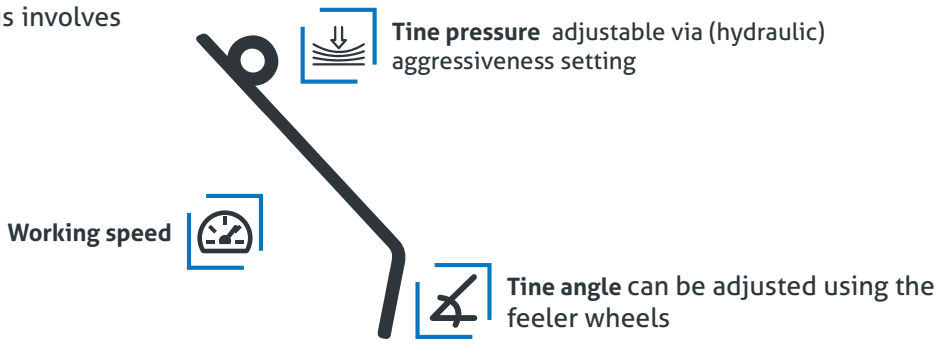
As a general rule: The working depth and therefore also the tine pressure should be adjusted to the seed depth and the seedling size to ensure it is not damaged. Optimum weeding can only be achieved with correct, constant tine pressure. This should preferably be set and "equalised" using the hydraulic tine adjustment.

Selecting the correct tine setting requires time.

Only adjust tine aggressiveness when tines are lowered. This ensures any adjustments are carried out evenly across all tine sections due to the counter pressure from the ground.

The tined weeder should be set on a level area of the field that is representative of the terrain, rather than the headland.

The tined weeder takes effective action against weeds. This involves 3 fundamental elements:



Calculation of "tine aggressiveness":
Tine pressure + working speed + pressure angle = aggressiveness

Tine angle

The more delicate the tine adjustment, the better the result. Tines can be set to aggressively "tipped forward" for effective weed control, then reset to "dragging" for gentle applications. To achieve the best results, we recommend setting the tines to a gentle "grip", preferably at a low to medium tine pressure. This ensures soil is well aerated and protects the crop from any potential harm. The best results are achieved when the tines are set to a medium "grip". They will then effectively remove weeds, uproot weed roots and "dance" around the rows of plants.

When you adjust the tine position (tine aggressiveness) significantly, make sure you also adjust the feeler wheels.

Feeler wheels

The front and rear feeler wheels must be adjusted to ensure the weeder is level with the ground. The front row of tines should be set to the same working depth as the rear row. This ensures precise depth control. This is extremely important, particularly when blind weeding as you want to avoid damaging delicate seedlings. The rear feeler wheels also ensure precise depth control, as the tines at the front and rear are guided to a precise depth on uneven ground.

If the weeder has a chassis or wheels at the rear, it must be driven using the upper link in the slotted hole.

Working speed

Working speed has a big influence on intensity – adjust this based on the conditions, crop and weed pressure. The faster you travel with the tined weeder, the greater its performance power and success in controlling weeds. Be mindful that travelling at higher speeds poses a greater risk to the crop. It is important to find the right balance here. Depending on the conditions, the working speed may vary from 1.5 km/h (very small plants) up to 10 km/h (e.g. last pass for grain).

- **Tines "tipped forward":** Limited crop burial. Effective weed control. Speed max. 6-8 km/h
- **Tines dragging:** Plants may be forced to the ground - higher risk of burial. Speed max. 10 km/h
- **Tines at 90°:** Weeds are covered. Select a faster working speed. Only use this setting once the crop has grown.

When working, the weeder should be adjusted using the upper link so that the frame and the tine sections are positioned horizontal to the ground.

- The faster you travel with the 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 may vary between 1.5 km/h (young crops) and 12 km/h depending on the conditions.

5 km/h*

9 km/h*

Take your foot off the pedal

Reduce your working speed to minimise crop damage, particularly in the early crop development stages or when working around delicate crops (such as beet, maize, small sunflowers, etc.).

Half a kilometre per hour faster or slower can be the difference between success and failure!

*Source: Images Naturland.de, Becherer & Hänsel 2004

Tine position during weeding

"Tipped forward"

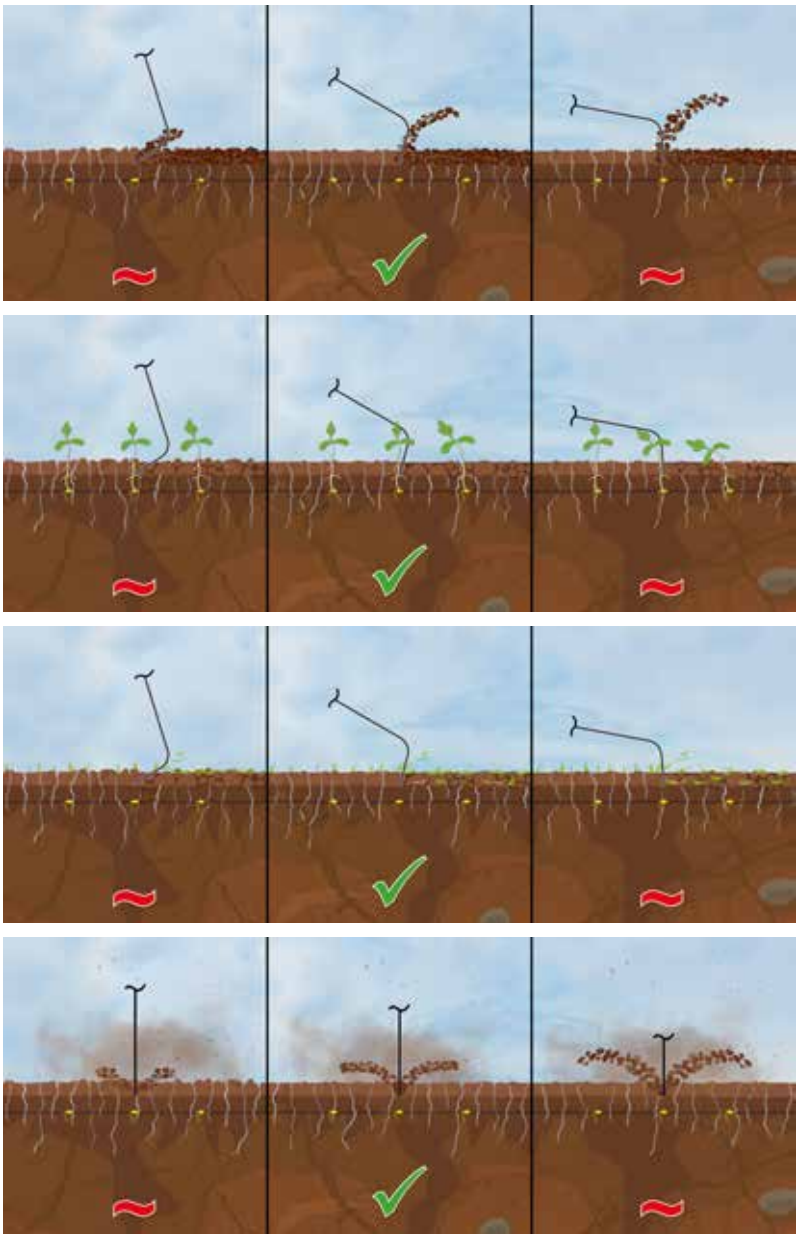
» Good soil adaptation
» Good earth movement
» Perfect aggressiveness
» Efficient earth turning action
» Limited crop burial

Excessive "tipping forward"

» Limited soil adaptation
» Insufficient earth movement
» Too aggressive at times

Insufficient "tipping forward"

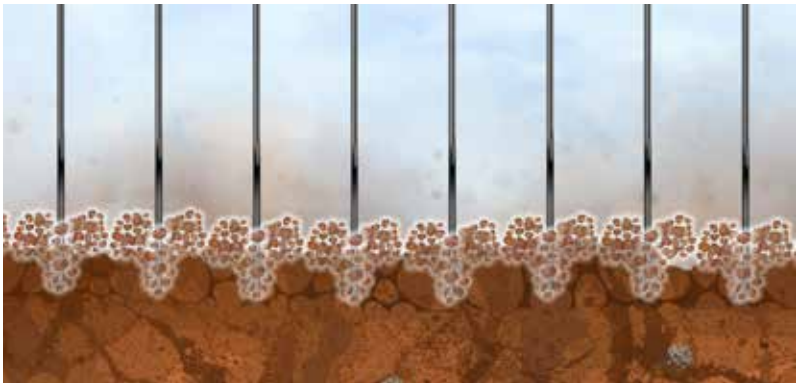
» Too much earth movement
» Plants are forced down
» Weeds are forced down
» Not aggressive enough
» Danger of burying the crop



Try out a range of different configurations to find the right tine position, aggressiveness and speed.

Line spacing when weeding

Line spacing of less than 2.8 cm (1.1") is essential to be able to successfully weed the entire soil surface When using a wider line spacing, insufficient weeds are buried and ripped out.



The perfect soil on the day

» **Loose soil**
Ideally, soil should be as dry as possible, able to withstand loads, of excellent tilth and crumbly (BEWARE: you do not want it too coarse). Note: for clay and silty soils, the pH level of the topsoil must be correct, otherwise crusting may occur.

» **Soil moisture**
Take care that the soil is not soggy as this will make the desired weeding result impossible (soil tends to become crusted). 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 soggy).

» **Weather conditions**
The day you weed the field and the 2-3 days after need to be frost-free and dry. Mechanical weed control can sometimes damage crops slightly. Temperatures that are above freezing will help these plants to heal quickly.

» **The right time**
The perfect moment is during sunny, windy weather, around midday. This will help weed seedlings to dry out in the sun, killing them. Aggressive driving will also be possible under these conditions, as the crop cell pressure will decrease, making it elastic.

When the soil is heavily frozen in spring, it is advisable to roll first, then weed once the plants are standing.

Place a glass plate to identify the ideal weeding date. Warmth will make it easier to see the first weed cotyledons, letting you know it's time to get the tined weeder out!

Constant control achieved by a farmer ready to get out of the cab

When working with a tined weeder or hoe, conditions can vary greatly. It is therefore essential that the farmer leaves the tractor cab regularly to continually adjust the machine settings.

10.5 Weeding out in the field

Blind weeding

Blind weeding is one of the most important weeding passes, and is carried out between seed sowing and crop emergence. Deeper seed placement ensures that the seedlings are not damaged. Notably, the best success with weed control is achieved in the tube stage at up to 80%. As well as helping to control weeds, blind weeding also breaks open the soil crust, enabling a better crop emergence.

Blind weeding in spring is very beneficial to crops, as weeds are controlled at an early (filamentous) stage. This is perfect for summer crops such as oats, beans like field beans and soy beans, maize, pumpkin, sunflowers, potatoes, peas, etc.

Blind weeding is carried out between seed sowing and crop emergence.

When to carry out blind weeding:

» Shortly before the crop "breaks through", e.g. the tips in cereals

Carry out blind weeding as late as your main crop allows.

The correct way to carry out blind weeding:

» Tined weeders "drag" at approx. 90° to the soil surface
» Tine pressure should enable a suitable working depth (e.g. 2-3 cm / 0.80-1.2"). The exact sowing depth and shoot length determines the maximum depth to which the weeder should penetrate the soil
» Operating speed approx. 5-10 km/h

If a seed lies at 6 cm (2.40") deep and the seedling is 2 cm (0.80") tall, the weeder must be set to a maximum depth of 3 cm (1.20").

The perfect soil for blind weeding

- **Summer cereals:** approx. 2-5 days after sowing; go for a slightly deeper seed placement
- **Maize:** approx. 3-7 days after sowing; seed placement 6-7 cm (2.40-2.80");
- **Soy:** approx. 3-5 days after sowing; seed placement 3-5 cm (1.20-2");
- **Field bean:** approx. 6-10 days after sowing ; aggressive weeding possible if the seed is placed deeply.
- **Sugar beet:** approx. 2-3 days after sowing; be precise with the working depth Blind weeding only possible to a limited extent.
- **Pumpkin:** Blind weeding approx. 2-6 days after sowing; not too deep, as the pumpkin is laid flat
- **Potato:** Blind weeding approx. 2-5 days after sowing; "stripping" of hills - the bottom of the hill does not have to be worked.

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

The blind weeding pass is one of the most important weeding passes!

Blind weeding: The TOP 10

1. Be aware of seed placement & working depth and adapt the process to the crop
2. Plan a blind weeding pass as early as the sowing stage
3. Check results (not on headlands). Do not touch/disturb seedlings under any circumstances
4. Adjust the angle of the tines to the soil and its current tilth
5. Select your driving speed according to the crop, sowing depth, soil type, tilth, etc.
6. Working depth for blind weeding: max. 3 cm (1.20") (depending on seed depth and crop)
7. Use a weeding diary + photos to record and learn from past experiences (also note tine position, driving speed, working depth, etc.). Farmers should record their own practical experiences to get the best results for the specific conditions on their farm.

Weeding after crop emergence

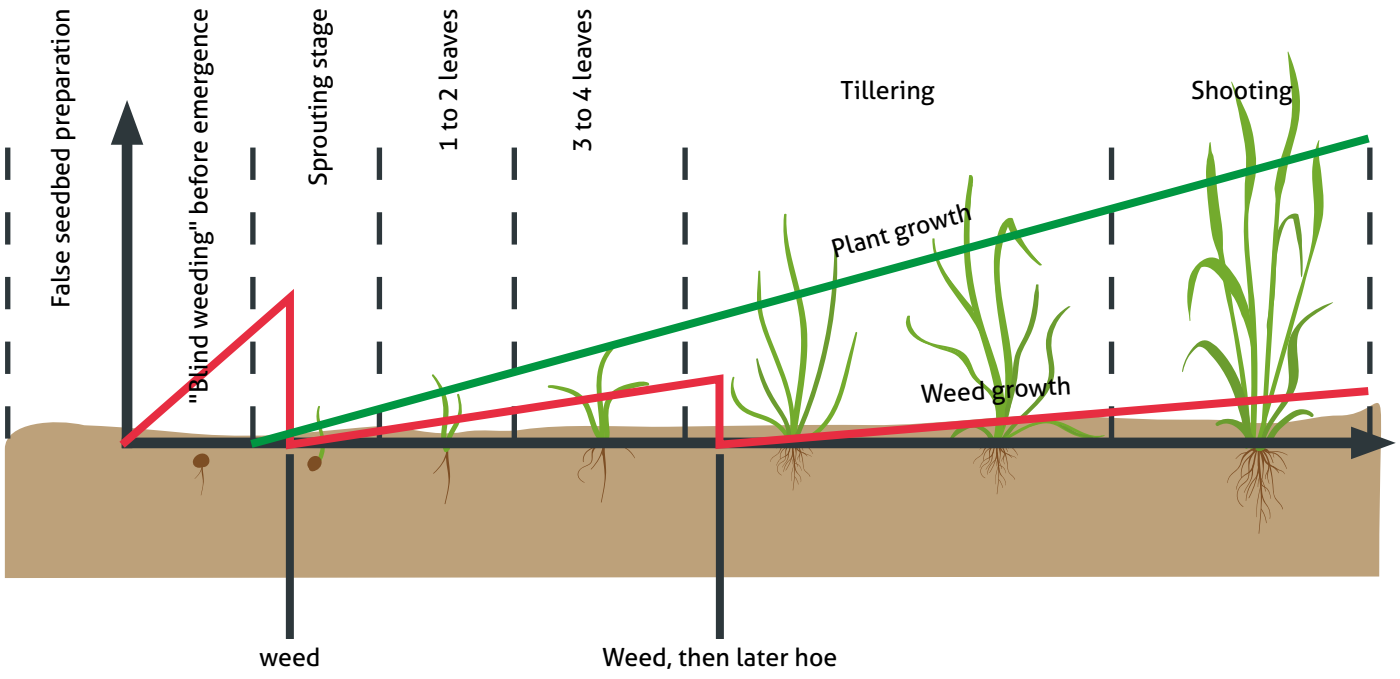
In principle, weed structure and soil structure (e.g. incrustations) determine when to weed cereals, grain legumes, maize and potatoes. Once the crop has emerged, the ground should be weeded to bury the weeds in the soil as long as possible, i.e. when the weeds are no further on than the cotyledon stage (tube stage).

Avoid weeding during the crop's delicate growth stages, e.g. cereals in the 2-leaf stage).

Adjustment during weeding after emergence

It is important you do not set the tined weeder to be too aggressive. Most crops are still sensitive to being buried at this stage, so the soil should be disturbed as little as possible.

- **Set tines to "tip forward":** less soil will be disturbed and weeds will be uprooted more easily
- **Delicate crops:** to avoid burial of crops, the tine end must be set at an angle of 30°-40° to the soil surface. Low tine pressure will prevent deep soil penetration.
- **Robust crops:** Select a tine angle of 50° - 70° for robust crops. This will move more soil. A stronger tine pressure can also be used to penetrate deeper into the soil (e.g. for soy)



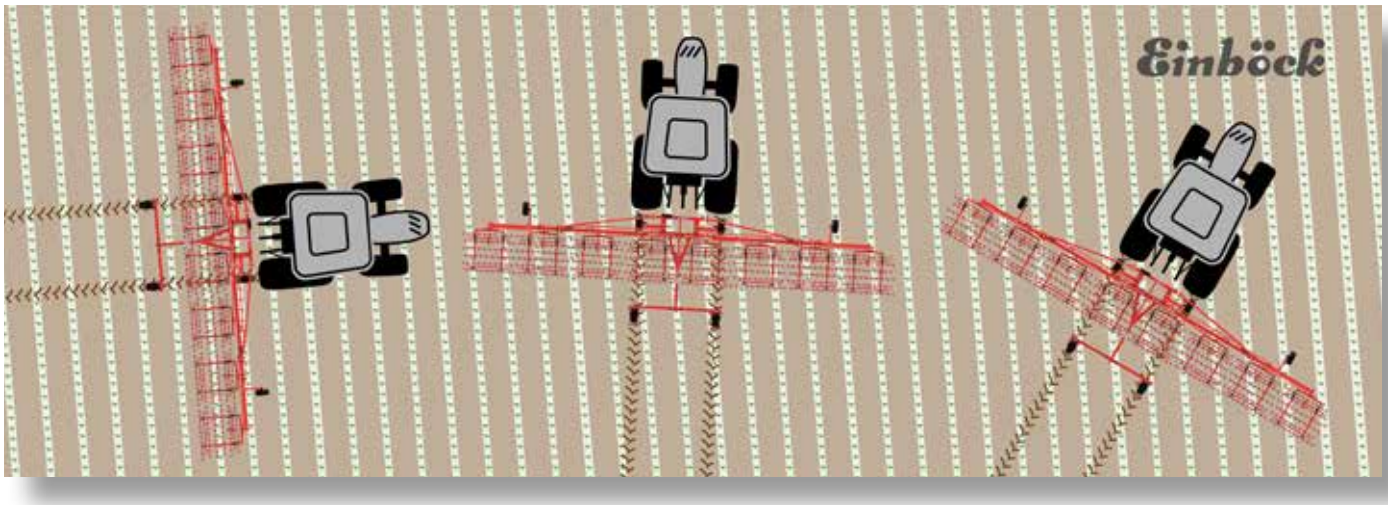
Adjustment when the weed is beyond the cotyledon stage

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. They also tend to survive being buried. In this case, one or more additional hoe passes with the row-crop cultivator can often be helpful.

Crosswise/angled weeding?

Certain crops (such as soy, maize, cereals, etc.) can be weeded crosswise/at an angle to the sowing direction on the first weeding pass, while the crop is still small. Note: only shortly after field emergence, and not when the crop has grown larger.

Crosswise and angled weeding enhances weed removal in the row.



10.6 Weeding at different growth stages

Cereals	Blind weeding	Rise	1 leaf	2 leaves	3 leaves	Tillering
Spelt	–	–	–	○	✓	●
Wheat	–	–	–	○	✓	●
Rye	○	–	–	–	○	●
Triticale	–	–	–	○	✓	●
Oats	○	–	–	○	○	✓
Barley	○	–	–	–	○	✓
Additional crops	**Blind weeding**	**Rise**	**5 cm (2.00")**	**10 cm (3.90")**	**20 cm (7.90")**	**40 cm (15.70")**
Field beans	✓	○	○	✓	✓	✓
Peas	✓	–	○	✓	–	–
Millet	–	–	–	–	○	–
Potatoes	●	–	–	○	✓	–
Pumpkin	✓	–	✓	✓	–	–
Flax	–	–	○	○	✓	○
Lentils	○	–	–	○	–	–
Lupins	–	–	–	○	○	○
Maize	✓	–	–	○	○	○
Soy beans	○	–	○	✓	✓	–
Sunflowers	○	–	–	○	○	–
Oilseed rape	–	–	–	–	○	–
Beets	✓	○	✓	✓	–	–
Safflower	○	–	○	○	✓	–
Vetches	○	–	○	○	–	–

- = do not weed
○ = weed with care
✓ = normal weeding
● = aggressive weeding possible

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

10.7 Weeding with the rotative weeder

The rotative weeder combines the advantages of a tined weeder and a rotary hoe. Steel pins moulded into a sloping plastic disc with a special rubber compound do the work in this machinery. The individually suspended, rotating working tools uproot and turn weeds. These till crops and can easily break up hard soil crusting. The rotative weeder was designed first and foremost for challenging soil conditions. It is also possible to carry out precise blind weeding with this tool by adjusting the hydraulic pressure.

The rotative weeder can also be used to efficiently weed a lot of organic material.

The advantages of a rotative weeder

- The rotating tines free up soil crusts and encourage the exchange of gas.
- The rotative weeder is particularly beneficial when there is a lot of organic matter and for mulch sowing.
- This tool extends the window for weeding when used early in the season: The rotative weeder can be used when the soil is still slightly moist, whereas conventional tined weeders must wait for drier conditions.
- This makes it perfect for changing weather conditions; weeding can even take place when the soil is moist in spring, without smearing the soil.
- Aggressive crust breaking and gentle weeding can be carried out quickly by setting the working speed and hydraulic aggressiveness settings.
- This tool is self-cleaning thanks to its rotating tools. These roll instead of "sweep" during weeding.

Rotative weeder configuration

The key rotative weeder setting is for how aggressive it is.

Aggressiveness = driving speed x contact pressure

- **Aggressiveness**
  The faster you drive, the more aggressive the weeding.
  The higher the tine pressure, the more aggressive the weeding.
  Caution: The more aggressive the setting chosen, the slower the tractor must be driven to avoid causing damage!
- **Working speed**
  The maximum working speed is 10 km/h. If the weeder is set to a medium aggressiveness setting, the maximum speed will be 5 km/h.
- **Soil**
  Before you start, ensure that the ground is passable on and is of suitable tilth. The rotative weeder is most effective on firm soil. Avoid preparing the soil with a rotary hoe or row-crop cultivator, this will only shift loose soil without providing a decent weeding effect.

Correct and appropriate adjustment of the rotative weeder requires experience and "prior knowledge"!

Weeding takes patience and precision – quality is more important than acreage performance!

10.8 Weeding limits & challenges

Even if you are using the best weeding technology, there are limits to when it can be used, such as the size and number of weeds, organic matter, moisture, and excessive incrustations.

10.9 Summary

The correct and therefore best adjustment settings for a weeder depend on the soil and plant conditions, as well as the prevailing weather conditions. Finding the right settings for your 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.

The earlier the weeding, the better the result. If you can already see weeds present in the field, it is usually too late.

10.10 Weeding: The TOP 10

1. **Weeding starts after sowing**
   Blind weeding needs to start even before the first crop emerges.

2. **Weed in moderation:**
   Each weeding pass weakens the soil structure and encourages weed seeds to germinate – make sure you carefully evaluate whether each pass is truly necessary.

3. **Choosing the right sowing time**
   Sowing should be timed with a view to the blind weeding pass and the appropriate weather conditions.

4. **Getting the setting right counts**
   Adjust the working depth of the weeder according to the depth of the seed placement and the seedling size so that you don't damage the seeds (leave the cab to keep checking while you work).

5. **Adjust the working speed to the weed pressure**
   Working speed impacts aggressiveness significantly – adjust your speed according to the conditions, crop and weed pressure.

6. **Make sure the time is right**
   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. **Tines "tipped forward"**
   Set the tines tipped forward – this ensures optimum weed control and coverage (the tined section must be set parallel to the ground during travel).

8. **Weeding efficacy**
   Weeding efficacy and aggressiveness is determined by the speed, the angle tines are set and the tine pressure.

9. **Keep a weeding diary**
   Use a "weeding diary" to record operations (operation, speed, depth, setting, etc.). This will give you a good overview of which settings work for your farm and for each set of conditions present.

10. **Success comes through experience**
    Success depends on many different factors. Weeding requires a lot of experience and patience. Don't be discouraged - people aren't born experts!

11. ROTARY HOE BASICS

Rotary hoes break up incrustations 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 crusts, rotary hoes also control weeds in the same pass. The rotary hoe can even replace hoeing if carried out early enough. Generally though, it is an important addition as a shared machine to organic and Fusion Farming operations and contractors.

The rotary hoe works very simply:
The rotor stars break up incrustations with their rotor blades, ensuring soil aeration. They throw up soil with their spoon-shaped star tips and uproot weeds at the filament stage. They deposit the weeds on the soil surface where they then dry out.

The rotary hoe is perfect for breaking the soil crust and aerating soil. It also uproots and buries weeds.

11.1 Using the rotary hoe

Wide time windows and high working speed

The high working speed of the rotary hoe is one of its biggest advantages. It can work up to 20 km/h, resulting in a high hectare output. The wider time window than usual also makes the rotary hoe very popular and extremely practical in conventional agriculture. The tool's "spooning" method means that work can be carried out if the soil is moist and can be driven over, and this is earlier than when weeding or hoeing.

The hectare output of a rotary hoe is extremely high as it can operate at speeds of up to 20 km/h.

Earlier operation post rain

The rotary hoe produces a crumbly surface, meaning the weeder can be used 1-2 days later with extremely effective results. Ideally, the rotary hoe should be used as soon as possible after rain. The drier the soil, the less effective the tool and the less breaking up of crust is possible. Using the rotary hoe half a day earlier or later can make a big difference (e.g. morning vs. evening).

Plan in a rotary hoe pass before a weeding pass!

The rotary hoe can "pre-loosen" soil so that a subsequent rotative weeder pass can be more effective and aggressive.

11.2 Rotary hoe technology at a glance

Spoon-shaped star tips

The spoon-shaped, hardened, self-sharpening and low-wear star tips by Einböck break and crumble crusts. Star tips can be unscrewed when worn and replaced individually. Due to their shape, which curves backwards, they "shovel" particularly well and weeds are "dug out" better.

Specially designed rotor stars - Einböck in-house design

The individually suspended rotor stars are designed to be extremely durable and to ensure the best results. Each star must be mounted and sprung individually. This significantly increases their efficacy as the stars can then work independently of each other. The high-quality bearings withstand extreme conditions and guarantee a long working life for these tools. Each rotor star can be adjusted hydraulically up to a contact pressure of up to 35 kg, ensuring excellent results even in heavily encrusted soils and under the most difficult conditions.

Hydraulic pressure and level adjustment

The rotary hoe benefits from precise hydraulic pressure adjustments. A hydraulically adjustable parallelogram allows the pressure on the double-row rotor stars to be adjusted to the prevailing conditions during operation. This hydraulic system also enables level compensation, so that on uneven fields the working depth and working pressure are precisely maintained across the entire working width.

The rotary hoe must be set to a sufficient aggressiveness setting to work reliably even in challenging conditions.

11.3 Rotary hoe operation

11.4 Rotary hoe configuration

1. **Attach the appliance to the tractor in the horizontal position**
   The lower links must be positioned at the same height on both the left and right.
   The upper link must be set so that the two rows of rotors are parallel to the soil surface when in the working position.
2. **Depth adjustment with feeler wheels**
   The front and rear star tips should penetrate the ground to an equal depth. Important: maintain the same working depth.
   Adjust the support wheels to the conditions using the half-hole grid socket pins. The higher the wheels run, the more aggressive you can set the rotor stars using the hydraulic levelling system.
3. **Set the preloading of the rotary stars with the hydraulic level regulation**
   a. Rotor star preloading can be adjusted using the hydraulic level compensation system. A certain level of preloading is always necessary to maintain optimum adjustment when passing over ruts and hollows in the ground. To do this, retract the hydraulic cylinders of the levelling system.
   b. The hydraulic levelling system's locking block prevents unintentional pressure loss via the tractor hydraulics.

Do not adjust the machine on the headland. Settings should be set suitable for the working speed to be used during operation.

The rotary hoe can be used for all standard arable crops such as cereals, maize and (soy) beans.

11.5 Using the rotary hoe on various crops

Spelt; Wheat; Rye; Triticale; Oats; Barley
Field beans; peas; lupin; soy beans; sunflowers; maize; beetroot; pumpkin

For more information on the individual crops, see the respective "Crop guidance".

11.6 Rotary hoe: The TOP 5

1. The rotary hoe is used to break crusts
2. It is best to use the rotary hoe before weeding (ideally separately)
3. Parallel and hydraulically adjustable rotor stars ensure the best possible ground adoption
4. Operating speed starts at **approx. 12 km/h**
5. To work efficiently, rotary hoes need to be set with at least 30 kg of contact pressure and rotor stars must be mounted individually.

Use the tined weeder and rotary hoe separately. First, do a blind weeding pass with the tined weeder (or blind hoe with the rotary hoe). THEN use the rotary hoe later on and weed or hoe once more.

12. HOEING TECHNOLOGY BASICS

Hoeing constitutes another extremely successful weed control measure. Row-crop cultivators are predestined to act as weed control measures in row crops. Targeted hoeing passes keep weeds in check and give the crop a head start in growth.

Hoeing also breaks up incrustations, promoting soil aeration and as a result, root growth. Water absorption is also significantly improved, capillaries are broken, and soil water evaporation is reduced. Once soil has been worked, it warms up quicker and encourages spring crop development.

Hoeing has many advantages, such as breaking up incrustations.

Hoeing technology has come on a great deal, especially in recent years. Particularly for row crops, mechanical weed control is currently enjoying a resurgence due to the decreasing efficacy of herbicides and continuing development of weed resistance.

A wide variety of hoeing systems are now suitable for weed control thanks to their ongoing development. In addition to rear and front sweep hoes, there are rotative row-crop cultivators and plate row-crop cultivators, for example.

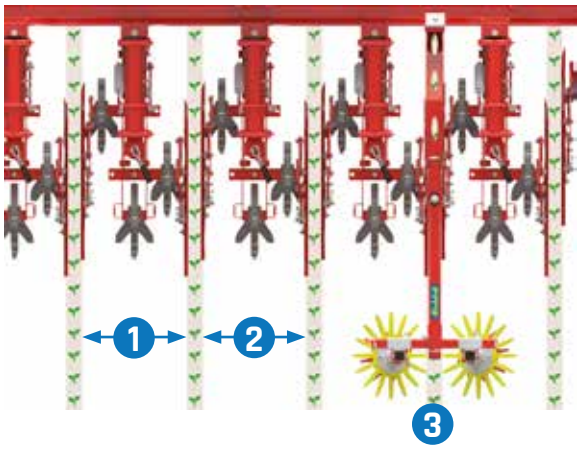
Over the past few years, a range of new options have been developed, such as SECTION-CONTROL, finger hoes, trailed rotative weeders, various sweeps and vibrosprings, ridging tools, crop protection elements, angle knives, cutting discs, etc.

In addition to the customary row spacings of 45/50 cm (17.70/19.70") in sugar beet and soy, and 70/75 cm (27.60/29.50") in maize and sunflowers, individual rows with a spacing of 25 cm (9.80") are now common in cereals, oilseed rape, field beans and peas. The correct row spacing for hoeing must therefore be considered at the sowing stage. Rows must be in parallel to be able to work as closely as possible to them. More information on this can be found in section on "Sowing".

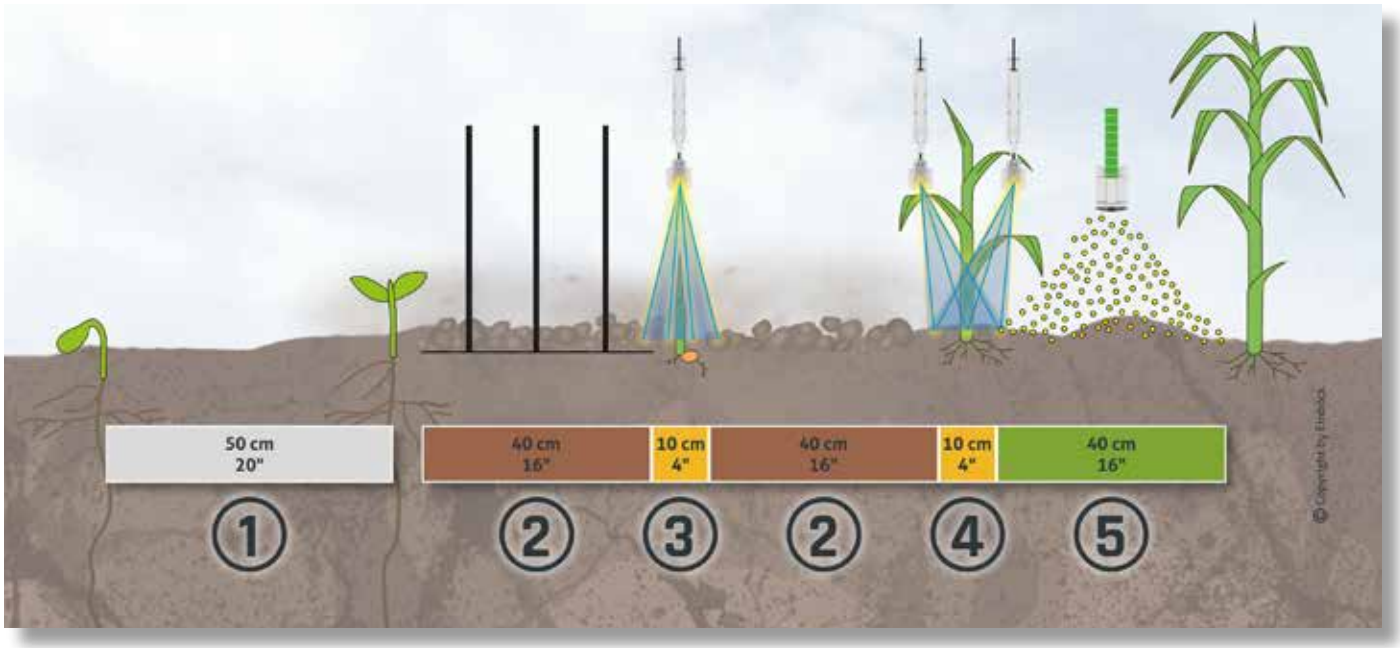
It is vital you purchase tailor-made tools for your farm, rather than ready-made solutions.

12.1 Hoeing basics

1. Row spacing
2. Hoed area = hoeing between the rows
3. Unhoed area = hoeing in the row



1. Unhoed area
2. Hoed area
3. Band spraying on leaves (not in organic farming)
4. Band spraying under leaves (not in organic farming)
5. Inter-row undersowing

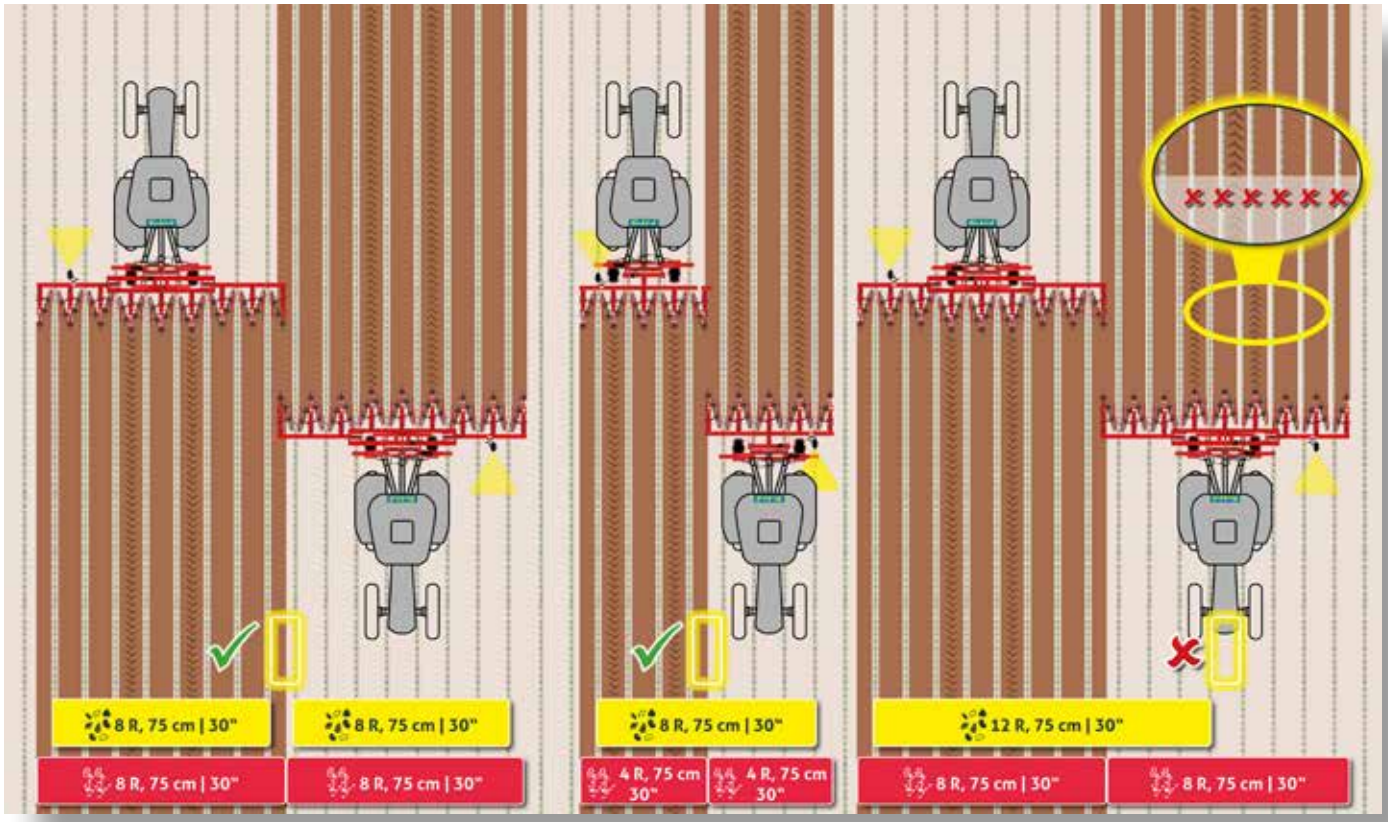


12.2 Hoeing configuration

The following points must be answered by working with a consultant or an expert to find the right row-crop cultivator for your farm:

Which crops need to be hoed?

How many rows have been sown?



Number of rows sown = number of rows hoed

Which row spacing has been used?
Examples for Austria/South Germany:

- Maize/sunflower 70/75 cm (27.60/29.50")
- Beetroot/soy 45/50 cm (17.70/19.70")
- Pumpkins 140 cm (55.10")
- Cereals 15/20/25/30 cm (5.90/7.90/9.80/11.80")

**Row spacing must be precise,
e.g. not 76-74-75-75-76-74-75 cm (29.90-29.10-29.50-29.50-29.90-29.10-29.50")**

Which tractor track is present/possible?
Why is the tractor track important?

Row width	Crop (examples)	Number of rows between the tracks	
		STRAIGHT	UNEVEN
25 cm (9.80")	Cereals	150 & 200 cm (59.10 & 78.70")	175 & 225 cm (68.90 & 88.60")
37,5 cm (14.80")	Field beans, soy	150 & 225 cm (59.10 & 88.60")	180 cm (70.90")
45 cm (17.70")	Beetroot, soy, field beans	180 cm (70.90")	225 cm (88.60")
50 cm (19.70)	Beetroot, soy, field beans, maize	200 cm (78.70")	150 cm (59.10")
70 cm (27.90")	Maize	150 cm (59.10")	210 cm (82.70")
75 cm (29.50)"	Maize, potatoes, sunflowers	150 cm (59.10")	225 cm (88.60")

Number of rows outside the track = **STRAIGHT (e.g. 8 rows)**	**SYMMETRICAL**
Number of rows outside the track = **UNEVEN (e.g. 5 rows)**	**ASYMMETRICAL**

What are the farm's methods and objectives?

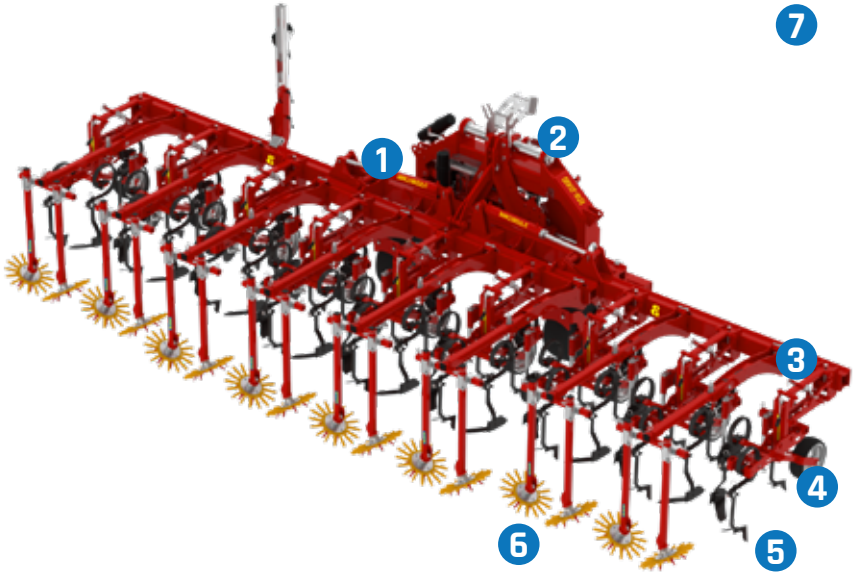
- Hectare output (hectares/season)
- Device steering (front or rear, camera, GPS, etc.)
- Farming methods (fusion farming, crop rotation, no-till, etc.)
- Objectives (crust breaking, weed control, etc.)
- Tools: Section-Control, pneumatic seeding box, band spraying

The perfect solution for every farm = customised and adapted to each farm's respective requirements.

13. DESIGN OF A ROW-CROP CULTIVATOR

Design of a row-crop cultivator

1. Main frame
2. Steering system
3. Parallelogram
4. Hoeing element
5. Hoeing tools
6. Trailed working tools
7. Additional tools (sowing/fertilising technology, SECTION-CONTROL, etc.)



13.1 Main frame

The basic element of every hoe is a stable main frame, to which the hoeing element parallelograms are attached. This can be fixed or hydraulically foldable. A special profile tube frame allows quick and simple assembly of hoeing elements/parallelograms. Thanks to the unique shape of the frame, there are no signs of wear and tear on the frame even after many seasons of use. Different row spacings can also be set quickly and infinitely.

As a rule, a hoe frame is not a "normal moulded tube" : this would not be able to withstand the hoeing strain for long.

13.2 Steering system

Possible steering of hoes:
1. No steered
2. Via the tractor - for front-mounted tools
3. Via upper link steering - for rear-mounted tools
4. Via hydraulic/mechanical steering wheels on rear-mounted tools
5. Via automatic camera steering system
6. Via GPS, ultrasound, etc.

Automatic camera steering systems have become established in recent years.

Front hoeing

Rear hoeing with upper link steering

Rear hoeing with camera steering

Rear hoeing with camera steering and longitudinal drive unit

Rotative row-crop cultivator with rear upper link steering

Rear hoeing with camera steering and double folding frame

ROW-GUARD camera steering system

The ROW-GUARD camera steering system steers the hoe with absolute precision along the crop rows via a sideshift frame. This guarantees precise and detailed hoe operation even at high speeds and aids the driver. In organic and conventional cultivation, the ROW-GUARD camera steering system offers increased precision even to very small plants (from approx. 2 cm / 0.80") as well as for different colours and heavily weed pressure.

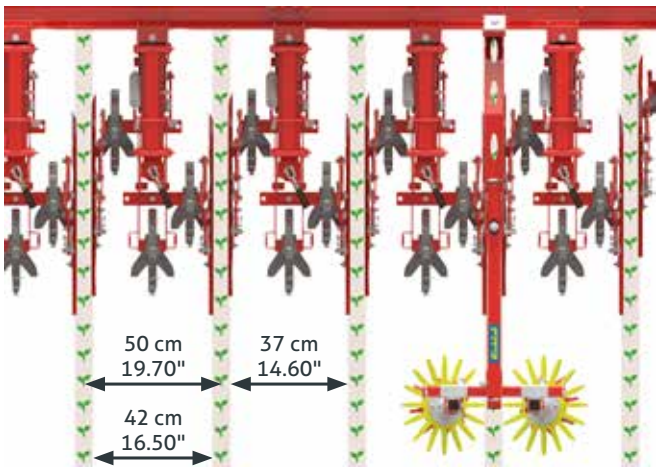
The automatic camera steering can be conveniently set from the tractor via an operating terminal. Using the different setting parameters, farmers can set a suitable grid over an image which is adapted to each crop (row spacing, number of rows in the camera's field of view, plant width and height). Based on this data, the hoe can then be centred exactly along the row with the help of the sideshift frame. This ensures a narrow hoeing belt guaranteeing maximum weed control.

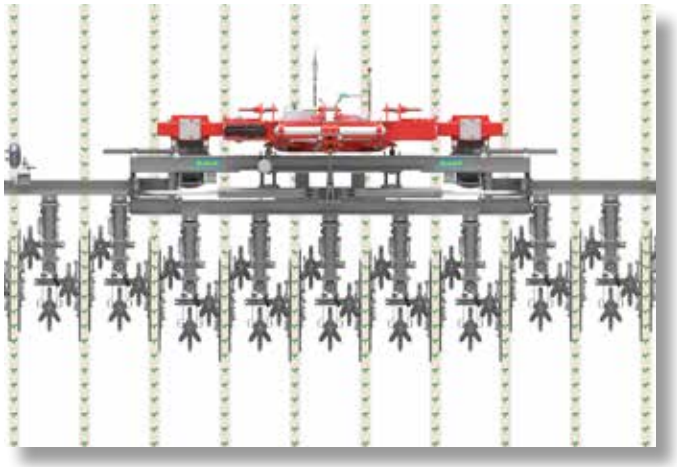
Efficacy & labour saving

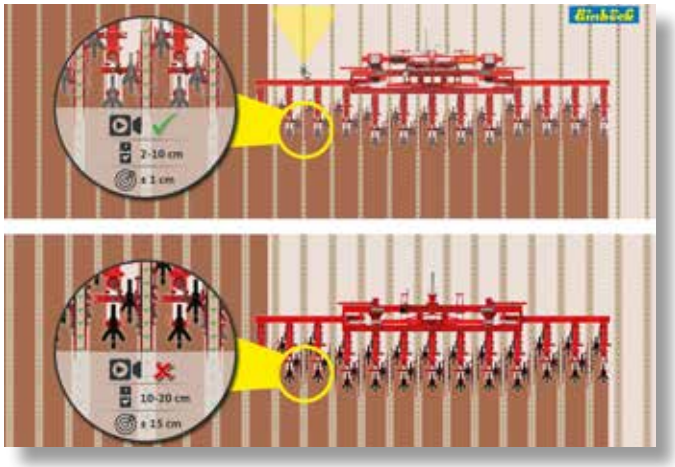
Practical example 50 cm (19.70") row spacing:

» **WITHOUT ROW-GUARD:**
Hoed area: 37 cm (14.60") - 13 cm (5.10") unhoed belt
= < 74% hoed

» **WITH ROW-GUARD:**
Hoed area: 42 cm (16.50") - 8 cm (3.10") unhoed belt
=> 84% hoed







The narrow design of the linear sideshift frame ensures that the centre of gravity remains as close as possible to the tractor, thereby only slightly increasing the rear axle load.

13.3 Parallelogram

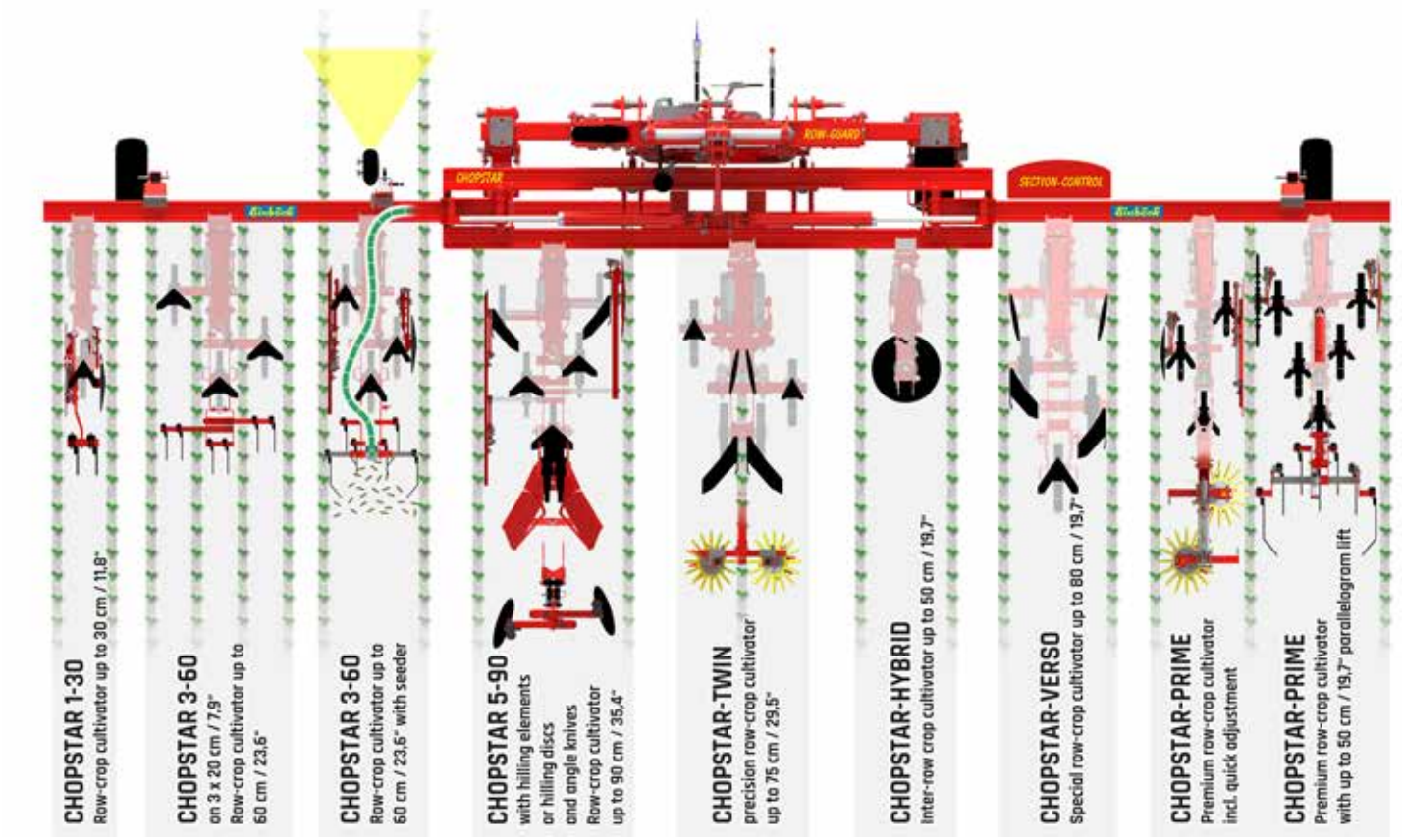
Important parallelogram features for a row-crop cultivator:

- Elongated for optimum ground adaptation
- Wide mounting for perfect grip
- Reinforced down pressure (preferably adjustable) on all parallelograms to ensure the sweeps into the ground even on hard soil
- Infinitely adjustable (via spindle) support wheels
- Dial for uniform working depth adjustment

A parallelogram must be able to compensate for uneven ground, offer good grip and operate precisely without moving sideways - even after years of use!

13.4 Hoeing element

A range of hoeing tools mean that you will always have the right tool for every crop, soil and condition you might come across.



New hoeing systems

CHOPSTAR-TWIN: The hoeing parallelogram does not work between the rows but is mounted directly above the row. Angle-adjustable cutting discs work in combination with the following angle knives allowing the hoeing width to be set precisely. This produces a very narrow unhoed belt, which can be entirely worked with finger weeders or rotative weeders.

The narrowest and most precise unhoed band is achieved when using a hoeing parallelogram above the row.

CHOPSTAR-VERSO: Similar to the CHOPSTAR-TWIN, the VERSO hoeing tool works away from the row, but this time, more traditionally it works between the rows. The cutting discs' angle can be adjusted to clear the plants out of the way, and when used in combination with following angle knives they produce a very narrow unhoed band. This enables young crops to be hoed very early, while ensuring narrow and precise weeding.

The latest technology facilitates use on very young crops and in close proximity to plants.

CHOPSTAR-TWIN

CHOPSTAR-PRIME

CHOPSTAR 1-30

CHOPSTAR 3-60

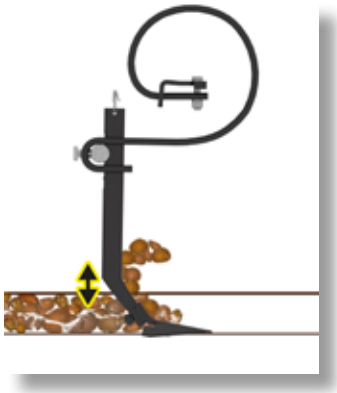
CHOPSTAR 5-90

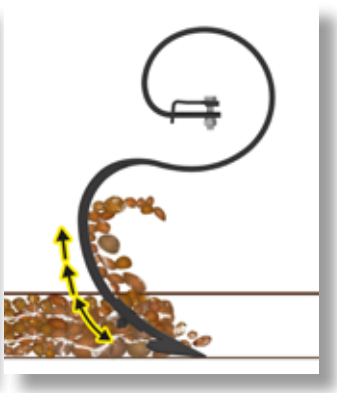
CHOPSTAR-VERSO

HILLSTAR

ROLLSTAR

13.5 Hoeing tools





Vibro-tine 32x12 mm (1.26x0.47") (image 1)

Advantages of vibro-tines over conventional S-tines

- Flatter adjustment and more precise (independent) depth control
- Improved crumbling due to vibration - weeds are cleared more efficiently
- Improved soil penetration in hard soil conditions - "chisel effect"
- Less earthmoving due to shallow working

Special Vibro-tine 40x12 mm (1.57x0.47") (image 4):

Einböck's special vibro-tines ensure reliable penetration, high stability and consistent precision, especially when working crusted and hard soils or stony areas. A range of widths of duckfoot sweeps can be mounted on the 40 x 12 mm (1.57x0.47") vibro-tines to deal with different row spacing, crop and soil conditions. Grids are also cutted into all holders for easier depth adjustment. The extremely wear-resistant duckfoot sweeps can be easily screwed in from the back. This results in a secure and rigid hold, while ensuring they can be replaced quickly and easily.

The Special Vibro-tine is Einböck's best-selling tine and comes highly recommended.

Einböck's special ultra-flat sweeps (image 3):

The Einböck special ultra-flat sweep produces a precise and clean cut at the minimum working depth. The extra-flat duckfoot sweeps ensure a safe cutting action, saving as much valuable capillary water as possible. The horizontal position of the sweep allows you to work at higher speeds without throwing up soil. This makes it ideal for narrow row spacings (up to 30 cm / 11.80") in particular, as the crop is not buried.

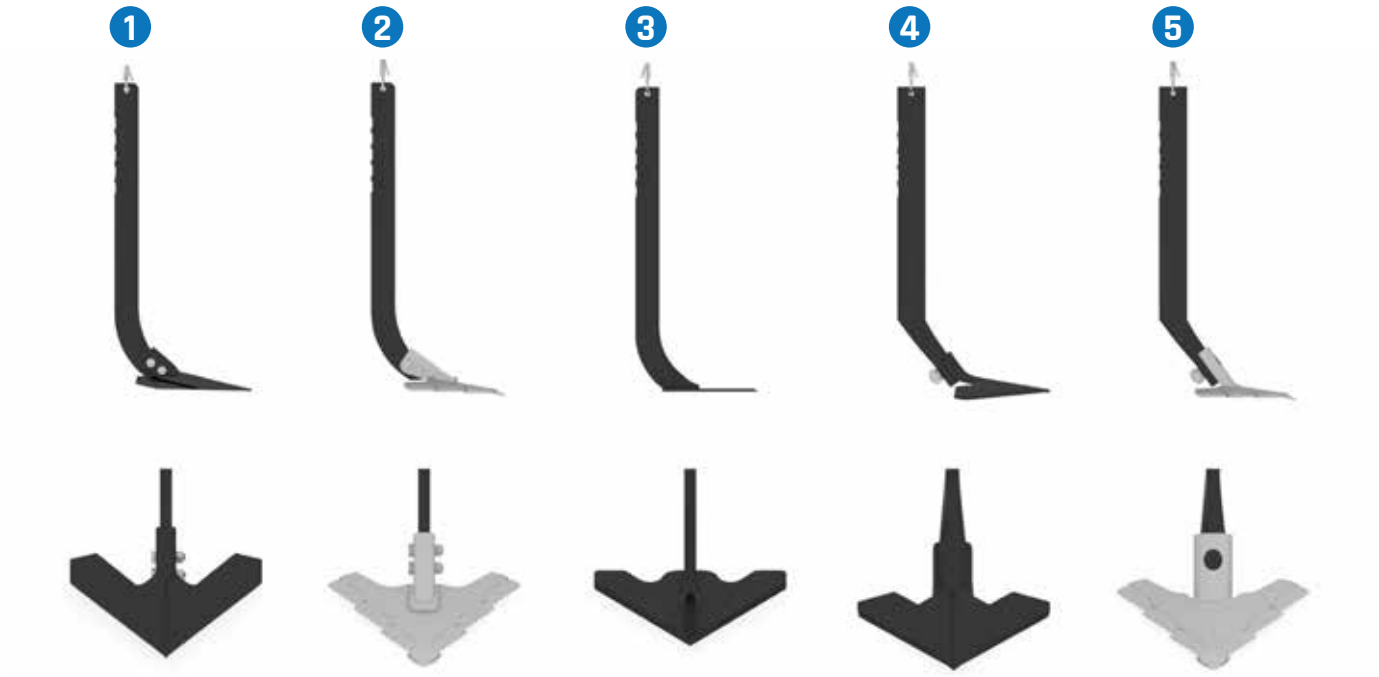
Recommended for use when hoeing cereals or small crops which may not be buried (e.g. beetroot).

Carbide metal sweeps (image 2+5)

Special base sweeps can be fitted with carbide tips or plates, then coated. These sweeps are 100 % compatible with all Einböck tines and holders. This process significantly increases the tools' service life, especially in soil conditions resulting in above-average wear. Sweeps retain their shape for longer, ensuring a precise cut with optimum soil tillage.

Carbide metal sweeps offer the following advantages:

» Service life is significantly increased - especially in soil conditions with above-average wear
» Time saving as a result of reduced changing of sweeps
» Sweeps retain their shape for longer, ensuring a precise cut with optimum soil tillage, even on dry ground
» Less traction is required due to sharp sweep tips. The sweeps are also self-sharpening thanks to the beaver tooth effect
» Especially recommended for contractors or large farms.



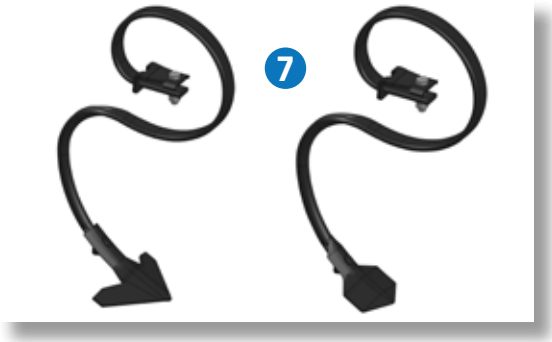
Angle knives (image 6)

These cut through the soil close to the plant row and guide the earth flow away from the row. Weeds are therefore cut as close as possible to the row, but the risk of burying is minimised. The unhoed band can be cleared by trailing tools such as finger weeders or rotative weeders.

Angle knives allow you to hoe closer to the crop row.

S-tines (image 7)

S-tines are extremely economical and are well suited to work deeper (e.g. hilling on the last pass).



13.6 Trailed working tools

A range of trailed tools such as finger weeders, rotative weeders, following weeder tines and raking tools carry out additional tasks, in addition to hoeing tools.

Trailed working tools perform tasks such as hilling, burying, tearing out and incorporating.

Finger weeders

Finger weeders are made up of two rotating rubber stars that work as close as possible to plants or even within the plant row. They can be used on almost any crop. Finger weeders work in the unhoed area to break it up. The weeds here are still in the juvenile stage and are buried or pulled out and dried on the soil surface. Precise adjustment of these weeders is crucial for success and to avoid damaging the main crop.

Trailed rotative weeder

Similar to finger weeders, the trailed rotative weeder processes a row's unhoed band. The rotating stars "comb" weeds out of the row. The trailed-rotative weeder is used in mulch-till and fields with organic matter, because it works without clogging. The trailed rotative weeder carries certain advantages over finger weeders when used on slopes, as it does not have to work directly above the row due to its inclined position, while still producing an effect right next to it. The holder on which the rotative weed element is mounted is the same as that of the finger weeder. Both tools can therefore be exchanged easily.

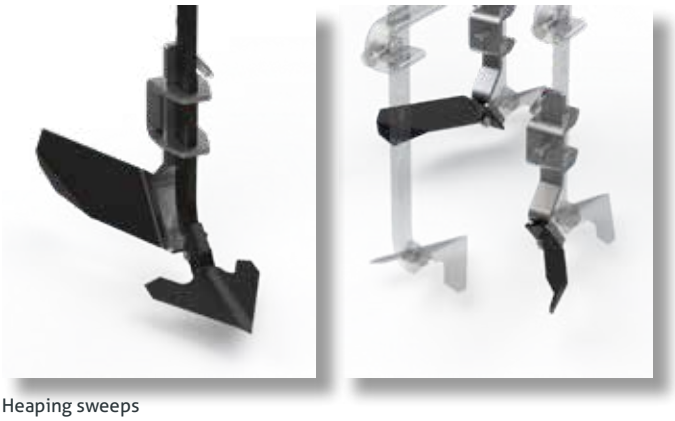
A trailed rotative weeder can operate more aggressively than a finger weeder.

Finger weeders vs. rotative weeders

Finger weeder	Rotative weeder
» Universally simple to use & adjustable » For beginners » Buries & tears out » Breaks up soil in the row » Simpler option	» Experience of adjustment required » For specialists » Can be set to be aggressive » "Sweeping" earth out of the row
	

13.7 Additional tools

1. Hydraulic parallelogram lifting SECTION CONTROL
2. Pneumatic front tank JUMBO-STREAM for spreading liquids such as e.g: band spraying
3. Pneumatic front tank JUMBO-SEED for precise distribution of fertiliser and seeds such as cereals, soy beans, catch crops, undersown crops, etc.
4. Pneumatic seeding box P-BOX-STI with electric adjustment of the seeding rate
5. Heaping tools (heaping sweeps, discs, elements)



Heaping sweeps

Automatic parallelogram lifting SECTION-CONTROL

SECTION-CONTROL lifts hoeing parallelograms using hydraulics to prevent crossing rows from being hoed out of the headland. The parallelogram can be raised to a lifting height of up to 50 cm (19.70") (e.g. with the special CHOPSTAR-PRIME hoe). The exact height depends on the machine configuration and soil conditions. SECTION-CONTROL can be controlled from the tractor cab by GPS or pressure buttons. With the hydraulic parallelogram lifting system, hoeing can even be carried out on uneven areas at the headland without the risk of crop loss. This precise machinery results in up to 20% more plant stock. This is especially recommended for contractors or farms with a high level of uneven areas. Hydraulic lifting is also available for finger weeders.

SECTION CONTROL is particularly well-suited to large working widths, small fields, steep headlands and uneven surfaces.

13.8 Hoeing out in the field

- **Sowing:** As a general rule: Number of rows sown = number of rows hoed. Your row-crop cultivator must always be perfectly attuned to 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).
- **Row spacing:** 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.
- **Headland:** The headland is hoed initially, and if necessary, once more at the end. This is because hoed-out weeds can become pressed down by the tractor tyres.
- **Timing:** Start as early as possible - if weeds are already clearly visible, it is already too late
- **Frequency:** Avoid too frequent hoeing as this causes more weeds to germinate, damages the crop and "disturbs" the soil structure. Better to hoe at the right time (too early), than twice at the wrong time (too late).
- **Time of day:** Midday is the right time for hoeing. There should ideally be no rain forecast after you have hoed.
- **Close working for high weed control:** Work as close as possible to the crop row (= narrow unhoed band) as this will ensure successful weed control.

Hoe as early as possible - the later you hoe, the more the weeds will compete with your crops for water, light and nutrients.

13.9 Row-crop cultivator configuration

Setting up your row-crop cultivator correctly is critical for a successful hoeing pass and therefore for your harvest. Allow yourself enough time to set up your hoeing technology correctly and professionally.

Adjustments when mounting a row-crop cultivator on a tractor

- **Lower links:** Height levelling of the lower links is optional for you to achieve better ground adaptation (for upper link steering and camera steering). The lower link struts must be the same length.
- **Row-crop cultivator without camera steering system:** When mounting a row-crop cultivator with high-gauge wheel steering (without camera steering), the side lower link stabilisers must be opened so that they can move side to side. If not, the row-crop cultivator cannot follow the tractor properly and the tool will soon end up alongside the track.
- **Row-crop cultivator with camera steering system:** When mounting a row-crop cultivator without high-gauge wheel steering (with camera steering), the side lower link stabilisers must be closed so that they cannot move side to side. In addition, the ball in the lower link bracket must be rigidly mounted. Distances may help in this situation. If the sideshift frame is not mounted rigidly onto the tractor, it creates a lot of play. If this happens, 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 (i.e. it will oversteer). 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.
- **Upper link:** 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, the sweeps will not all work at the same working depth. This can lead to the machine not operating at full width. The hoeing sections should be set parallel to the ground (or sloping to the rear slightly).

(Pre-)adjust the row-crop cultivator in advance while on your farm and in peace and quiet. This will save you from unnecessary and stressful adjustment out in the field under the hot midday sun!

Working depth and tool adjustments

» **As deep as necessary- yet as shallow as possible:** The working depth should ensure that the sweeps cut through the entire surface of the soil - however, go no deeper. If cultivation is too deep, a lot of moist soil will be brought to the surface. Excessive earth movement increases the risk of erosion and water loss. Furthermore, a large quantity of new weed seeds are brought to the surface which have the potential to germinate. This can cause weeds to regerminate faster and crops to lose out on vital moisture.
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.

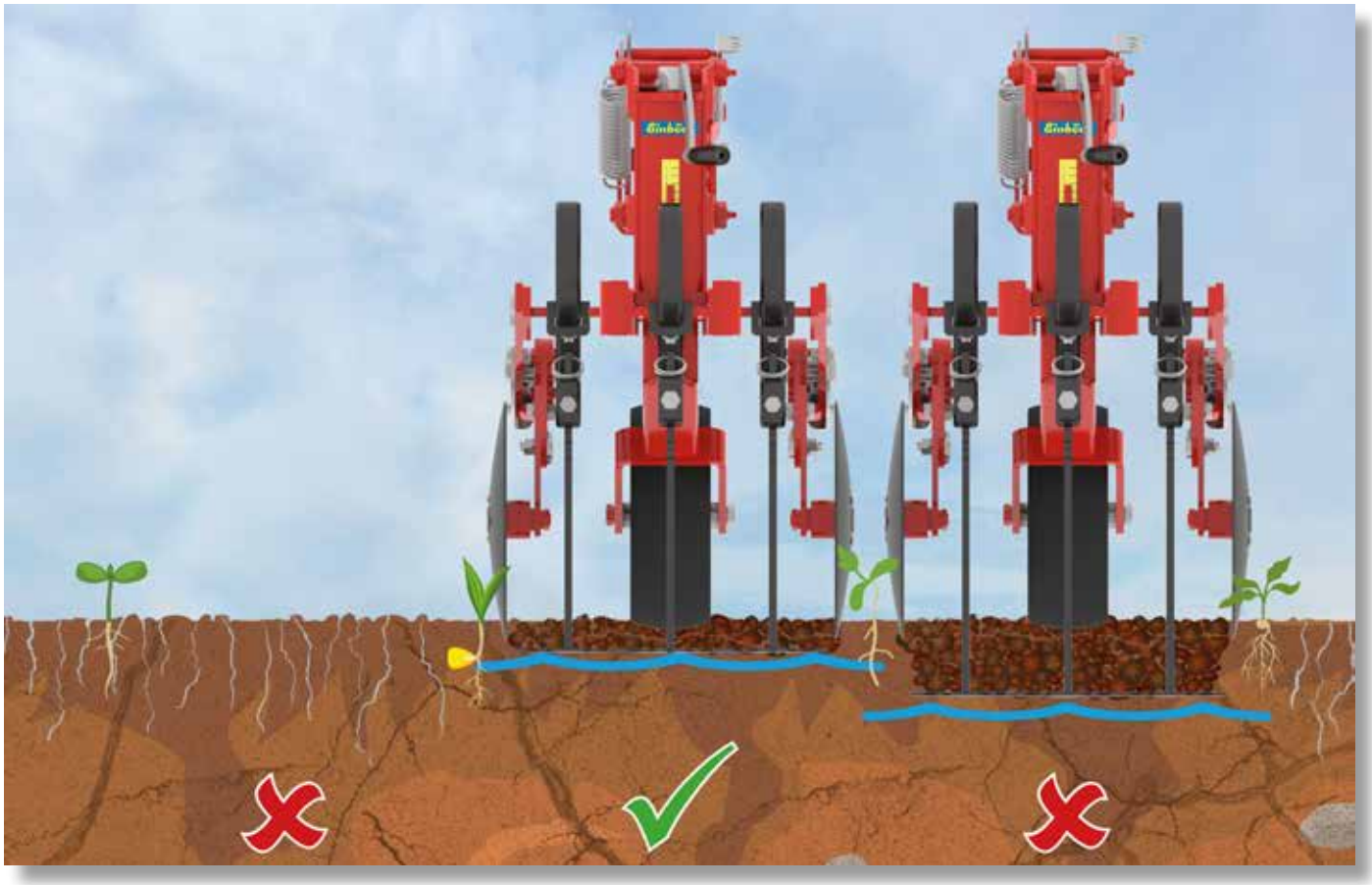
» **Full-surface cut:** Weeds should be cut across the whole area and allowed to dry on the soil surface. To guarantee your tool is working at full width, sweeps must overlap slightly. Use the spindle to quickly adjust each element to the correct working depth - in practice, this is 2-4 cm (0.80-1.60").

» **Select the correct tool:** Depending on the soil type and conditions (e.g. presence of stones, organic matter, etc.), sweeps of different widths can be fitted to align with row spacing. Depending on the crop and purpose of use, various heaping sweeps, angle knives, ultra-flat duckfoot sweeps and trailed working tools can also be used. This is where it is important to choose the tool best suited adapted to the conditions.

» **Parallelogram:** Adjust the retraction spring to the ground conditions so that the parallelogram works smoothly and precisely.

The row-crop cultivator can be adapted to the following crop as early as winter.

The working depth and cutting setting should be checked multiple times while working.



Parallelogram and hoeing section adjustments

» **Set sweeps to the size of your crop:** The smaller the plants, the closer they should be hoed (unhoed band). The aim is to get the sweeps as close as possible to the crop without covering it with soil. The larger the plants, the further away the sweeps must be so as not to damage the roots and or assimilation surfaces.
» **Align the parallelogram exactly:** When in the working position, the parallelogram should be parallel or slightly inclined to the floor. This enables the retraction spring of the hoeing parallelogram to be preloaded and guarantees hoe sweep penetration, even on heavily crusted soils. In this position, the parallelogram also has the largest amount of scope to adjust upwards and downwards.

A 3-stage adjustable retraction spring ensures that the parallelogram can put increased pressure on the ground.

Crop protection element adjustments

» **Adjust element depth:** The smaller the plants, the deeper the protection elements must be set so that plants are not buried or damaged.
» **Simple folding:** Shortly before the crop canopies, the protection elements are unnecessary and can simply be lifted up out of the way.
» **Types of protective elements:** The type of protection required (e.g. crop deflector shield or disc) once more depends on the crop and soil conditions (e.g. organic matter or large amounts of stones).

Most legumes such as soy and field beans are not weakened when covered with soil and while still small. No protection elements are therefore required in these circumstances.

Once a crop is well established, protection elements are no longer needed at all. Faster working speeds and various ridging tools are used at later stages to shift some 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, alleviating some of the weed pressure.

No protection elements are needed for well-developed stands!

Finger weeder adjustments

» **Adjust finger distances precisely:** Fingers should be set approx. 2 cm (0.80") apart. 2 cm (0.80") spacing is only possible in practice, however, when a camera steering system is fitted at the rear. If machinery does not have camera steering, it is virtually impossible to detect 2 cm (0.80") with the naked eye, making this setting nigh on impossible. If the cultivated crop has already grown a little, the finger weeder should be set further apart as the crop plants and their roots will be thicker.

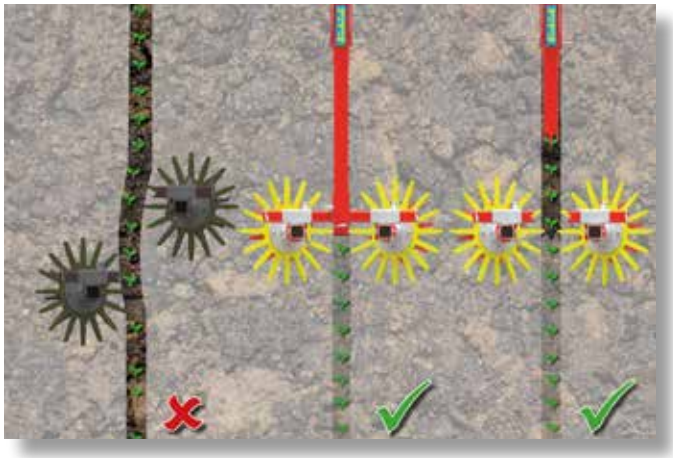
» **Light pressure for ideal adjustment:** The fingers of the plastic stars should all bend slightly upwards, i.e. light pressure should be applied. Springs on the finger weeder arm should be slightly under pressure when driving. This will allow the fingers to work properly and adapt well to uneven ground. The pressure can be adjusted by altering the height of the finger weeder holders. Springs also compensate for any weeder frame movements that may be caused by support wheels or feeler wheels.

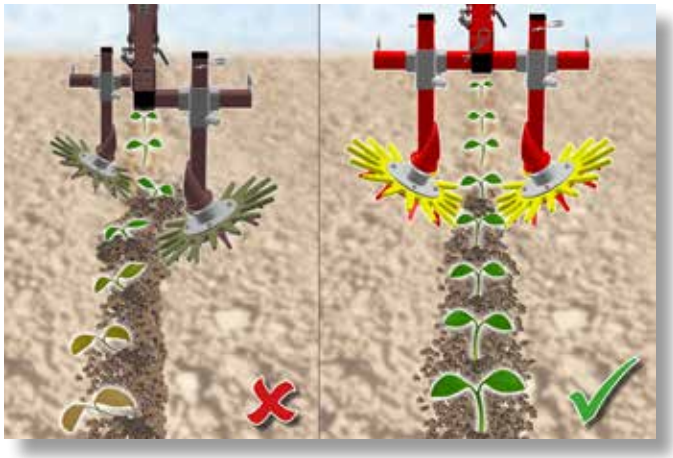
» **Set the depth:** The steel weeder fingers penetrate the soil and work to an appropriate depth (not too deep, but not too shallow either), according to the soil composition, soil type and crop stage. Adjust the finger weeder so that it operates at a shallow depth. It is important that it does not go too deep.

Finger weeders must work independently of leading tools.

It is important to use a separate bracket for each individual row of crops, on which each pair of stars is mounted. When stars are mounted directly on the hoeing element without their own parallelogram, they work at different heights. This results in one-sided pressure on the row of plants. The finger weeder should also work a row parallel and without offset. This is the only way to ensure precise work that avoids harming the crop. When finger weeders are staggered in relation to the row-crop cultivator frame they can damage the crop, operate at different heights and shift or damage the rows of plants. Weed control is also then limited as the fingers do not work simultaneously on the left and right of the row.

Finger weeders must work parallel to each other.





Trailed rotative weeder adjustments

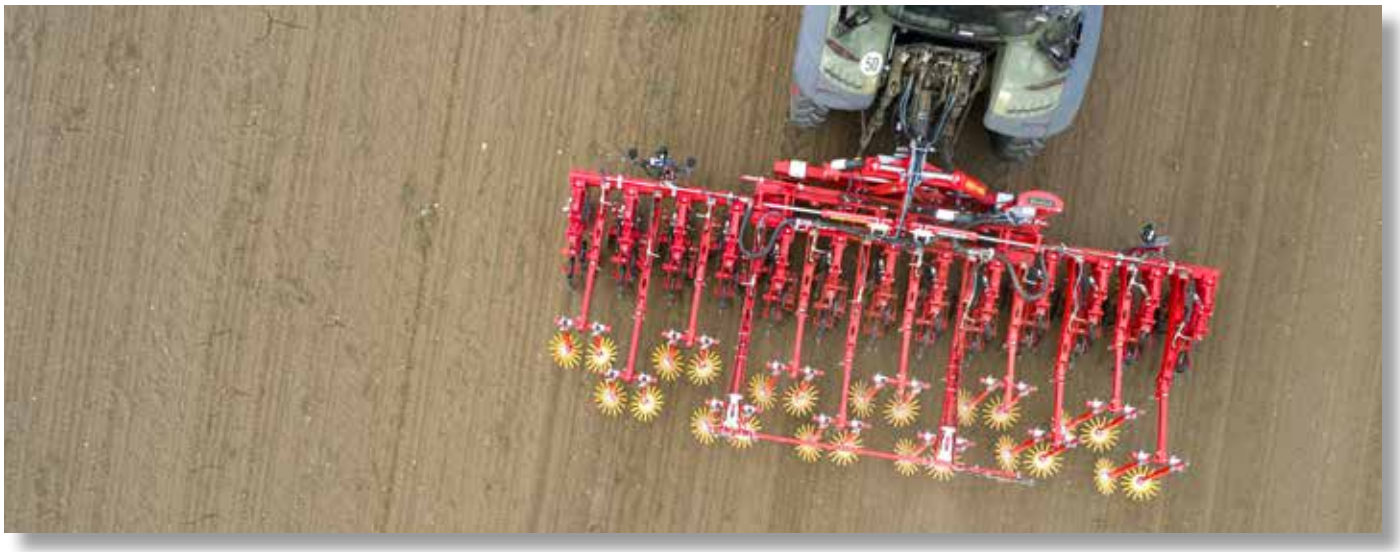
» **Working speed:** The faster you drive, the more aggressive the work.
» **Down pressure:** Down pressure can be set from "floating" to "heavily spring-loaded". The higher the down pressure, the more intensive the mode of operation.
» **Tine angle:** Great care must be taken in this respect as crops can be entirely severed if the setting is sharp.

To achieve the right level of aggressiveness, control the working speed, and down pressure and angle of the rotor star sweeps. The perfect combination of these three parameters is vital in order not to damage the crop, while still maximising the weed control.

Rotative weeders are more aggressive than finger weeders.

13.10 Summary

It is worth noting that there is no single setting that will work for all conditions and plants. A row-crop cultivator must be adapted to the crop (and its size) as well as the soil, and weather conditions. Hoeing only becomes easier, faster, and more precise with experience. Above all, you need calmness and patience, because using a row-crop cultivator correctly, will ultimately contribute significantly to the success of your harvest.



13.11 Hoeing: The TOP 10

1. **Sowing width = hoeing width**

2. **NEVER** adjust tools at the headland

3. Use the row-crop cultivator and additional tools **as close as possible to the crop**.
The most important area lies right around the crop → BEWARE don't go too narrow.

4. **Set the parallelogram slightly downwards** so that it adapts to the ground level and exerts enough pressure to run smoothly.

5. Hoe only as deep as necessary, but as shallow as possible → The depth is usually between **2-4 cm (0.80-1.40")**

6. **Adjust your speed** to the condition of the soil and the size of the plant → The quantity and height of the earth moved is a decisive factor for optimum speed.

7. The sweeps must always **overlap** to ensure a full-surface, clean cut

8. **Check your machinery** → Do not process large areas without rechecking your settings.

9. **The proof is in the pudding** → Every crop, soil and time is different everytime.

10. **Share knowledge** with those around you. Discuss what works and what doesn't!

14. MECHANICAL WEED CONTROL IN CEREALS

In organic arable farming, the tined weeder is most often used to control weeds that grow in cereals. This is because it is very good at controlling black grass, windthale and cleaver up to the single-leaf and cotyledon stage. This weeder boasts many advantages, especially on clayey, loamy soils or as regards silting and drying out. In principle, however, cereals can also be grown as root crops. Standard row widths are 12.5-18 cm (4.90-7.10") for drill sowing and 20-37.5 cm (7.90-14.80") for row sowing.

Crop	Requirements	Soil	Altitude/climate	pH level	Crop rotation	Weed pressure	Particulars
Wheat (Triticum aestivum)	Highest demands, needs the most nitrogen	Deep, medium to heavy soil with great storage capacity	Wheat up to 800 m; Wheat up to 1400 m; balanced climate, little rain	6.1 – 7.5	After clover grass, grain legumes, beets or potatoes	Good, especially varieties from the GZPK and Molinera crop program	Sprouting resistant, compatible with late sowing
Emmer (=hulled wheat)	Undemanding, very robust, (old country varieties)	Thrives on light to medium-heavy soils; ideal for poor soils	Up to 1900 m; prefers areas with low levels of precipitation (compared to spelt)	5.0 – 7.5	After root or oil crops, at the end of the crop rotation	Poor, thin stands, often wintering, late weed infestations	Less stable; additional 5% wild flower strips
Spelt (grain, Triticum spelta)	Undemanding, very robust	Medium to heavy soils, peaty soils are less suitable	Up to 1400 m; suitable for higher, rugged areas, high in precipitation	5.0 – 7.5	Not after wheat	Good, often bedding, then late weed infestation	Sprouting resistant, compatible with late sowing
Rye (Secale cereale)	Low demand on soil, climate, and nutrient supply	Heavy, poorly drained, and waterlogged soils are unsuitable	Up to approx. 2000 m, spring rye up to 1000 m	5.0 – 7.0	Also after wheat	Good thanks to growth height (except when stored with late weeds)	Sensitive to snow, mould and moisture, prone to overgrowing
Triticale (Triticum x secale)	Less demanding than wheat; stable and robust as regards diseases	The same as wheat	Up to around 1200 m	6.0 – 7.5	Should not be grown after wheat or rye	Good thanks to plant height and lots of straw	Matures after wheat; more prone to sprouting than wheat; high protein and lysine content
Barley (Hordeum vulgare)	Low water and temperature requirements; high nitrogen demand	Favours medium to heavy, deep soils; acidic, poorly drained soils are not suitable	WBarley up to 800 m; SBarley up to 1200 m; limited by snow cover duration	6.5 – 7.5	Suitable after other cereals; works as a "final crop" as field is cleared early	Suppresses weeds when in dense stands	Sufficient time after the harvest for stubble cultivation and sowing a grass clover meadow
Oats (avena sativa)	Better suited to cultivation in cool, humid climates than barley	Low demands; unsuited to light, dry soils	Winter oats only in favourable locations; Spring oats up to 1000 m	5.0 – 7.0	Spring oats loosen up winter cereal rotations; "recovery crop"	Good for early sowing and dense stands	Edible oats (white oats) should reach a hectolitre weight of at least 55 kg

* Source: Fibl leaflet 2018 | Swiss edition | No. 101

14.1 Summer cereals

Crop rotation

Spring cereals such as oats, spring barley and spring wheat are usually the last crop in the rotation after root crops, such as maize or potatoes. Legume catch crops and farm manure can make good use of these after summer cereals. However, if the crop is too heavily fertilised, it has a risk of lodging.

Sowing

In principle, spring cereals should be sown as soon as possible. However, any type of cereal will struggle to tolerate compacted or waterlogged areas of soil.

Mechanical weed control for spring cereals

1. **Blind weeding:** If the seed placement is a little deeper, the first blind weeding pass is possible 2–5 days after sowing.
2. **Weeding after emergence:** Weeding can be done after the 2-leaf stage using medium (to intensive) tine positioning. In addition to controlling weeds, this process also stimulates tillering.

3. **The final weeding pass:** Before the crop is closing its rows, you can work fairly intensively and with high pressure on the tined section.

14.2 Winter cereals

Crop rotation

To avoid disease within your crop rotation, the usual rules and cultivation breaks apply as set out in the "Crop rotation" section. In addition, the proportion of cereals should not exceed 50% of the land set aside for crop rotation, otherwise the risk of disease and problem weeds will increase. With frequent cultivation of winter cereals, autumn-germinating weeds such as cleaver, windthale, camomile and root weeds such as dock and thistle increase rapidly due to the long growing period. In this case, weeding success depends on starting well before winter, and weeding in autumn.

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

Sowing

Winter cereals must be sown in good time so that the first weeding can be completed in autumn. Plant winter barley, triticale and rye before the end of the growing season and winter wheat and spelt will then ideally overwinter in the 3-leaf stage.

Undersown crops

Read about the advantages of undersown crops in the section "Undersown crops". In cereals, undersown crops are particularly useful during the advanced stages. This is when leaves shrink and more light falls on the ground once more allowing undersown crops to form valuable organic green matter and roots in just a few weeks. For cereals, undersown crops should be sown between tillering and cereal shooting, i.e. after the second weeding pass. The undersown seeds will quickly grow if fine weeding is carried out between the rows of seeds.

The issue of cleaver

Cleaver can cause a lot of damage, especially to cereal crops. This is mainly down to the competition they create for nitrogen in the soil, light and water. Cleaver attaches to crops and pushes them to the ground, making harvesting more difficult and increasing the moisture content of the crop. The damage threshold is as low as 0.1 plants/square metre.

Cleaver can be effectively controlled with a tined weeder while it is in in the very early germination to 2-leaf stages. If weeding is not possible at this stage (due to plant cultivation or weather conditions) larger cleaver plants can also be "combed out" later. Cleaver branches out as it grows causing it to become entangled in weeders and meaning it can be "combed out".

Weeder tines are tipped forward and do not touch the ground. Raise and clear the tined weeder at the edge of fields.

Do NOT comb out when ear emergence first starts in cleaver and vetches as stalks will snap easily at this stage.

Mechanical weed control of winter cereals using the tined weeder

In autumn (depending on climate, soil moisture, weather, etc.)

Blind weeding: Blind weeding in autumn is often tricky and sometimes impossible due to the weather at this time of year. We suggest a guideline of 2-5 days after sowing - in suitable weather conditions. Above all, sensitivity is required: work should be carried out carefully so that the grain seedling is not damaged. Set a low tine pressure, depending on the soil and weather conditions.
Aggressiveness: gentle to moderate

Weeding after emergence: Roots are already well developed when the grain reaches the 2- to 3-leaf stage in autumn. Weather permitting, tines must work slowly across the field in a moderate to aggressive setting. Tine penetration can be relatively stronger than when blind weeding - once more, depending on the soil and weather conditions. Weed pressure will determine whether weeding is necessary. Usually however, weeding is required in the 3-leaf stage as a minimum. In addition to controlling weeds, this encourages tillering, and the humus is loosened and aerated.
Aggressiveness: moderate (rotative weeder tine pressure: soft)

During persistently wet weather in autumn, the tined weeder cannot be operated; instead the rotary hoe can be used. This aerates the soil and breaks the soil crust. The rotary hoe can be used during higher soil moisture levels than the tined weeder.

Tined weeding is not always possible in autumn due to the weather.

In spring

Tined weeding with moderate aggressiveness: Tined weeding must be carried out as early as possible in the spring. Tillering should be stimulated as soon as the frost abates, and the soil dries out. A tined weeding pass carries a number of advantages: By breaking up the crust in the spring, soil is aerated and warms up faster. Vegetation can therefore start more rapidly, stalks grow stronger, and tillering is stimulated.
Aggressiveness: gentle to moderate on soil and plants

If the soil is extremely hard and crusted, a rotary hoe pass is advisable before tined weeding. The soil tilth is then suitable for tined weeding.

Be patient in spring - conditions should be dry before doing the first tined weeder pass.

Tined weeding at approx. 30–40 cm (11.80-15.70") plant height: After the first weeding pass in spring, tined weeding can be carried out whenever required - up to a plant height of 30-40 cm (11.80-15.70"). At this point, nutrients are mobilised once more, late weed germination is prevented, and balanced growth conditions exist for plants and micro-organisms.

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 a rotative weeder

Do not weed when it is frosty!

It is essential that no late frosts occur in the days following a tined weeding pass in spring. Weeding reduces frost hardiness as these measures increase the crop's sensitivity to the cold, therefore do not carry out tined weeding if there is a risk of frost during the night.

As a general rule: 3 days afterwards no frost - 10-14 days afterwards growth phase

Overview of winter and summer cereal applications

Overview Winter and spring cereals	Frequency	Timing	Working depth	Setting
Blind weeding	Once	As long as the seedling remains 3 cm (1.20") below the surface	Max. 2 cm (0.80") (pay attention to seed depth and shoot)	Tines dragging and/or set lightly tipped forward
Weeding	1. 3rd pass	2nd and 3rd leaf stage	2 to 3 cm (0.80-1.20")	Tines set lightly tipped forward
	2nd pass and possibly the following	Until row covers, depending on weed growth	2 to 3 cm (0.80-1.20")	Tines tipped forward dragging
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 (0.80-1.60")	Parallel and/or slightly heaped

Source: Allgäuer Bauernblatt 25/2020

Tined weeder pass in spring

Rotative weeding in spring in wet conditions

With the rotary hoe

» In winter cereals: In spring once there are no more night frosts. Particularly effective at breaking the crusts in spring (March/April)
» In summer cereals: From the 3-leaf stage

Find out more in the section "Rotary hoe basics"

Different cereal crop details *

Organic buckwheat

Blind weeding is possible. Other than this, used of the tined weeder must be limited, as this plant is very sensitive. Blind weeding and careful use of the tined weeder is possible from the 3-leaf stage. Buckwheat is highly competitive against weeds. Due to its lost seeds and dormancy, buckwheat can itself act as a weed.

Organic rye

Rye suppresses weeds well. It can be blind weeded in autumn. After this, weeding is possible from the 3-4 leaf stage on.

Organic summer oats

Blind weeding is useful to reduce weed pressure (as with most crops). Afterwards oats can be gently weeded after the 4-leaf stage.

Organic spring wheat

Blind weeding before the crop emerges is suitable for spring wheat. Under favourable growing conditions, the crop develops quickly and suppresses weeds effectively. Afterwards, spring wheat can be weeded from the three-leaf stage. A weeding pass can also be carried out before shooting - depending on the weed pressure.

Organic spring barley

Barley does not have much resistance to weeds. Seedbeds that are as weed-free as possible are beneficial to this crop. Spring barely is quite sensitive to the weeder, even during the 3-leaf stage, therefore weeding is only carried out again during tillering. In general, vigorous, and long-stemmed spring barley varieties suppress weeds better.

14.3 Mechanical weed control with the row-crop cultivator

Sowing

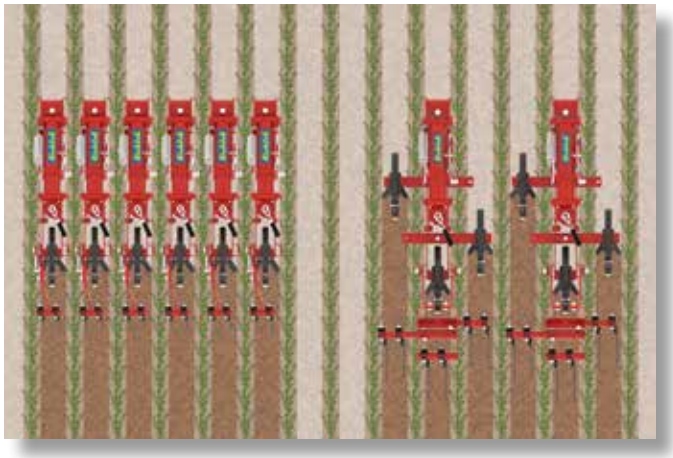
The correct row spacing must be defined at the time of sowing when hoeing cereals. 25-30 cm (9.80-11.80") is ideal. If the spacing is narrower, only a short pass with a row-crop cultivator with camera steering is possible due to the row closing sooner. If the spacing is wider, e.g. 37.5 cm (14.80") or above, the row does not cover by the end of growing and late weed infestation is a risk. At 25-30 cm (9.80-11.80"), 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.

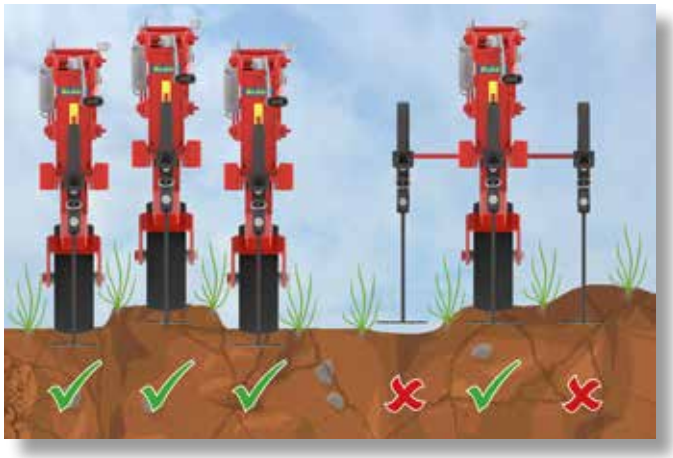
1. **First hoeing pass:** These should be carried out from the 4-leaf stage. For this reason, we advise weeding the cereal first (blind, if necessary) to capture weeds in the rows.
2. **Additional hoeing passes:** The second and third hoe passes (if necessary) can be carried out up to the point the row is covered or ears emerge.

Late hoeing of cereals mobilises up to 15kg N/ha!

*Source: LK OÖ

To avoid hilling the cereal crop too much and/or moving too much earth in narrower row spacings, you should use the shallowest sweeps possible (ultra flat sweeps).





Individually guided sweeps adapt to the soil much better and as a result, main the working depth more consistently.

Drill seeding (normal row)

Row seeding (wide row)

Advantages & disadvantages of growing cereals in wide rows

Advantages:

» **High level of nitrogen mobilisation:** Hoeing, with its deeper and more extensive soil disturbance compared to weeding, supports a higher degree of nitrogen mobilization.

» **Better/simpler weed control:** Using the tined weeder and hoe in combination results in better weed control. Tined weeders tackle large weeds and hoes are most effective for root weeds. Problem areas in rows can therefore also be sown while achieving a virtually weed-free field.

» **Hard crusts are broken up:** 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. This is also possible with the tined weeder, but if the crust is extremely hard, it will probably require several passes to achieve the same effect. The best solution in these conditions is the rotary hoe.

» **Water is saved:** Interrupting the capillary effect prevents unproductive evaporation.

» **Reduction in sowing costs:** Wider rows mean up to 30 % less seed is required per hectare, thus reducing costs.

» **Dense stocks:** Tillering of crops is markedly improved since each individual plant is exposed to more light.

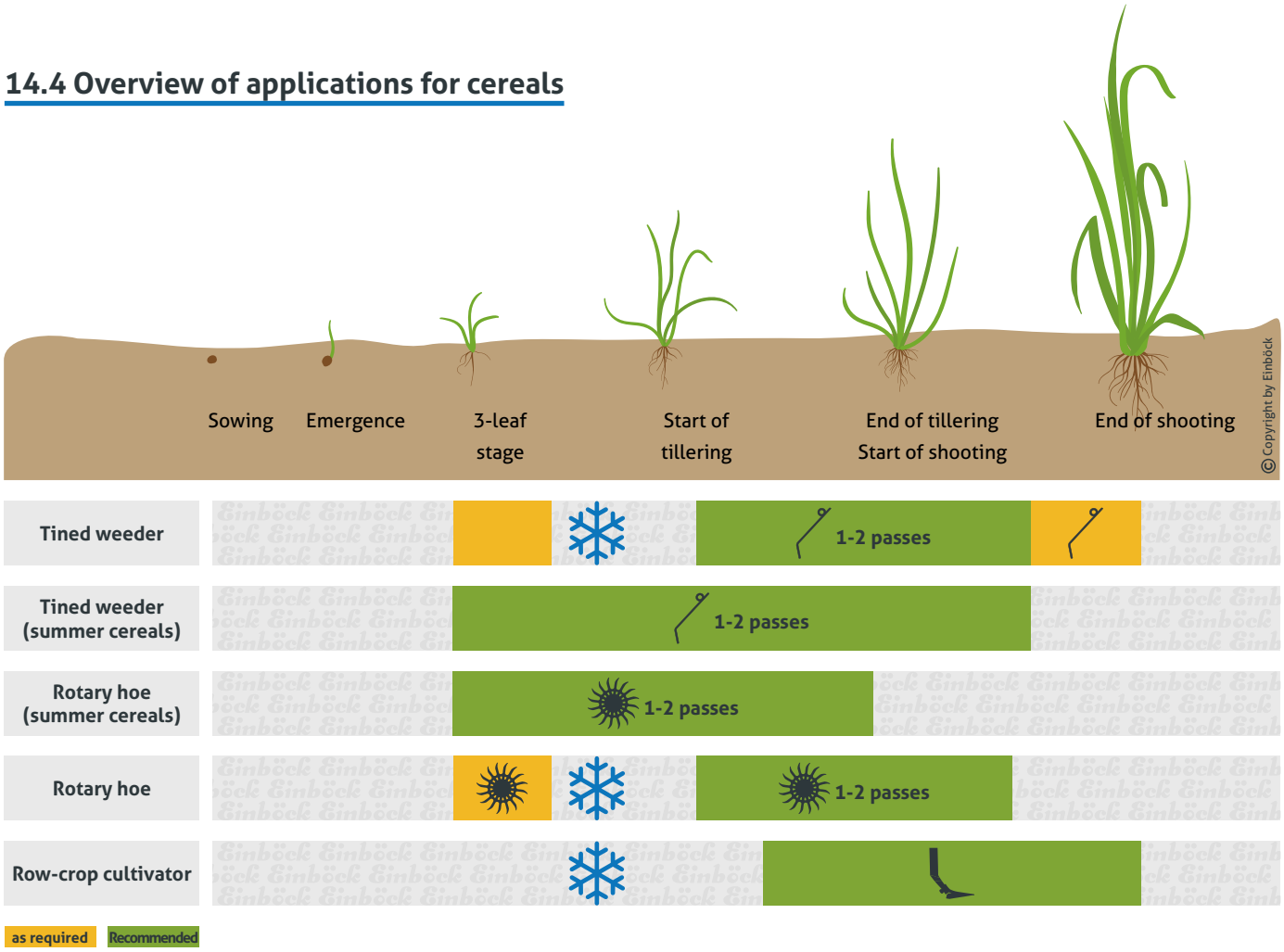
» **Stronger crop:** Improved tillering means that each plant forms more leaves. This can lead to the crop assimilating for longer. As a result of extended growing, the grains generally grow bigger, and the protein content is increased. In addition, the protein content is increased as a result of soil mineralisation during hoeing.

Disadvantages:

» Potentially lower yield

» Increased weed pressure due to less soil shading

14.4 Overview of applications for cereals



14.5 Mechanical weed control in cereals: The TOP 10

1. Getting crop rotation right helps prevent diseases and weeds in cereals.
2. Blind weeding is a vital and effective measure when used as a first step for weed control.
3. Autumn weeding is not always possible. Always make sure the conditions are suitable before you commit.
4. Blind weeding of cereals up to the tips is possible - but select the level of aggressiveness carefully.
5. Do not weed during a period of night frosts. No frost should occur in the 3 days following.
6. Weeding and hoeing breaks soil crusts, which is extremely useful in spring.
7. The rotary hoe can be used even in wet conditions.
8. Combining weeding and hoeing when growing cereals results in a virtually weed-free field.
9. Rotative weeders are effective when weeding cereals, even when there is a lot of organic matter in the field.
10. Cereals can be weeded "crossways".

15. MECHANICAL WEED CONTROL IN MAIZE

As a root crop, maize provides a welcome break amongst a cereal-heavy crop rotation, as well as a simple solution for managing root-propagated weeds. Maize consumes nutrients and is not highly competitive with weeds in its early stages. When the seedling is about to break through and emerge out of the soil's surface, this crop is very sensitive. Weeding should be avoided during this stage. From the 1-leaf stage (BBCH 11), the seedling is more robust, and weeds can be controlled with low speed passes. Maize is late to cover soil, so weeders and hoes must be used very precisely. This crop therefore needs to be kept weed-free right up to the 6-leaf stage, which requires continual plant monitoring.

To achieve the best weed control, choosing the right time for each cultivation measure is particularly important when growing maize. Regular hoeing after maize emergence is therefore essential to keep rows clean. A setting with accuracy to the nearest centimetre is recommended. This is usually only possible with a rear camera steering system, however.

15.1 Crop rotation

Maize is usually only grown after other crops or winter cereals, and in combination with a legume catch crop. If cereals are used as the preceding crop, extra care must be taken to ensure they are weed-free. Clovers with a close C:N ratio offer the ideal option when selected as catch crops, as they generally only supply nitrogen when mature.

One possible reinforced crop rotation: Red clover - Cereals - Maize

15.2 Sowing

Successful weed control for maize is significantly influence by a late sowing date and choosing maize varieties that offer good weed suppression. To ensure young plants develop quickly, the soil temperature during seed sowing should be at least 8°C (preferably 10°C) over a long period of time.

A sowing unit on the maize drill must be precisely coordinated with the hoeing element row spacing: 75 cm (29.50") needs to be precisely 75 cm (29.50"), for example.

15.3 Undersowing

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 best for undersowing. Undersown crops can also be sown using a weeder equipped with a drill. The main advantage of undersown crops is that they suppress weeds, reduce erosion, and provide excellent soil conditions. On one hand, undersowing supports soil life, on the other, it makes the ground better to drive over during harvesting due to the widespread growth.

15.4 Mechanical weed control in maize

1. **Blind weeding (essential)** Blind weeding should be carried out shortly after sowing (3-7 days after), using the tined weeder to control the first weed seedlings. To successfully plan this in, the sowing date must be coordinated with the blind weeding pass, and this must be taken into consideration when review the weather conditions. At this stage, weed germ tubes are easily eliminated, greatly reducing the subsequent weed pressure. However, be careful not to weed too early, as this will not be successful. And don't weed too late, or seedlings may be damaged.

2. **Weed as required:** If necessary, an additional weeding pass can be carried out no faster than 2-4 km/h in the 2-3-leaf stage. If the working speed exceeds this, plants may be buried or set on an incline. The maize plants will then be slow to straighten and will lag behind in growth and development. At this growth stage, the crop should be blind weeded in the morning on warm days when the plants become more flexible in the heat of the sun. This stops them from bending over.
Practical tip: Weeding crossways effectively buries weed seedlings between the rows.
Technical tip: The CHOPSTAR-TWIN precision hoe is suitable for use at this stage. This hoe offers the crucial benefit that is works extremely close to the crop, meaning it can be used to hoe very young crops. It also produces a very narrow unhoed band of less than 5 cm (2"), which ensures crops are cleaner and weed infestations are reduced.

3. **Break crusts as required:** If the soil is heavily crusted, use a rotary hoe to aerate the soil and interrupt the capillary effect.

4. **Hoe from the 2-leaf stage:** Approx. 1 week after a weeder pass, the row should be hoed as close and flat as possible. Camera steering on the row-crop cultivator will assist the tractor driver and compensate for any mistakes. If the pass works too deeply, seeds will germinate and moist soil will be brought to the surface, increasing the risk of erosion.
   Depending on the maize crop and weed pressure, 2–3 more hoeing passes can be carried out. To control weeds between plants in the row, finger hoes and rotative weeder elements can be fitted. The basic rule is: hoe whenever necessary, but as little as possible.
5. **Last hoeing pass just before row closure:** Tines should be set close together during the final hoeing pass, so that roots are undamaged.
   Hilling recommended: Just before the end of each row, we recommend setting heaping sweeps or discs. When the maize is approx. 40 cm (15.70") high, small weeds in the rows can be buried resulting in less weed pressure. The plant will also benefit from the "hill effect". Faster working speeds and ridging tools are used to earth more soil into the row. This encourages the soil over the plant roots to warm up thanks to the larger surface area created and guarantees more rapid growth.Once the row is covered, no further crop care measures are required/possible.

If, however, hoeing is, or needs to be done due to erosion or incrustations, a finger feeler can help control the sideshift frame when hoeing shortly after row closure.

Mechanical weed control with the rotary hoe in maize

1. "Blind weeding" or "blind hoeing" to the maize plant tips (pay attention to working depth)
2. As required from the 2-leaf stage

15.5 Detailed overview of operations - maize

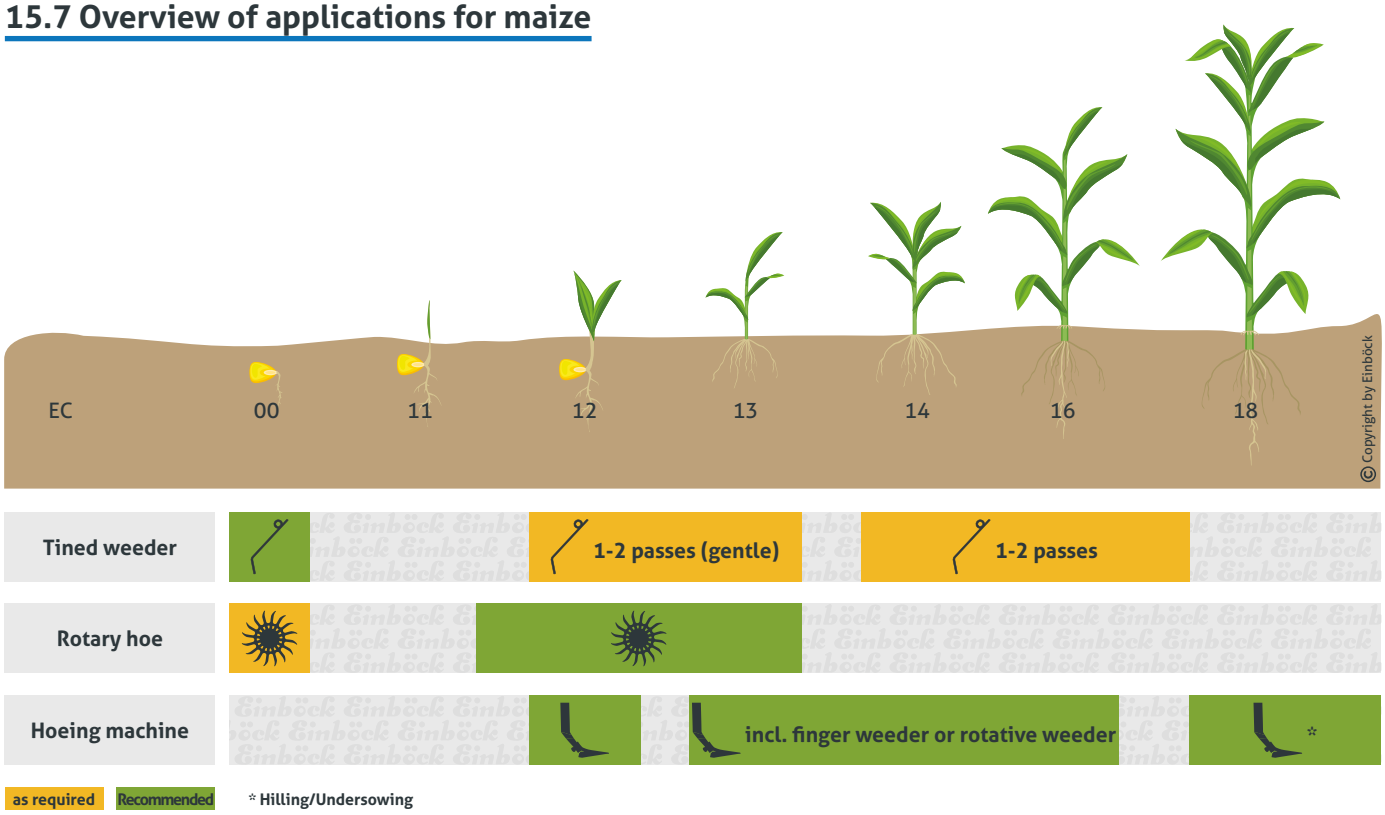
Maize overview	Frequency	Timing	Working depth	Setting
Blind weeding	Once	As long as the seedling remains 3 cm (1.20") below the surface	Max. 2 cm (0.80") (pay attention to seed depth and shoot)	Tines set to dragging
Weeding	1. 3rd pass	From the 2- to the 4-leaf stage (approx. 5 cm / 2" high)	2 to 3 cm (0.80-1.20")	Tines set lightly tipped forward
	2nd pass and possibly the next	Until row covers, depending on weed growth	2 to 3 cm (0,80-1.20")	Tines tipped forward dragging
Mechanical hoeing	1st pass	From view of the rows	2 to 4 cm (0.80-1.60")	With crop protection
	2nd pass	Depending on weeds	3 to 5 cm (1.20-2")	Lightly hill rows
	3rd 3rd pass	Until row covers, depending on weeds	4 to 5 cm (1.60-2")	Heavy hilling possible
Rotary hoe	until the 2nd pass	To tips and as required from the two-leaf stage	down to 3 cm (1.20") deep	Adapt aggressiveness to incrustations

Source: Allgäuer Bauernblatt 25/2020

15.6 Mechanical weed control in maize: The TOP 6

1. Only sow when soil temperatures are warm enough.
2. Do no crop care measures when seedlings are emerging from the soil surface - except for very careful use of the rotary hoe.
3. While young, maize is not very competitive compared to weeds, making blind weeding and early hoeing essential.
4. Constant monitoring is essential when selecting the right moment to hoe or weed. Beware - maize grows very quickly!
5. Sweeps must be used as close as possible to the crop without burying them - be sure to use protective elements.
6. Heaping before row closure ensures faster plant development.

15.7 Overview of applications for maize



16. MECHANICAL WEED CONTROL IN SOY

Soy is weak while young, therefore mechanical weed control is particularly important during this stage. It should be encouraged to grow quickly with a well-prepared seedbed. To sufficiently grow and thrive, soy makes significant demands on the soil, especially in regard to heat and water.

The plant grows best in deep, well-settled, and not too fine seedbeds. Medium-heavy soils in a warm and humid climate are ideal. Soil should warm quickly but must not be too heavy or light - rather, just right. The pH level should be between 6.0 and 7.0. Avoid soils with a high nitrogen supply as these inhibit nodule formation, which is an extremely important stage for soy. Soy also does not do well in compacted soil, therefore avoid areas that are heavily compacted and with many weed roots.

16.1 Crop rotation

The soy bean makes few demands on the preceding crop. The less nitrogen present in the field, the better this crop grows, and the worse crops grow. This means that all cereals are well-suited to being preceding and following crops, as the carbon (C) - nitrogen (N) ratio is perfect. In certain situations, maize and beet are also workable. Note: legumes, sunflowers and potatoes are not suitable.

16.2 Sowing

To develop young plants quickly, the soil temperature during sowing should be at least 10°C. For successful blind weeding, the sowing depth must be 3-5 cm (1.20-2") deep.
For soy to achieve even and rapid emergence, stable and warm weather is required after sowing.

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

16.3 Mechanical weed control in soy

1. **Blind weeding:** plan a blind weeding pass 3-5 days after sowing to control the first wave of weeds which will be at the thread to cotyledon stage. Set the sowing date so that blind weeding can be carried out under the right weather conditions.

2. **Hoeing with a row-crop cultivator or rotary hoe:** Cotyledons must be hoed as soon as they are fully developed. Soy bean plants may even be slightly covered with soil during this pass.

3. **Gentle (crossways) weeding:** Weed 1-2 days after hoeing to remove soil from the soy crop. **3–4-leaf stage:** Hoe and break any crusts with a hoeing element, such as a finger weeder or rotative weeder element, rotary hoe or rotative weeder.

4. **Additional hoe or tined weeder passes:** Depending on the weather, weed or hoe 1-2 weeks after a pass with the hoe.

5. **The final hoeing pass:** The final pass is made using the finger weeder shortly before flowering. This enables weeds in the row to be captured and easily hilled. Additional hilling can be done with heaping sweeps or hilling discs.

Mechanical weed control for soy with the rotary hoe:

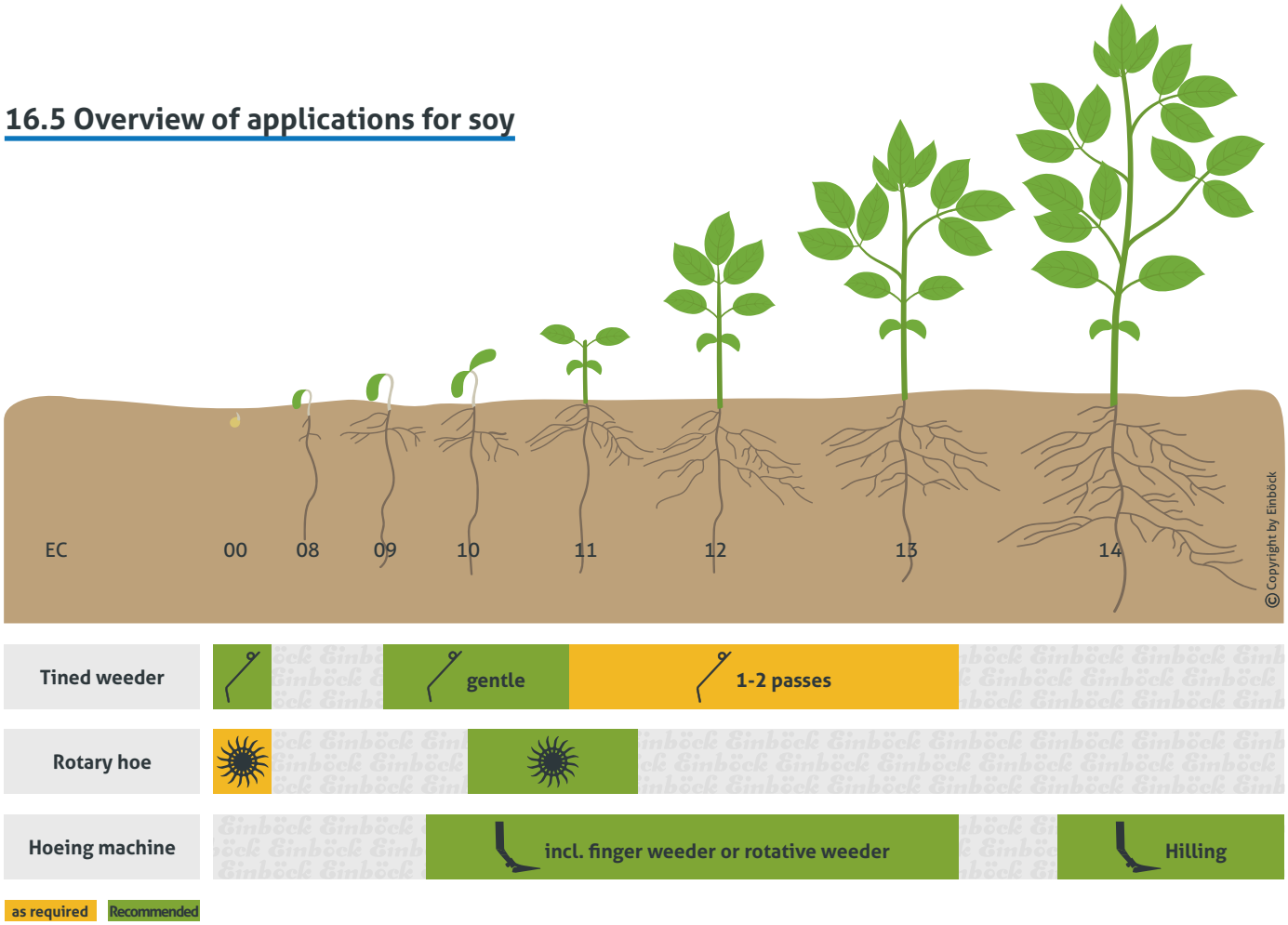
1. Blind weeding and blind hoeing. Pay close attention to the working depth.
2. As soon as cotyledons are fully developed, you can use the rotary hoe to easily earth up the soy plant without any damage.
3. Add a rotary hoe pass at the 3-4 leaf stage if required for hoeing or incrustations.

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

16.4 Mechanical weed control in soy: The TOP 6

1. Prepare the seedbed well - soy makes high demands on soil.
2. Inoculate seeds with a rhizobial inoculant.
3. Pay attention to the sowing depth during blind weeding.
4. Soy plants can be gently earthed up in the early stages.
5. Aggressive late weeding is recommended to get rid of weeds in the row.
6. Use a finger weeder or heaping elements for the final hoeing pass.

16.5 Overview of applications for soy



17. MECHANICAL WEED CONTROL IN FIELD BEANS

Field beans store nitrogen and have good root penetration. Deep, heavy, lime-rich soils are suitable, and a cultivation break of a minimum of 5-6 years must be adhered to. The winter field bean can be grown in drought-prone locations and heavy soils, but the seedbed should not be too fine.

This crop is relatively robust, so there is little plant loss during tined weeding. Weeder passes are therefore based on weed size, rather than crop size, due to the sturdy nature of this crop. Field beans are usually sown as a drill crop, but root cropping with wide row spacing is also suitable.

17.1 Crop rotation

Just like soy, the field bean makes few demands on the preceding crop. Too high levels of nitrogen in the soil is just as harmful as too much fertiliser in a preceding crop such as maize. Winter cereals therefore make good preceding crops.

17.2 Sowing

The beginning of March is the ideal time to sow field beans, however always try to sow as early as possible. Seeds should be placed at approx. 6-10 cm (2.40-3.90").

If the soil becomes silted or crusted after early sowing, use a rotary hoe to loosen the soil and create a crumbly and pourable surface.

17.3 Mechanical weed control in field beans - drill sowing

1. **Blind weeding:** Carry out blind weeding 6-10 days after sowing or as soon as the first weeds are visible. If you placed the seed deep enough, set your weeder to an aggressive setting.
2. **Second tined weeder pass:** When field beans are around 5 cm (2") or higher or approx. 10 days after blind weeding, carry out a tined weeder pass.
3. **Final tined weeder pass:** Carry out the final weed control measure around 10 days after the second weeder pass or when the crop is around 15 cm (5.90") tall. No further weeding is necessary.

17.4 Mechanical weed control for field beans in wide rows

Sowing

Row spacings of 25 or 37.5 cm (9.80 or 14.80") are effective when growing field beans in wide rows as this ensure row closure. Row closure reduces late weed infestations and weed suppression.

1. **First hoeing pass:** Carry this pass out with finger weeders when plants are 5-10 cm (2-3.90") tall. To capture weeds in the row, it is therefore important to carry out both a blind weeder pass and a tined weeder pass.
2. **Additional weeder pass:** An additional tined weeder pass should occur when the crop is 15-20 cm (5.90-7.90") tall. This loosens and aerates the soil before row closure.
3. **Second & final hoeing pass:** Soil in the rows should be hilled by a rapid tractor pass according to the weed pressure and before row closure.

17.5 Mechanical weed control in field beans: The TOP 5

1. Field beans can be drill seeded or sown in wide rows.
2. This crop is robust, so there is little plan loss during weeding.
3. Weeding passes depend more on the size of the weeds, than the size of the crop, because field beans can withstand relatively aggressive measures.
4. Blind weeding produces the best control results.
5. Field beans tolerate aggressive hilling, which enables good weed control.

18. MECHANICAL WEED CONTROL IN SUGAR BEETS

Sugar beet consumes nutrients but is also valuable as a preceding 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. To achieve a good result from weeding, soil should be loose and sufficiently pourable, without too many coarse clods. When blind weeding, it is important to have an even, reconsolidated seedbed with any deep ruts.

The time required for manual weed control 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. Sugar beet is not competitive when young, so it is important to mechanically control any weeds in the early stages - from the cotyledon to the first pair of leaves. Sugar beet only achieves enough shading at the ends of the rows sufficient for good weed suppression.

When using the tined weeder on this crop, carefully set your desired weeding intensity. The losses as a result of blind weeding and tined weeding at the cotyledon stage depend on soil condition and type, the seed drill closing device, the tined weeder system and the setting chosen. To achieve the best results, you must carefully select the correct working speed and depth, the spring preload and the tines' angle of attack. It is impossible to offer a wide-ranging recommendation regarding the best working speeds and weeder settings as these vary per farm and site.

18.1 Crop rotation

Sugar beet is best grown after a legume catch crop. It thrives when it follows restorative crops and in suitable locations. When harvested early, wheat, winter spelt, or triticale can follow.

18.2 Sowing

Higher ground temperatures substantially improve even crop emergence. Even and deep seed placement is important in achieving a good blind weeding pass. The ideal seed depth for sugar beet is approx. 3 - 3.5 cm (1.20-1.40"). The sowing rate should be increased to compensate for any weeding losses.

Do not include maize in beet crop rotations.

18.3 Mechanical weed control in sugar beets

1. **Blind weeding:** Blind weeding is recommended 2-3 days after sowing in pre-emergence, depending on the weather and location. This weed control measure only has a short time window; used too early, success will be limited as the weeds will be too small to be buried. However, poor timing in the seedling stage can result in high crop losses. The sowing depth is an important factor.

Do not weed during crop emergence or the cotyledon stage.

2. **Second weeder pass:** Beets are well rooted from the 2-leaf stage, making careful weeding possible. Silting and crusting can reduce gas exchange in the soil and severely restrict sugar beet growth. The rotary hoe can be used to break up these crusts, loosen soil and loosen and uproot weeds from the 2-leaf stage.

The rotary hoe can be used to break crusts during early crop growth.

3. **First hoeing pass:** Only possible from the cotyledon stage onwards. Sugar beet is especially poor at competing with weeds at this stage. Therefore: The smaller sugar beet, the closer plants should be hoed. Sweeps should be used as flat and as close as possible to the crop without covering it. To stop this from happening, we recommend using deflector discs or protection shields. Caution: Do not use finger hoes.

4. **Second hoeing pass:** The next hoeing pass is possible from the 2-leaf stage when using a camera steering system. All a row-crop cultivator will leave behind is a narrow, unhoed strip, which can use worked by fingers hoes within the row. Precise adjustment of finger hoes is necessary to avoid significant beet losses.

5. **Tined weeder pass:** The beet is robust from the 4-leaf stage, which means two hoe passes can be carried out to manage the narrow unhoed band in the beet rows.

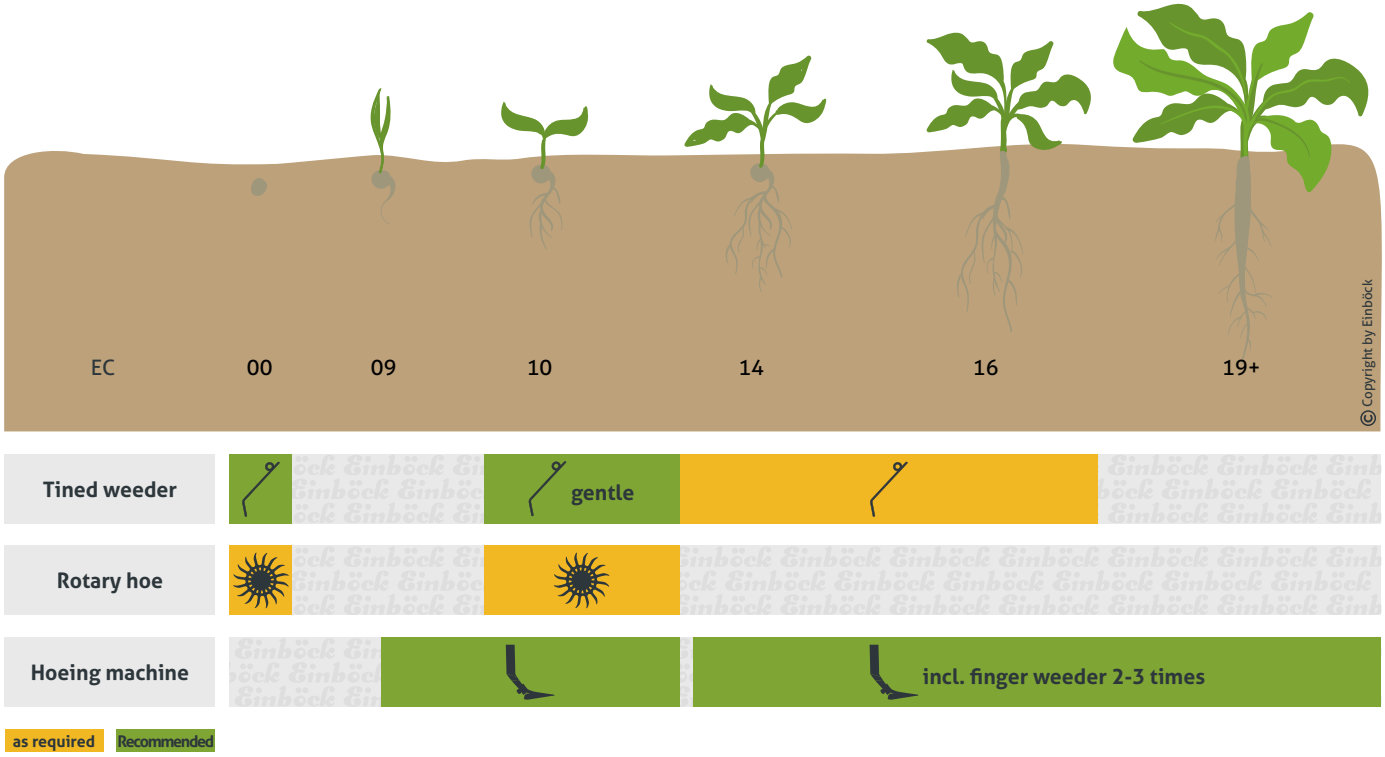
6. **Additional hoeing passes:** Depending on the weed pressure, additional hoeing is possible until the row closes. For good weed management, light hilling can be carried out after the 3-4-leaf stage, and until the final hoeing pass before row closure.

Drive slowly when using finger hoes in the 2-leaf stage.

18.4 Mechanical weed control in sugar beets: The TOP 6

1. Good soil preparation and the correct sowing date are crucial when achieving good results from blind weeding.
2. Sugar beet is not competitive when young, therefore early and regular weed control is required.
3. Never bury sugar beet.
4. Sugar beet's tolerance to weeding increases significantly from the 2-leaf stage.
5. Cross weeding and hoeing results in good weed control, but this must be planned in precisely with the sowing date.
6. Hilling right up to row closure achieves excellent weed control within the row.

18.5 Overview of applications for sugar beets



19. MECHANICAL WEED CONTROL IN POTATOES

Hill crop potatoes prefer light to medium-heavy soils that are acidic, well-draining and fertile. Soil should be soft and moist, with a crumbly structure and round mounds. The soil should give slightly when you tread on it. Good, compaction- and smear-free soil cultivation is a prerequisite for good hill formation and weed control. Potatoes are sensitive to frost so can only be planted in spring once the danger of frost has passed. It is important that these tubers are not exposed to light, otherwise they will turn green (similar to with shoots) and become poisonous.

19.1 Hill crop

For hill crops, a hill is created which guarantees the crop good structure and sufficient space so that the potato plant can grow. The large volume of soil ensures ideal tuber formation. Weeds are also prevented from growing and can be uprooted, buried or dried out during targeted creation and removal of hills.

19.2 Crop rotation

A hill crop of potatoes has its merits during the summer fermentation, and draws lots of air into the soil, creating the perfect soil for arable farming. In this sense, it creates the ideal conditions for e.g. wheat as a following crop. A cultivation break of at least 4 years (including early potatoes) should be maintained between crops.

19.3 Sowing

The perfect time to sow depends on the region. However, as a rule, soil temperature must be at least 8°C and must be sufficiently dry. Rapid emergence is guaranteed by warm soils, therefore shallow hilling and blind weeding are possible. This minimises the risk of emergence diseases (Rhizoctonia and Erwinia).

19.4 Mechanical weed control in potatoes

1. **Blind weeding:** Weed control must be carried out 2-5 days after sowing and before weeds are visible. At the latest, it must happen at the 2-leaf stage of weeds. Hills must be "sealed". Blind weeding promotes rapid emergence in potato plants.

2. **First hoeing pass:** The newly emerged haulm is sensitive, therefore must not be weeded. As soon as it has turned green and has reached a height of approx. 10 cm (3.90"), the rollstar cultivator can be used to re-hill ridges and work the hill sides.

3. **Second hoeing pass:** This pass is carried out by the rotative row-crop cultivator and hill weeder, allowing the ridge to be hoed and the plants to be weeded in a single pass. Important: If the plants are more than fist-sized, they must not be entirely covered.

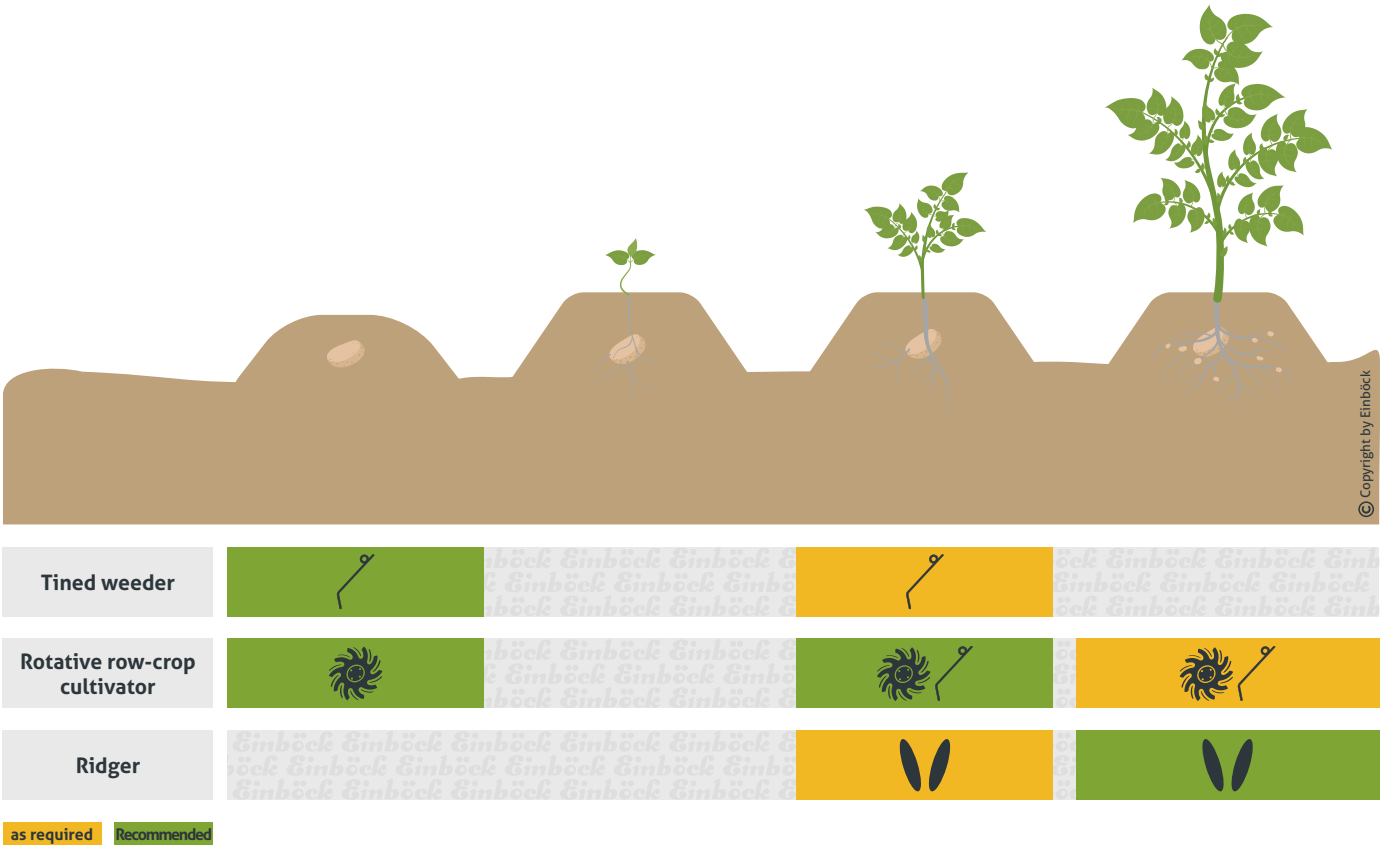
4. **Third hoeing pass with ridger:** To ensure the ridge sides are not cultivated too intensively (which would damage the potato roots), the ridges should only be earthed up lightly, i.e. only lightly worked. The plants themselves should be weeded using a guided hill-weeder. Potatoes are best hoed in the evening to minimise leaf covering.

We recommend "weeding down" the potato hill immediately after it has been set with a tine weeder with a high frame clearance.

19.5 Mechanical weed control in potatoes: The TOP 5

1. Blind weeding should be done with a tine weeder with a high frame clearance. This promotes rapid potato plant emergence and ensures the hill and valley weeding results are good.
2. Carry out hilling after weeding.
3. Avoid weeding while plants are emerging.
4. Using a rollstar cultivator with hill weeder means weeding and hoeing can be carried out in a single pass.
5. For the second, third & fine hoeing pass, work in the evening when the leaves face upwards.

19.6 Overview of applications for potatoes



20. MECHANICAL WEED CONTROL IN SUNFLOWERS

When growing sunflowers, maintaining a cultivation break of 6-7 years is vital, from crops such as rapeseed, soy beans, camelina and the sunflower itself. These crops can transmit sclerotinia. For preceding crops, all cereals and root crops are suitable; legumes such as clover (grass) are not, as they supply too much nitrogen.

20.1 Sowing

The sunflower is very weak when young, therefore increasing the seed density by 10% is worthwhile. Sunflowers should be grown from a sowing depth of 3-4 cm (1.20-1.60").

20.2 Crop rotation

The sunflower makes few demands on the preceding crop and is considered "erosive". A key benefit of sunflowers is their mobilisation of nutrients no longer accessible to other plants. It is important to remember that this crop extracts a lot of water from soil, therefore care should be taken in the following year to ensure the following crop grows well. This makes clover-grass particularly suited as a following crop for sunflowers.

20.3 Mechanical weed control in sunflowers:

1. **Blind weeding:** Sunflowers have weak juvenile growth, therefore carry out this step approx. 2-3 days after sowing. (Note: pay close attention to the seed depth!)
   Sunflowers are extremely sensitive to weed pressure right up to when they have 5-6 pairs of leaves. They are also easily damaged by mechanical measures. Blind weeding is possible, but extreme care must be taken. The sowing depth must be 5 cm (2") as a minimum.

2. **First hoeing pass:** This pass should be as early as possible - ideally as soon as the rows are visible. Using a camera steering system is recommended as it can control the row-crop cultivator more precisely, meaning this pass can be carried out as early as possible. Young plants should not be buried. Prevent this from happening by using crop protection elements.

3. **Second hoeing pass:** Hoe weeds when the crop reaches the 3-4 leaf stage, using a finger weeder or rotative row-crop cultivator for in the row.

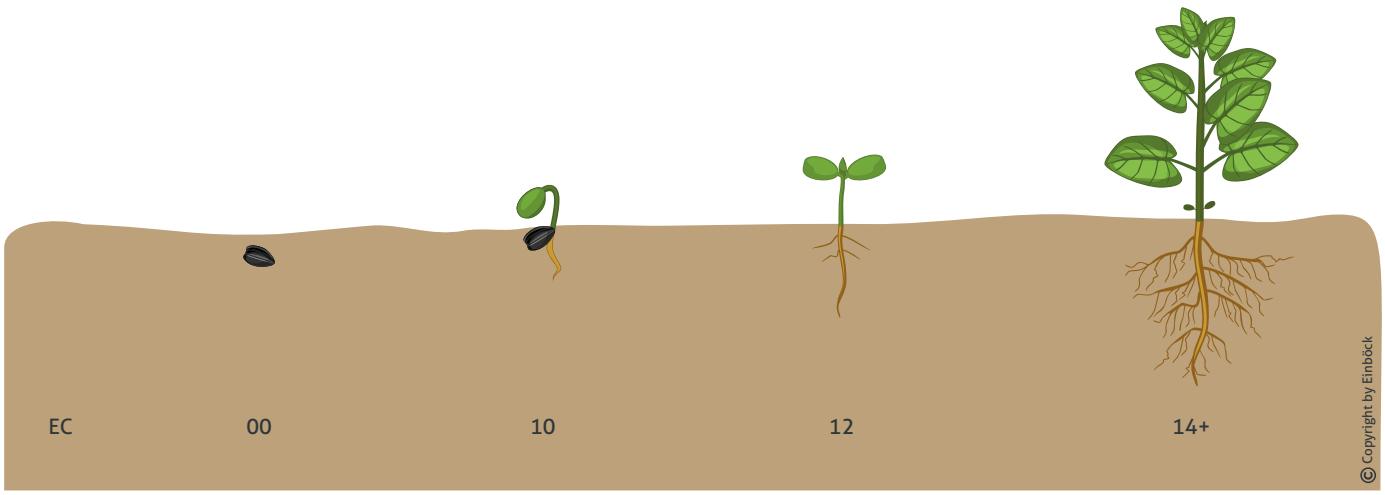
4. **Additional hoeing passes:** Carry out extra hoe passes as and when needed. Take care during the final passes to ensure rows are hilled to cover any weeds present. This also increases stability and encourages fine root growth. Hoeing passes must be up to 30 cm (11.80") high (the 5-6 leaf pair stage) or at the latest, by row closure.

20.4 Mechanical weed control in sunflowers: The TOP 5

1. Sunflowers are not competitive when young.
2. Do not include cruciferous and sclerotinia-susceptible crops in the crop rotation.
3. Sunflowers are sensitive to mechanical damage in the early stages.
4. The sowing depth should be at least 5 cm (2") for blind weeding.
5. The first hoeing pass should be completed as early as possible.

Sunflowers quickly grow in width - the unhoed area (hoeing band) must therefore be set very wide at an early stage.

20.5 Overview of applications for sunflowers



Tined weeder	as required	as required	
Rotary hoe	as required	as required	
Hoeing machine		1-2 passes	1-2 passes incl. finger weeder *

as required Recommended * Hilling

21. MECHANICAL WEED CONTROL IN PUMPKINS

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.

21.1 Crop rotation

Pumpkins can work with any preceding crop. Avoid crops with sclerotinia (soy, sunflower, rape, etc.) in the crop rotation. In areas with little rainfall, it is important to sow a catch crop for a long period of time after harvesting the previous crop and sowing the pumpkin crop. This allows the rain available to be stored in the soil, making it available to the pumpkins.

21.2 Sowing

Pumpkin cannot tolerate frosts, therefore sowing early in the year is not an option. Pumpkin row spacings are between 70 cm (27.60") in conventional farming and 140-210 cm (55.10-82.70") in organic farming. 70 cm (27.60") row spacings has the added benefit that the pumpkin rows close earlier, although they can be hoed less. This is why the 140 cm (55.10") row spacing is often chosen in organic farming as a good compromise. The distance in the row also depends on the distance between rows. In 70 cm (27.60") row spacings, pumpkins are almost sown in squares, as the spacing in the row is 75-85 cm (29.50-33.50"). In 140 cm (55.10") row spacings however, the distance is only 40-50 cm (15.70-19.70"), and in 210 cm (82.70") row spacings, it is 30-40 cm (11.80-15.70").

21.3 Mechanical weed control in pumpkins

1. **Blind weeding:** Must be carried out 2-6 days after sowing. Do not work too deeply, as pumpkins lay extremely flat.
2. **Additional hoeing passes:** As soon as the plants are visible, 2–4 hoeing passes can take place depending on the weed pressure. Use finger weeders as much as possible. Pay attention to the width of the unhoed area.

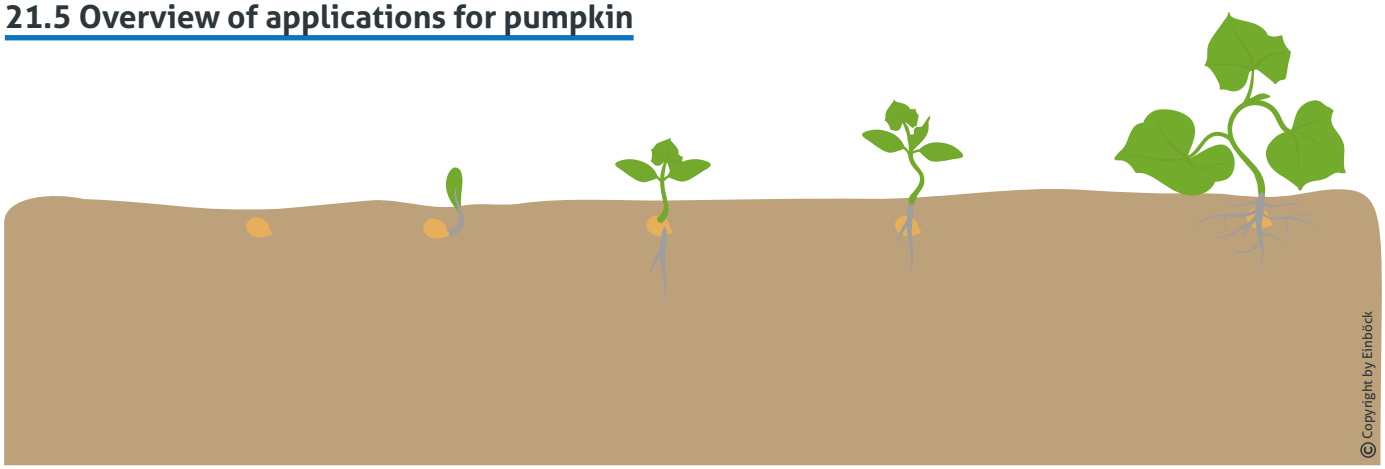
Pumpkins are sown immediately after maize has been sown as long as the soil temperature is above 10 degrees.

21.4 Mechanical weed control in pumpkins: The TOP 5

1. Pumpkin makes a good addition to crop rotations. It is well suited as a preceding crop for cereals.
2. The soil should have good water-bearing qualities and have good drainage.
3. The soil must be covered until sowing of pumpkins.
4. Blind weeding must not go too deep.
5. When hoeing, make sure you use finger weeders.

Do not blind weed too deeply as pumpkins lay flat.

21.5 Overview of applications for pumpkin



Tined weeder	
Hoeing machine	2-4 passes incl. finger weeder

as required | Recommended

22. MECHANICAL WEED CONTROL IN RAPESEED

Rapeseed enhances soil structure, making it particularly valuable in crop rotations. Mild loamy soils and soils with good, deep root penetration are particularly suitable. Rapeseed cannot be grown in areas with compacted soil and waterlogging. Whereas deep, nutrient-rich fields with a pH value between 6.5 and 7, and which benefit from rapid warming in spring are perfect. The basic rule is: A soil that is suitable for wheat is also suitable for rapeseed.

Rapeseed roots deeply and loosens soil meaning following crops grow more easily. These deep roots also allow rapeseed to access nutrients (even from deep soil layers) and leave them behind in harvest residues for the following crops to benefit from. For this reason, wheat, barley and rye are often grown after rapeseed. Rapeseed requires a lot of nutrients; therefore a good supply of nitrogen is important. This crop also requires a good supply of lime.

Pests and disease constitute the main risks for organic rapeseed.

22.1 Crop rotation

The preceding crop requirements are relatively high in terms of N. It is important the preceding crop is sown early to allow enough time for tillage and sowing. Cultivation breaks of 6 years are required and care must be taken with crops in the rotation such as soy and sunflower which are susceptible to sclerotinioa. Avoid including sugar beet in this crop rotation as rapeseed acts as a host plant for the beet cyst nematode. Successful cultivation relies on rapid early development in autumn, and this requires sufficient nitrogen. Preceding crops such as clover grass, grain legumes and winter barley help perfectly in this respect.

Companion sowing/undersowing

Companion sowing plays a key role in securing successful organic rapeseed cultivation. Good choices made at this point increase soil fertility and increase the soil's yield capacity in a sustainable manner. In practice, companion sowing only works when rapeseed is grown in row, as companion sowing goes between the rows. Companion sowing is suitable for drilled rapeseed, but low weed pressure must be ensured for this to be successful.

- Companion sowing results in covered soil, which in turn results in reduced weed pressure.
- Nitrogen-fixing plants in the companion crop such as legumes, absorb nitrogen in the air, store it and release it for the rapeseed, thus increasing the rapeseed's supply.
- Plants like oil flax, lupins and legumes with mycorrhizal symbiosis can be chosen to promote soil life. This is required because rapeseed is a cruciferous plant and as such, does not perform this symbiosis.
- In autumn, plants freeze for the winter and form a mulch layer which protects against soil erosion. This turns into humus in spring.
- When growing rapeseed, it is crucial to promote strong autumn plant growth, and to prevent uncontrolled sprouting. This will result in resilient overwintering and a successful harvest.
- In autumn, the flea beetle can cause significant damage to this crop. Sowing a companion crop can act as a diversion and this protective measure has great value. Flea beetles cannot spread as rapidly, and they infest both the rapeseed and the companion crop.
- Ideal companion seeds: mungo, horse beans, alexandrine clover, linseed, lentils

Phacelia would make a good companion seed, however it should not be included in the mix, as together with rapeseed, they encourage each other to sprout.

22.2 Sowing

Standard seed drills can be used as well as single grain seed drills for rows. The ideal sowing time is mid to late August. The seedbed should be fine-crumbled and nicely settled. Early sowing allows the plants to absorb nitrogen and promotes plant growth so that they can overwinter better. The aim is for these plants to overwinter as well-developed rosettes with 8 to 10 (0.31 to 0.39") leaves, a root crown diameter of a minimum of 8 to 10 mm (0.31 to 0.39") and a taproot length of 15 to 20 cm (5.90 to 7.90"). Rapeseed should not bolt before winter. The higher the root collar, the greater the risk during winter.
The shelf depth should be approx. 3 cm (1.20") - depending on water supply, this may vary. If there is sufficient water, the crop should be placed relatively shallow. If there is less water available, placement should be a little deeper.

Plant rapeseed in wide rows of 25 - 50 cm (9.80 - 19.70") to make hoeing possible.

22.3 Mechanical weed control in rapeseed

1. **1-2 weeder passes before sowing:** Good soil cultivation is important here. Soil is usually ploughed, as blind weeding is often tricky due to the shallow sowing depth of rapeseed. Weeding too early after emergence can damage these plants. We suggest weeding once or twice pre-sowing.

2. **Weeding after emergence:** Only gentle use of the tined weeder is possible after plant emergence, and without a lot of pressure. This makes results unconvincing. It is therefore often possible to avoid a weeder pass altogether.

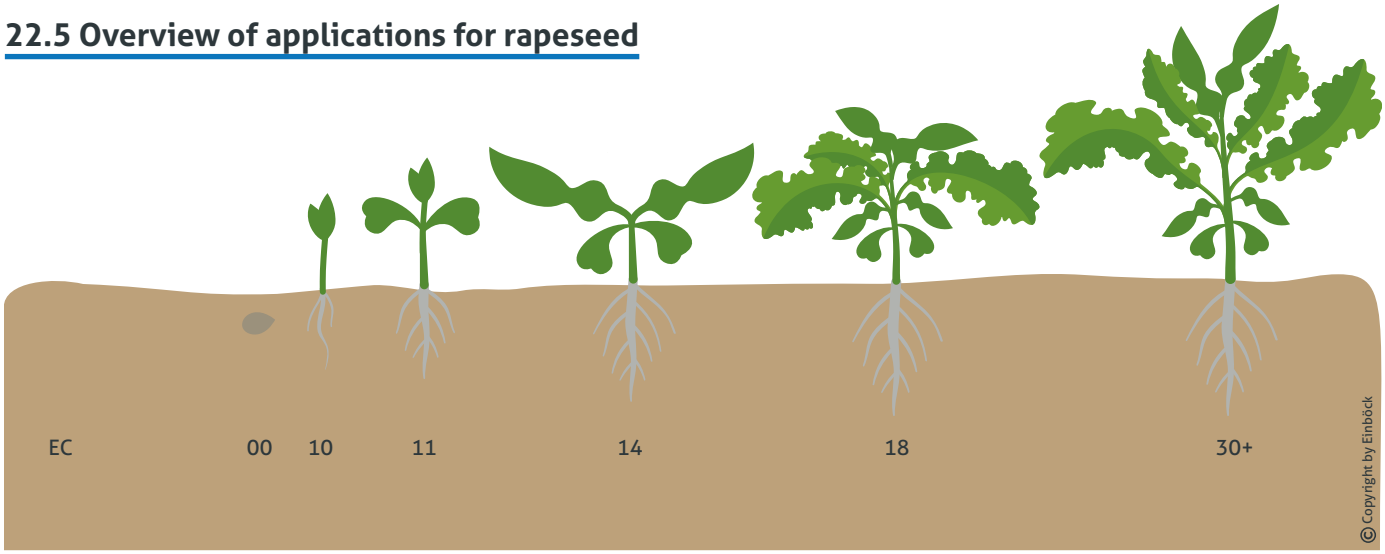
3. **Hoeing:** If the rapeseed has been sown in rows, hoeing can control weeds, and this has proven effective. Recently, row spacings of 25-50 cm (9.80-19.70") have become standard. When wider row spacings are chosen, rows do not entirely close, meaning weeds can grow through on a continuing basis. One or two hoeing passes should be carried out in autumn and another in spring if necessary.

Tined weeding of rapeseed is tricky and requires precision.

22.4 Mechanical weed control in rapeseed: The TOP 5

1. Adhere to growing breaks (crop rotation).
2. Do not include cruciferous and sclerotinia-susceptible crops in the crop rotation.
3. Companion sowing helps with weed suppression and the development of organic rapeseed.
4. A fine, level seedbed is important.
5. Blind weeding is extremely demanding.
6. When sown in rows, the hoe can be an effective weed control measure.

22.5 Overview of applications for rapeseed



23. MECHANICAL WEED CONTROL IN PEAS

Grain peas bind nitrogen from the air and add it to the soil, promoting soil life. This makes this crop a good preceding crop to cereals and potatoes. Peas have a symbiotic relationship with the nodule bacteria that colonise their roots. This bacteria utilises the pea's root excretions, while binding nitrogen from the air. The pea then uses the nitrogen to grow and form protein, meaning the pea does not require any extra nitrogen fertilisation when cultivated.

For optimum growth, peas need nutrient-rich, light to medium-heavy soil, sufficient sunlight, and a constant supply of water. Very light sandy soils and very heavy clay soils are not suitable. Good soil aeration is vital as is supports the formation of the nodule bacteria, which ensures the yield will be high. During germination and flowering, water supply is extra important, however take care that the soil does not become waterlogged. For a high yield harvest, make sure there is adequate lime available in the soil. The pH value should be above 6.

23.1 Crop rotation

Grain peas make few demands on the preceding crop, and are usually grown after a second or third crop. Clover grass, grain legumes and catch crop legumes are not suitable as preceding crops, however cereal, maize and potatoes are. Fields must be free of couch grass and other weeds.

This crop leaves behind a good soil structure, and their harvest, removes around 40-60 kg of nitrogen/hectare. Good following crops include barley, wheat, triticale and potatoes. Cultivation breaks of more than 6 years need to be ensured, as peas are self-incompatible.

23.2 Sowing

When to grow peas depends on the weather and region. It generally occurs between the end of February and the beginning of April. Early sowing is beneficial as long as the soil is sufficiently dry, warm and drivable. This crop is extremely sensitive to soil smearing and soil compaction. It also reacts poorly to frost, therefore should not be grown too early in the year. Avoid soil compaction and waterlogging in the field.

The recommended sowing rate is 70-90 seeds per m^2. The usual guidelines apply: Increase the sowing rate by 10% to compensate for weeding losses. An even and finely crumbled seedbed is important. The sowing depth should be 4-6 cm (1.60-2.40") due to the high water demand of this crop. Ensure uniform, deep seed placement to ensure good weeding results.

Peas can be grown as a mixed crop with oats, or even better, barley, due to their similar maturation rate. The additional crop then acts to suppress weeds, which can be a problem for peas as they grow slowly when young. The peas then return the favour for the second crop and protect against late weed infestations, leaf fall, and provide support for stored cereals.
As a result, peas are often grown in a mixed crop. See the section "Undersowing and mixed crops".

Increase the sowing rate by 10% to compensate for weeding losses.

23.3 Mechanical weed control in peas

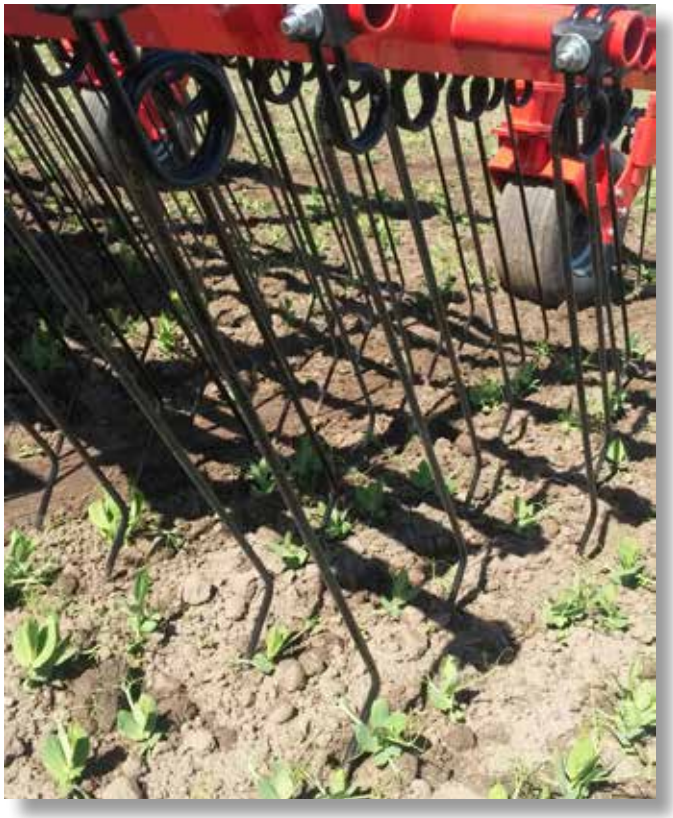
1. **Blind weeding:** This should take place 4-6 days after sowing. It is important that the first weeds are controlled shortly after the sowing date as the peas are sown deeply and grow slowly when young. Weeding should be careful and should be carried out during higher daytime temperatures or around midday.

2. **2nd tined weeder pass:** after crop emergence. Do not weed before this point as peas are sensitive to mechanical interventions. Peas should not be weeded until they reach the 3-leaf stage. Once they are 5-10 cm (2-3.90") tall, any damage is minor and even buried plants can keep growing.

3. **Hoeing:** As soon as the camera registers the plant row, carry out 1-3 hoeing passes depending on requirements and weed pressure (this is only possible with large row spacings). Finger hoes are very effective when controlling weeds in rows of peas. **CAUTION:** be gentle and avoid burying the peas.

4. The rotary hoe can break any crusts pre-weeding ensuring that this pass is efficient.

5. **Additional tined weeder passes:** Depending on the weather, plants can be weeded until their tendrils start to meet. Once the peas bolt however, weeding is not possible as plants can easily be caught in the tines and pulled out.



Do not entirely cover grain peas with soil.

The rotary hoe can break crusts during early crop growth.

23.4 Mechanical weed control in peas: The TOP 5

1. Peas need a deep, light to medium-heavy soil.
2. Sow only if the soil is sufficiently dry.
3. Blind weeding is very important due to peas' slow juvenile development.
4. Hoe as soon as the camera recognises the plant rows.
5. Avoid weeding from crop emergence to the 3-leaf stage.

24. SUMMARY

24.1 The key factors in organic farming

The future of organic farming looks very promising due to the growing demand for organically produced food and the increasing need for environmental protection and sustainable agriculture. The key trends and aspects of organic farming:

- **Increasing demand for organic products:**
  The demand for organic food and raw materials is increasing around the world, resulting in a rise in the cultivation of organic crops to fulfil consumer needs.
- **The promotion of soil health:**
  Organic crop farmers rely on diverse crop rotations to promote soil health and avoid the use of pesticides. This involves cultivating different plant species in successive years to protect the soil and promote biodiversity.
- **Use of catch crops:**
  Catch crops such as legumes and clover are increasingly grown as they enrich the soil with nitrogen, suppress weeds and improve the soil's structure.
- **Mechanical weed control:**
  Organic farms rely on innovative mechanical approaches to weed control. Organic farming yields are increasing thanks to ever more precise weeding and hoeing technology and practical knowledge of these methods.
- **Precision agriculture:**
  Organic farmers are increasingly making use of modern technologies such as GPS, cameras and sensors, helping them to use their resources more efficiently, minimise costs and increase yields.
- **Cooperation and knowledge sharing:**
  Increasingly, organic farmers are working together to share knowledge and resources, encouraging them to share experiences and support the development of sustainable practices.

Agriculture is continuing in the trend towards environmentally friendly and sustainable practices, which support soil health, reduce chemical usage and promote diversity in agriculture. Many governments and institutions are supporting organic farming with financial incentives and funding for research. In the agricultural technology sector, mechanical weed control is growing in importance.

24.2 Organic farming: The TOP 10

1. To improve soil in a targeted manner and to understand more about it, a range of soil samples should be taken each year.

2. Even in conventional farming, an entirely weed-free field and yield is not the aim, and this is just as difficult to achieve in organic farming.

3. Catch crops, companion crops and cover crops cover the soil surface, improve its structure, build up humus and reduce weed pressure.

4. Successful weed control begins long before sowing with crop rotation design and suitable soil cultivation.

5. A varied, well-coordinated crop rotation that has been adapted to the farm's objectives is essential in organic arable farming.

6. It is vital to ensure that the soil is entirely worked, with no unworked areas left behind.

7. In organic farming, successful crop care relies on the sowing date, soil temperature and sowing depth.

8. The correct timing of the weeding and hoeing passes and the appropriate set-up of technology have a decisive influence on weed control efficacy.

9. Choosing the right setting for each field demands experience and courage to try new approaches.

10. Documenting your own first-hand experiences helps your farm continue to develop and grow in expertise.

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Related brochures regarding "organic farming & mechanical weed control":

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