

Einböck

**When crop-care
is joy!**

The FUSION-FARMING Handbook

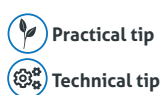
A GUIDE TO A COMBINED WEED CONTROL
MECHANICALLY AND CHEMICALLY TO SUCCESS
WEEDING, HOEING & SPRAYING IN DIFFERENT CROPS



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This handbook will act as your guide, rather than a guarantee for success.
Farmers should gain their own practical experience to achieve the optimum result for their specific conditions.
Do you have any practical tips and experience? Send an email to info@einboeck.at to share your knowledge.

Summary of symbols:



PREFACE



We have been involved in mechanical weed control for more than 40 years and are experts in cultivation and hoeing technology. For a considerable length of time, these practises were 'only' necessary for organic farming, and were therefore only practised by this sector. Over the last few years however, conventional farms have also started to recognise the benefits of cultivation and hoeing and, in addition, the advantages mechanical and chemical weed control offer, specifically when used in combination. It is this combination that we call Fusion-Farming.

In this, our third handbook (we have already published the "Organic Farming Handbook" and the "Grassland Care Handbook"), we have summarised our experiences from the last few years, and hereby pass on all the tips and tricks we have learnt. This manual doesn't just contain our product managers' and consultants' expertise, but also that of countless customers around the world who actively and successfully deploy Fusion-Farming in their fields year after year.

Every region, farm, culture and field is different to the next, therefore the practical instructions and examples we have brought together will not always be applicable, relevant or even appropriate. Instead, this handbook is intended to inspire farmers to think "outside the box". We hope that it will act as a catalyst for the generation of new ideas, so that companies will try out new approaches.

We welcome any feedback and comments, and hope that the first edition of the Fusion-Farming Handbook will help you find the perfect strategy for your farm.

Best wishes from Austria!

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

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1. INTRODUCTION

An increasing global population, shrinking agricultural areas, water shortages and continually changing political guidelines are some of the issues and challenges that modern agriculture faces daily. Agriculture and agricultural technology are continually evolving to meet these challenges as best they can. Our company endeavours to overcome these obstacles by way of a constant stream of new innovations and solutions from and for the field.

New approaches to weed control

In recent years, the methods commonly used to control weeds have repeatedly reached their limits, whether as a result of resistant weeds, the discontinuation of various active ingredients or political requirements. Consequently, the "old" technique of mechanical weed control, which was nigh on forgotten in conventional agriculture, is now increasingly being remastered and brought back to centre stage. The intention is not to do away with chemical approaches, rather to achieve the best results by combining mechanical and chemical processes in order to meet both current and future requirements. Only in this way, can we ensure the ecological and economical production of food in line with the highest environmental and quality standards in the years to come.

Fusion-Farming is the name we have given to this agricultural approach. More and more farms are searching for suitable alternatives to the current system, due to resistance to various active substances and increasingly long dry spells. Mechanical alternatives are being utilised and farms are quick to seize the opportunity to gain experience in combined

processes. When investing in new technology, it is noticeable that great importance is attached to the utmost precision, reliability, quality and durability. Our machinery has met these demanding requirements for decades now. Thanks to continuous updates and the highest quality standards across all areas, from design to final assembly, we are this industry's pioneers.

We do not keep the knowledge we have gained over the years to ourselves, though - we share it with farmers right across the world. This handbook contains an overview of the basics, plus detailed cultivation instructions with practical examples and field reports. We go into important crop-specific points such as crop rotation and sowing, as well as the possible combinations of equipment and methods. There is a section dedicated to each crop, where we go into detail using practical examples from companies already experienced in these areas.

The Fusion-Farming handbook is a valuable resource enabling you to develop a deep understanding of Fusion-Farming principles and practices, while discovering the benefits that go hand-in-hand with this sustainable farming approach.

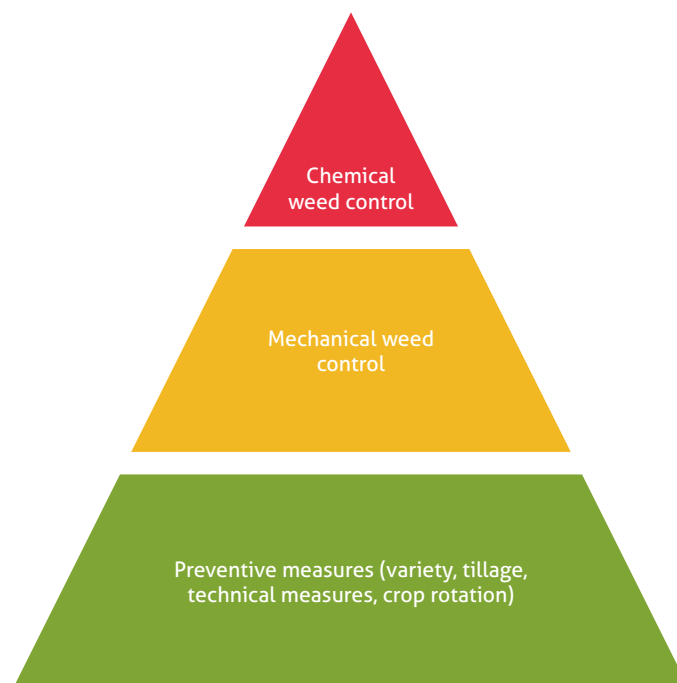


2. FUSION-FARMING WEED CONTROL

Fusion-Farming combines the advantages of organic and conventional farming. By uniting the best solutions from both methods, the efficiency and added value for farmers worldwide will increase enormously.

In Fusion-Farming, we make a fundamental distinction between 2 users. Farmers with crops that have already developed a resistance to pesticides, and those who wish to control weeds mechanically, thereby reducing their usage of pesticides.

Mechanical weed control essentially consists of pulling out, burying or raking weeds. It is useful to note that an entirely weed-free field is not the organic farming method's goal, nor is it the goal in Fusion-Farming. There are a number of factors that must also be taken into account when using the tined weeder and hoe in order to achieve a successful pass. Primarily these include: the crop development stage, location, weather conditions and selection of the appropriate device and device settings.



Fusion-Farming combines the benefits of organic and conventional farming.

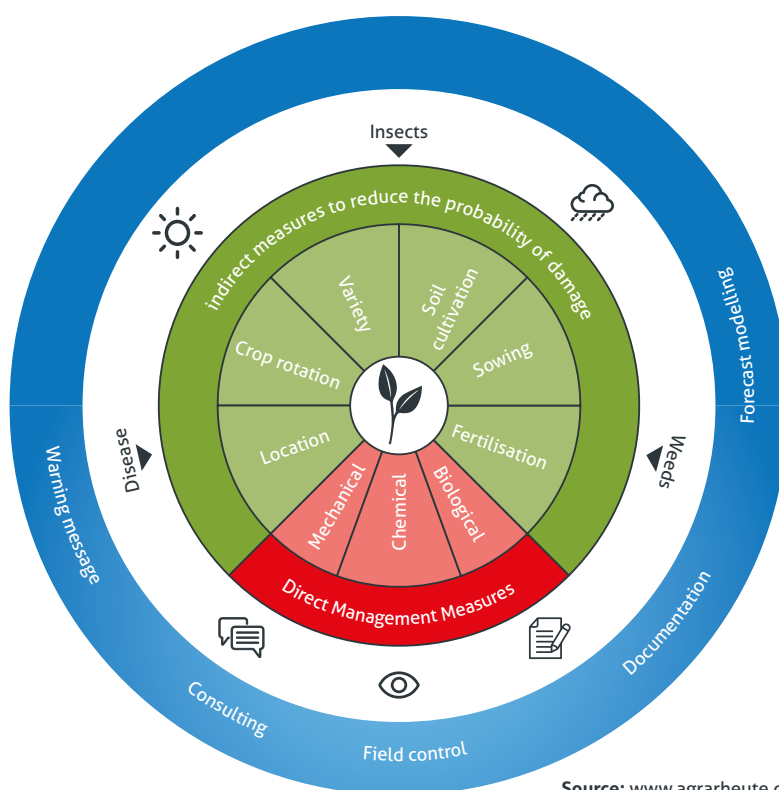


2.1 The combined weed control trend

As agriculture continued to develop and become more efficient it led to an increase in the use of synthetic chemical pesticides. In recent years however, there has been a clear shift towards Fusion-Farming and this is reflected in the decreasing use of chemical active ingredients. This is partly due to political measures such as groundwater protection programmes, however it also reflects growing public demand to limit the use of synthetic chemical pesticides. In addition, this change is being supported by new brand programmes offering farmers the opportunity to access better prices for their agricultural products.

Conventional agriculture often gets caught in the middle of economic and ecological interests due to the use of synthetic chemical pesticides. This leads to the proliferation of weeds, pests and pathogens in monocultures and negatively impacts the normal balance of natural communities. Synthetic chemical pesticides can be used to counteract these adverse effects. Farmers who prefer organic farming however,

rely on mechanical weed control to manage undesirable weeds in their crops. One way conventional farms can be more sustainable in their land management is to combine their farming processes. Accordingly, the available non-chemical plant protection measures are applied first, before farmers turn to chemical-synthetic agents. This results in the same yield (or better!) being achieved at a lower cost than when a chemical approach is used in isolation. In addition, pesticide usage can then be significantly reduced, thus increasing public acceptance.



Source: www.agrarheute.com, 08/2022 edition

2.2 The combined weed control advantages

Important additional "advantages" to practicing mechanical weed control with tined weeders, row-crop cultivators and rotary hoes:

- » Save water - avoid unproductive evaporation
- » Aerate soil - break the crust and support the crop
- » Mineralisation

For more detail, see Einböck's
Organic Farming Handbook.
www.einboeck.at/en/know-how



A single pass when weeding maize, beet or soy = 2 x "the irrigation"!

3. PREVENTIVE MEASURES

Targeted measures can significantly reduce weeds even before herbicides, hoes or tined weeders are used. The appropriate combination of preventive measures makes weed control far simpler.

3.1 Healthy soil

Healthy soil produces healthy plants, which in turn, produces healthy animals and people. Healthier plants also improve feed quality and promote consistent yields. Healthy soil is also crucial when it comes to weed control, even before any plant protection measures (be they mechanical or chemical) are deployed. As a rule, soils with poor structure and low humus content tend to have higher records of trespel, amaranth, mugwort, knotweed, bindweed, couch grass and windthale. A soil that is healthy and balanced inhibits the growth of weeds. Weed seeds are often introduced into soil through a variety of sources, however these too, can be broken down by healthy and undisturbed soil (life), and thus rendered harmless. This forms the foundation for successful weed control long before the sowing stage.

Soil surveys should therefore always be carried out before commencing a soil improvement process. The following details are clarified in the "Soil analysis" chapter in our Organic Farming Handbook:

- » **Suitable soil survey techniques**
 - Spade sample
 - Laboratory analysis
 - Visual plant & crop assessment
 - Earthworm population
- » **What results does the soil survey return?**
 - Is the soil lacking in anything?
 - Does the soil have a surplus of anything?
 - What is the nutrient ratio?
 - What kind of soil is it?
 - Which activities are ongoing?
 - Which activities should I halt?
- » **Indicator plant interpretation**
 - Why are certain weeds present?
 - What measures must be taken to get rid of certain weeds?
- » etc.



For more detail, see Einböck's
Organic Farming Handbook.
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Preventive measures are essential in ensuring that mechanical weed control is successful!



3.2 Crop rotation

Well-planned crop rotation is very beneficial in reducing diseases and pests in the main crop. Appropriate crop rotation is one of the most important tools for successful weed control, optimum plant growth, good soil fertility and a balanced nutrient supply. Good crop rotation alternates stalk and leaf crops, and winter and summer crops, for example. If a farm is struggling with weeds such as goosefoot and melilot, which mainly occur in summer crops, they can simply and effortlessly control this by way of a subsequent cultivation of a winter crop. Crop rotation is therefore vitally important for economic success.

The next section will cover a short summary of crop rotation.

Crop rotation goals:

- » Weed control e.g. Clover grass: Thistle management
- » Maintenance of soil fertility
- » Maximum nitrogen fixation
- » Disease prevention and pest defence
- » Nutrient mobilisation

For more detail, see Einböck's
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Example of winter crop rotation with black grass and loose windthale

Frequent cultivation of winter tillage encourages black grass and loose silky bent propagation. This is because these weeds have adapted their life cycle to the grain and as a result, access the best growing conditions. Their life cycles are interrupted by alternating summer and winter harvesting. A multi-layer crop rotation with a balanced proportion of winter and summer crops and the alternation of stalk and leaf crops makes weed control simpler. This is because the development of

hard-to-control weeds is impaired. This results in a broader weed flora containing weed species that are easier to control.

The following table shows a range of crop rotation approaches and their results.

Crop rotation approach	Result
Maize on maize with reduced tillage	Perennial weed issues
Rapeseed and beet in crop rotation	High herbicide usage due to the need to control volunteer oilseed rape
Rapeseed content above 33%	Problems with cruciferous weeds (rocket species, shepherd's purse, ...)
High proportion of winter grain	Increases problem weeds such as black grass and loose silky bent

Crop Rotation: The TOP 5

- 1 Balanced crop rotation is a crucial tool in weed control.
- 2 Diverse and varied crop rotation promotes the soil's natural abilities and enhances soil fertility.
- 3 Year-round ground cover facilitates permanent rooting.
- 4 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.
- 5 The supply of nitrogen can be improved by nitrogen-consuming plants with nitrogen-collecting legumes.

3.3 Crop selection

Selecting the right varieties is another preventive measure which helps reduce weed pressure. For example, different wheat varieties can suppress weeds in a range of ways due to their various leaf positions. Wheat varieties with flat, widespread leaves (see picture) are particularly effective at reducing the effects of sunlight. This excellent shading visibly affects the growth and cover of weeds. Long stalks and narrow row spacing also increase the suppression of weeds. Root penetration is another criteria when considering plant variety. Soil naturally likes roots. If this is not taken care of by the cultivated plants present, nature takes care of it itself, i.e. by letting unwanted weeds grow. It is therefore worthwhile paying attention to which plant varieties root well in soil. This is beneficial in terms of drought resistance

too, as plants with longer and more extensive roots can access water and nutrients far longer. For example, older cereal varieties have more pronounced root systems than modern varieties. This good root system means that weeds can be better suppressed.

When growing maize, it is logical to choose varieties with strong and, above all, rapid juvenile development to offer competitive strength against weeds.

Crop Selection: The TOP 5

- 1 Appropriate crop selection can significantly influence weed suppression.
- 2 Excellent plant shading visibly affects the growth and cover of weed plants.
- 3 The use of plant varieties with long stems and the application of narrow row spacing increases the suppression of weeds.
- 4 Varieties with strong soil rooting suppress weeds better than those with little rooting.
- 5 If necessary, go for varieties offering rapid juvenile development to increase competitiveness against weeds.



Planophilic leaf position (left) and erectophilic leaf position (right) *

* Source: Mücke 2021

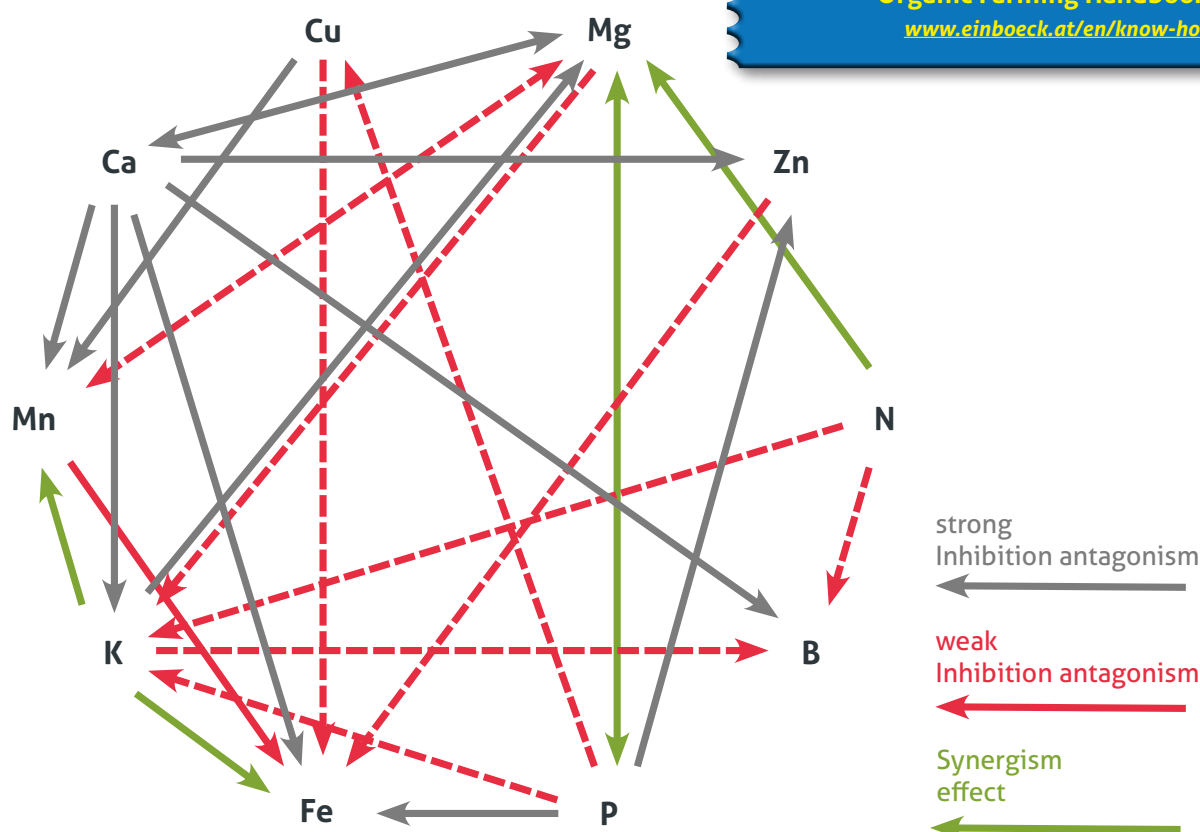
3.4 Nutrient balance

When it comes to nutrient balance, it is important to ensure that there are no nutrient surpluses or deficits. Soil reacts to nutrient surpluses with increased weed emergence. From the point of view of the soil, an oversupply of nutrients in the form of organic matter can be meaningfully utilised. The best results for weed control and yield can be achieved when the soil is balanced in terms of nutrients. Soil surveys are used

to find out how balanced an area is. Survey results can be used to determine the soil's nutrient supply and set appropriate measures.

Nutrient interaction

For more detail, see Einböck's
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For healthy crop growth, the necessary nutrients all need to be available in sufficient quantities at the right time. The ratio of potassium, calcium and magnesium, in particular, plays an important role in nutrient availability. Nutrient imbalances can lead to physiological disorders and symptoms of deficiency, such as leaf discolouration.

Weed	Result
Field bindweed	» Excess potassium due to tight calcium/magnesium ratio
Goosefoot	» Phosphorus availability blocked & potassium availability too high » Enhanced by over-tillage
Amaranth	» Calcium and phosphate blocked » Bare soil can increase the stocking rate
Millet	» Nitrogen indicator, especially on sandy soil » Assisted by a tight calcium/magnesium ratio with low calcium » Occurrence increased with the use of saline fertiliser and years of maize herbicide usage against millet

3.5 Nitrogen dynamics

Nitrogen dynamics must be considered separate to nutrient balance. Every farm's primary goal must be to ensure that no nitrogen is lost or leached from the soil. This can be achieved with various measures such as well-thought-out crop rotation. Care must be taken to ensure that nitrogen introduced into the soil by legumes, for example, is not leached into deeper soil layers, since there it is no longer accessible to crops and can only be utilised by weeds like thistles. Appropriate crop rotation with intelligent intercropping is therefore essential for good nitrogen dynamics.

An additional element in nitrogen dynamics is tillage. Around 95% of the nitrogen in the soil is bound organically in the form of humus. Nitrogen is mineralised with every soil cultivation, meaning that nitrogen is then available to plants, while the humus is broken down. Humus content is therefore another

important element in nitrogen dynamics, since the higher the humus content in the soil, the more nitrogen can be mineralised.

Even the weather can influence nitrogen dynamics. Boosts of nitrogen usually occur after heavy frosts in winter or dry periods in summer. This is because soil organisms, such as bacteria and fungi from the uppermost soil layers, die off during weather events such as these. Afterwards, the organic matter is broken down by the intact soil life of deeper layers. It then becomes available to the plants.

Practical examples:

- » Before planting legumes, there should not be too much nitrogen present in the soil → or the nodule bacteria will not be effective.
- » Nitrogen-boosting crops (legumes) should be followed by nitrogen-consuming crops
- » Nitrogen freely available in the soil (which is highly susceptible to leaching) should be bound by vegetation as quickly as possible

The following table shows the effect of different levels of nitrogen on the frequency of individual weed occurrence:

Weed species	Frequency in %	
	< 50 kg N/ha	> 100 kg N/ha
Shepherd's purse	32	36
Common fumitory	37	27
Knotweed species	33	31
Speedwell species	32	38
Cleavers	23	42
Deadnettle species	24	43
Field forget-me-nots	25	42
Chickweed	29	49
Field pansies	16	42



Every farm's primary goal must be to ensure that no nitrogen is lost or leached from soil.

3.6 Catch crops

Appropriately planned crop rotation using the right catch crops is an effective preventative measure in Fusion-Farming and is often the key to success.

Catch crops, green fallow and mixed crops keep the soil covered all year round safeguarding soil life. Similar to appropriate crop rotation, catch crops can be an effective method to suppress weeds. Catch crop cultivation reduces the seed production of weeds, however, the laws of nature still apply: Diverse, year-round rooting and continuous, vigorous growth.



Weed control in Fusion-Farming using catch crops

To successfully control weeds, soil needs to be quickly covered after sowing the catch crop. Fast-emerging crops such as mustard, buckwheat and mung should therefore be included in an intercrop mix.

It is important not to use these crops in isolation however, as although they quickly cover soil, they have little impact on soil life and structure.

To promote healthy soil, catch crops should be made up of a mix of crops. We generally advise combining different plant families, deep rooters, shallow/fine rooters and legumes. Take caution when selecting intercrop plants, particularly if cruciferous plants such as oilseed rape are included in the crop rotation. In this respect, Phacelia is great to include as a catch crop, since it is not related to any other crop family.



Phacelia is not related to any other crop family and "cleans" the field. It should therefore be included in every catch crop mix.

Living plant matter for weed suppression

Using living plant matter as a weed suppressor is based on the competition between intercrop plants and weeds. Catch crops need light, water, nutrients and space to grow, leading to effective suppression of weeds.

Biofumigation

This is a biological method to reduce pathogens, pests and weed seeds in soil. It primarily makes use of plants with a high glucosinolate content, mostly cruciferous plants. When these intercrop elements are sufficiently crushed and worked into soil, the glucosinolates are converted into isothio- and thiocyanates during the decomposition process. These are gaseous substances and toxic, and can therefore kill various weeds, pathogens and pests.

Allelopathy

This is a phenomenon whereby plants gain the competitive advantage by releasing toxic substances. These can be released through both roots and leaves. When these secreted substances are released into soil, they become active and usually have a germination-inhibiting effect on other plants, even in low concentrations. This phenomenon also occurs with intercropping plants such as phacelia and rough oats, which secrete these kinds of substances, and thus inhibit the germination of other plants. Care should therefore be taken when selecting catch crop mixes.



Catch crops in a nutshell

- » Balanced intercrop 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, germination conditions, N-binding, 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.

3.7 Tillage

Tillage has a significant effect on 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 tillage 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.

Weed control by means of tillage

Tillage affects both soil life and structure, and is also an effective tool in weed control. Soil compaction, smear layers and barrier horizons can be removed through tillage. This increases space for crop roots and helps them develop better, meaning that weeds are better suppressed.

Additionally, each time tillage is carried out, it promotes mineralisation, i.e. the release of nitrogen into the soil. In principle, this supports crops, however if too much nitrogen is mineralised, classic nitrogen indicators such as burdock, speedwell or goosefoot can increase.

Ploughing is a popular soil tillage tool for reducing weed pressure. The entire surface of the soil is worked and turned down to 30 cm (11.80"), burying any weed seeds and pathogens which were to be found on the surface. This results in a clean, weed-free start the following year. Unfortunately, if the field is ploughed the following year, some seed potential will have survived through the year. Ploughing will then bring this back to the surface where it will subsequently germinate once more. Ploughing is therefore very

effective in the short term, but merely postpones the problem for a few years later when used in the long term.

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 tillage that transfers a great deal of power indirectly to the soil, and crushes as little as possible. Cultivators and disc weeder are some of the most important tools in non-rotative 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.).



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

Tillage mistakes

Tillage mistakes can also lead to problems with various weeds. If, for example, a smear layer is created in the seedbed area, burdock weed can occur more frequently, if ploughing when too wet, increased thistle and camomile growth can occur, resulting in a smear layer or plough pan. Cultivated plants cannot root through these and therefore cannot access sufficient water and nutrients. Weeds such as thistle make it through this soil layer and therefore have a larger

nutrient pool and access to more water. In addition, it is important to avoid soil compaction and to maintain soil tilth. Otherwise, root weeds will emerge, such as dock or couch grass.



Tillage mistakes promote weed growth, therefore think carefully about the "consequences" before you begin!

False seedbeds

When conditions are right, "false seedbeds" are possible. 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 once

or twice in between using a seedbed combination or potentially also a tined weeder. This enables weed pressure to be distinctly reduced, particularly during the early stages of the main crop.

For more detail, see Einböck's
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Prepare a false seedbed to control the first wave of weeds before sowing.

4. SEEDBED PREPARATION

To provide a solid foundation for effective mechanical weed control, it is essential to prepare a level sowing area that is well compacted. Seeds should be distributed at a uniform depth so that subsequent mechanical weed control can be accurately and successfully carried out.

In a nutshell

- » **Optimum seed distribution:** To ensure successful seed distribution, sowing conditions should promote germination and ensure even plant emergence.
- » **Fast water absorption:** There should be an even ratio of fine, coarse and medium pores to allow seed roots to deeply penetrate the soil. This will ensure water absorption is quick and easy for seeds.
- » **Suitable technology:** The correct technology is needed to prepare the seedbed well with just one pass. This then also creates the optimum conditions for weeder and hoe usage.
- » **A crumbly seedbed:** Soil should be as crumble and pourable as possible so that optimal tining and weeding can be done.
- » **Perfect preparation:** The aim of seedbed preparation is to create the perfect ratio between fine and coarse soil to counteract silting and evaporation and to retain soil moisture.
- » **Shred organic matter:** To use the weeder and hoe, it is important that there is not too much organic matter present, and that it is well shredded. If not, machinery can quickly become clogged up.
- » **Tool choice:** Using the right tools is essential. Choices should be adapted to the specific soil composition to achieve the best results.
- » **A level seedbed:** In Fusion-Farming, it is important to maintain a level surface after sowing so that tools such as tined weeders and hoes are able to operate at the same depth right across the field.



Take care when using old, worn out sowing technology: row spacing can vary greatly - making subsequent hoeing almost impossible!



For more detail, see Einböck's Organic Farming Handbook.

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5. SOWING

Appropriate sowing is an important component of weed control. In addition to suitable crop rotation, the right sowing rates and periods can also significantly influence the success of a crop and the quality of a harvest.

For maize, soy or beet, for example, sowing on sufficiently warm soil during stable, warm weather with rising temperatures is advantageous. Soil temperatures of over 10°C on the sowing date guarantee rapid juvenile development. This allows the crop to germinate quickly, resulting in rapid juvenile development and giving the crop a significant head start on the weeds.

5.1 Sowing objectives

» **Accurate sowing between rows in preparation for subsequent hoeing** As a rule, sowing is a precise process if you are to ensure an even sowing depth, row spacing and margins. 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.

» **Good compaction** Additional compaction with the help of rollers can help the tined weeder and hoe perform better. Depending on the crop and cultivation method (drill sowing, row sowing, single grain, 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.

For more detail, see Einböck's
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5.2 Sowing: The TOP 10

- 1 Uniform sowing depth: not too deep, not too shallow
- 2 Sow at a deeper depth when blind weeding
- 3 Increase sowing rate to compensate for crop losses
- 4 Coordinate sowing depth, seedbed and seedlings
- 5 Seedbeds should be the perfect ratio of coarse vs. fine
- 6 Ensure precise row spacing
- 7 Seeds should be distributed on a water-bearing layer
- 8 (Soil) temperatures are decisive when choosing a sowing date
- 9 Choose dry conditions when selecting a sowing date
- 10 Where possible or necessary, "compact" soil with a roller

6. FUSION-FARMING TECHNOLOGY

In mechanical weed control, a basic distinction is made between row independent and row dependent techniques. Row independent technology aims to control weed growth in the entire sections, regardless of the row distance. A row independent method is, for example, weeding or crossing with a rotary hoe.

Row dependent techniques focus on weed control between and within the crop rows, including hoeing. The choice depends on various factors, such as the crop, the soil, the climate or the available resources and objectives.

	Row independent	Row dependent
Weeding	<p>Tine & rotative weeder</p>  <p>Rotary hoe</p> 	
Hoeing		<p>Tined row-crop cultivator</p>  <p>Rollstar cultivator</p> 

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

6.1 Weeding technology (row independent)

Tined weeders have been a trusted tool in mechanical crop care for decades, as well as providing an alternative or addition to chemical weed control. Through their successful use with cereals, maize, beets, potatoes, vegetables, peas, soy beans, broad beans, pumpkin,

etc., these tined weeders provide crucial benefits when it comes to crop care.

Their thorough and effective mode of operation makes the tined weeder an essential component of a sustainable farming concept.

Weeding technology in a nutshell





- » Weeding promotes the aeration of soil and tilling, and regulates water balance.
- » Thanks to its mobilisation of nitrogen it also ensures a high-yielding crop.
- » The correct and therefore optimal adjustment settings for a tined weeder depend on the soil and plant conditions as well as the prevailing weather conditions.
- » The ideal tine pressure is achieved by correctly adjusting the tine tilt in accordance with the depth and speed settings.
- » The success of a tined weeder in controlling weeds is primarily accomplished by it burying the weeds in soil at the cotyledon stage (50–70%) in addition to pulling the weeds out of the ground (30–50%).
- » The best time for tined weeding is around midday on a sunny, but windy day, since weed seedlings dry out in the sun and this causes them to die off. It also allows you to drive more intensively because

the cultivated crop is more flexible under these conditions (cell pressure in the plants diminishes). (Take care on subsequent frosty nights: these can increase crop damage)

- » Blind weeding (a few days after sowing, before the crop germinates) often produces very good results and provides another opportunity to control germ tubes from weeds before germination. Virtually all crops should be blind weeded in this way. The best success with weed control is achieved in the tube stage at up to 80%.
- » Whenever possible, a false seedbed should be prepared, as this causes the first wave of weed seeds to germinate, enabling them to be eradicated before seed sowing.



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
			
<ul style="list-style-type: none"> » 2.5 cm (1") line spacing, direct spring-loaded » For cereals, soy, maize, grassland... → Mixed farms » "Simple", economical, efficient, often "sufficient", etc. 	<ul style="list-style-type: none"> » 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. 	<ul style="list-style-type: none"> » 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. 	<ul style="list-style-type: none"> » 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



As the conditions and objectives on each farm are different, the tined weeder must also be adapted to each farm.

For more detail, see Einböck's
Organic Farming Handbook.
www.einboeck.at/en/know-how



Blind weeding

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



Look for germ tubes to recognise when the time is right.

The correct way to carry out blind weeding:

- » Weeding tines "drag" at approx. 90° to the ground surface
- » Tine pressure should enable a suitable working depth (e.g. 2-3 cm / 0.80-1.20"). The exact sowing depth and shoot length determines the maximum depth to which the tined weeder should penetrate the soil.
- » Operating speed approx. 5-10 km/h

When to carry out blind weeding

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



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



For more detail, see Einböck's Organic Farming Handbook.
www.einboeck.at/en/know-how

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 blind weeding 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!



6.2 Rotary hoeing technology (row independent)

Particularly in regions with heavy rainfall, rotary hoes ensure plants are encouraged to grow. The rotary hoe can even replace a tined weeder if started early enough. Generally though, it is an important addition

as a shared machine for organic and Fusion-Farming operations and contractors.

Rotary hoe principles

- » **Good soil aeration:** The rotary hoe breaks up crusts and promotes soil aeration.
- » **Straightforward operation:** Rotor stars (or tools) with their spoon-shaped tips break up crusts and throw up the soil. Weeds are pulled out at the thread stage and deposited on the surface.
- » **High speed:** Rotary hoes can travel at speeds up to 25 km/h and have a high hectare output. This increases the window of time for this process and makes it particularly popular in conventional agriculture.
- » **Prolonged time frames:** Thanks to the 'spooning' action of a rotary hoe, it can be used earlier than other tools such as the tined weeder or hoe, even with higher soil moisture and corresponding passability.
- » **Earlier use possible:** The rotary hoe should be used as soon after rain as possible. This is because dry soil reduces the effect that breaking the soil crust has. Even small timing differences, such as morning operation versus evening can result in a significant difference in result.



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



The hectare output of a rotary hoe is extremely high due to being able to operate at speeds of up to 20 km/h.



For more detail, see Einböck's
Organic Farming Handbook.
www.einboeck.at/en/know-how



The rotary hoe can be used in all standard arable crops such as grain, corn or (soybean) beans.



The 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 tracking
- 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 individual rotor stars must be mounted individually.

6.3 Hoeing technology (row dependent)

Hoeing technology has developed considerably, especially in recent years. Due to the increasing gaps in the effectiveness of herbicides and the further development of resistance in weeds, there is currently a renaissance in mechanical weed control, especially in row-crops.

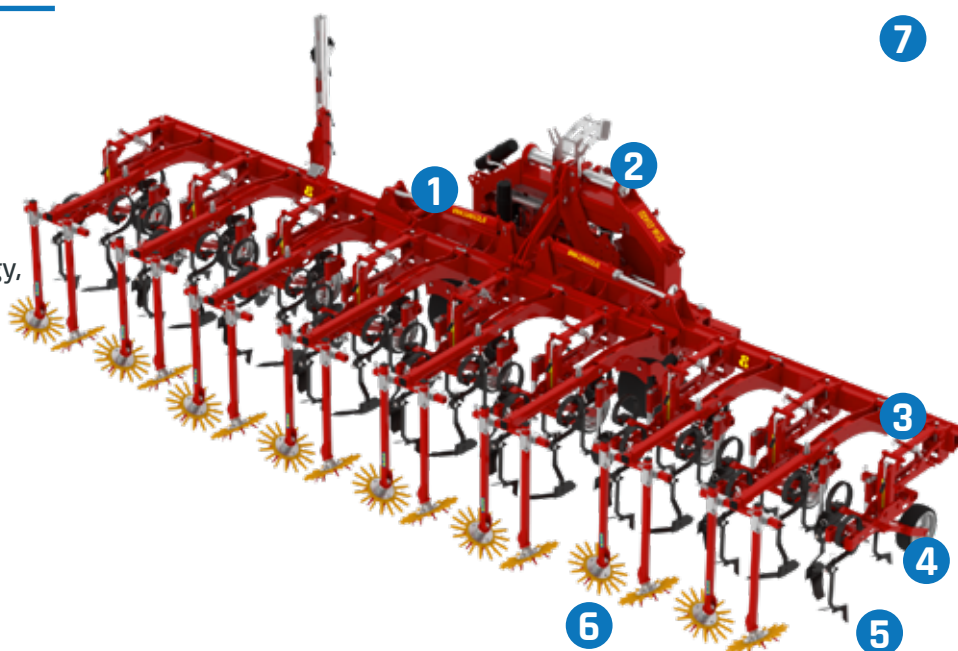
The use of hoeing technology enables savings to be made on herbicide use. Weeds such as goosefoot, camomile, nightshade and chickweed can also be adjusted very effectively by repeated hoeing. Costs

can be saved and work processes can be efficiently combined by using a band sprayer.

In addition to the conventional row distances of 45/50 cm (17.70/19.70") in sugar beet or soybean and 70/75 (27.60/29.50") cm in corn or sunflower, single rows with a distance of 25 cm (9.80") are also common in grain, rapeseed, field beans and peas. The correct row distance for hoeing must therefore be taken into account at the seeding stage. The rows must be parallel in order to be able to work as close as possible to the rows.

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.)



The devices must be suitable for your own business and configured accordingly - prefabricated standard technology is not always the right choice!

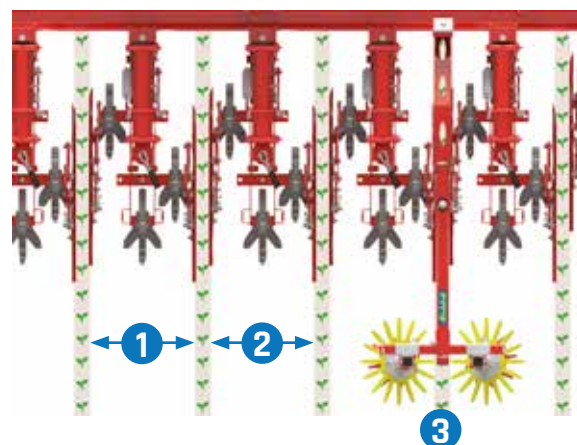


Principles of hoeing

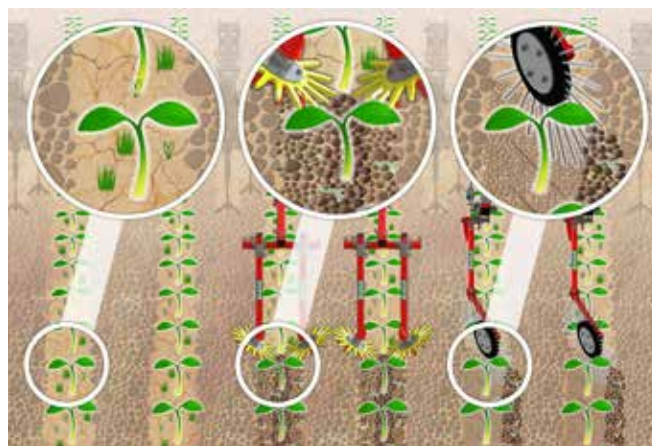
- » **Seeding:** The basic rule is: number of rows sown = number of rows hoed. A row-crop cultivator must always be perfectly matched to the seeder. The number of rows of the seed drill equals the number of rows of the row-crop cultivator (half the width of the seed drill is also possible).
- » **Row spacing:** In addition, the row-crop cultivator's row spacing must be identical to that of the seeding machine. This means that accurate and precise seeding is the starting point for later hoeing success. If the row distances already vary here, it will be difficult or even impossible to work precisely when hoeing.
- » **Headland:** The headland is hoed at the beginning and, if necessary, again at the end, as the weeds that have been hoed out can be pressed down again with the tractor tyres.
- » **Timing:** Start hoeing as early as possible - if weeds are already clearly visible, it is already too late.
- » **Time of use:** As soon as a row becomes visible (2-3 leaf stage), hoeing can begin. Thanks to modern camera technology, it is possible to start hoeing at the cotyledon stage and when weeds are very thick.
- » **Precision:** The closer the hoe gets to the cultivated crop, the better the result. (Protection shields or protective discs prevent spillage on sensitive crops).
- » **Frequency:** Do not overdo it with hoeing - frequent hoeing causes more weeds to germinate, damages the cultivated crop and "disturbs" the soil structure. It is better to hoe at the right time (earlier) than twice at the "wrong" time (too late).
- » **Time of day:** Hoeing should be carried out at midday. Ideally, no rain should be forecast after hoeing.
- » **Working as close as possible to the crop row (= narrow unhoed area) enables great success in weed control:** There are various tools for weeds within the row, such as finger weeders, rotative weeders, ... or the band sprayer.

Hoeing basics

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



Trailed working tools take on tasks such as hilling, spilling, tearing out and "incorporating"!



Hoeing configuration

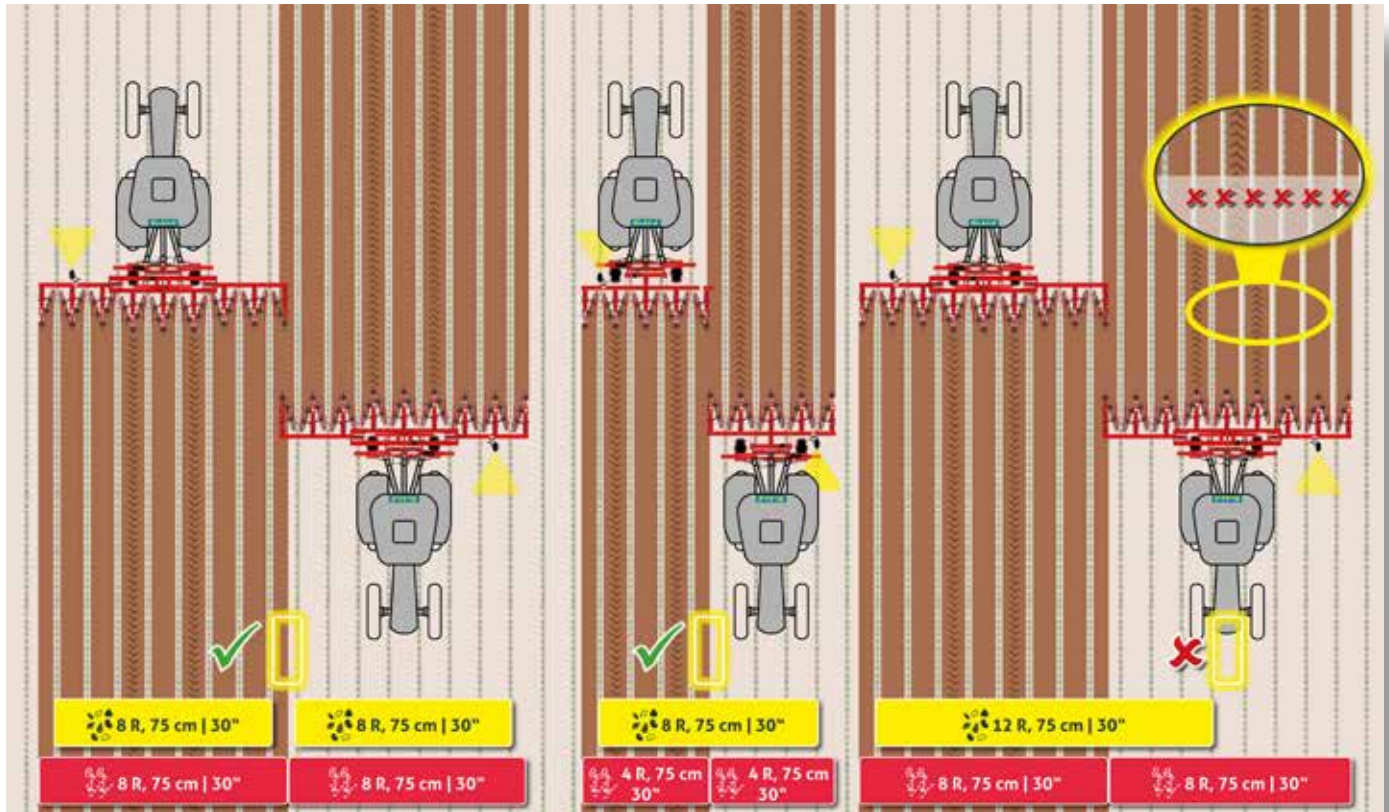
The following points must be answered by working with a consultant or an expert to find the right row-crop cultivator for your farm:



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)

Number of rows outside the track = **UNEVEN** (e.g. 5 rows)

SYMMETRICAL

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.



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!



For more detail, see Einböck's
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www.einboeck.at/en/know-how

6.4 Band spraying technology

Band spraying is an indispensable tool in Fusion-Farming. In contrast to methods which spray large areas, band sprayers spray chemicals specifically on the plants and the soil around them. The spray is therefore applied precisely, minimising the use of pesticides, and reducing the environmental impact. In addition, band spraying combines two processes - both the mechanical treatment between rows and the chemical treatment on rows can be carried out in a single pass. This saves pesticides, diesel, labour and consequently, money.

With its precision, versatility and modern technology, the band sprayer is a prime example of the continual development and innovation that goes into meeting the growing demands and challenges in agriculture.

Einböck technology for band spraying

Einböck's new JUMBO-STREAM is a custom solution that can be used to spread liquids such as pesticides, liquid fertilisers and plant additives. It can be combined with a hoeing tool, meaning processes are efficiently combined, spray rates are reduced and weed control is more efficient. The inbuilt camera ensures that the individual hoes are guided precisely between the rows, and the nozzles are positioned exactly above the rows of plants to be treated. This means that most of the weed management is carried out by the hoe and only a very small area is treated chemically.



Double the benefit with "band spraying". The band sprayer guarantees efficient and accurate weed control within rows, while the hoeing unit ensures removal of late weeds between rows!



Principles of the band sprayer

» Reduction of application rates by up to 70%

All the requirements placed on the Fusion-Farming system are met by the band sprayer: Application rates of plant protection products can be reduced by up to 70% without having to run the risk of a field that is not clean.

» Treatment within the row

The system is clear: chemical agents within the row, mechanical measures between the rows. This limits the application to the cultivated crop and protects the uncovered soil.

» Reduce labour costs

The combination of band sprayer & row-crop cultivator can significantly reduce costs. Instead of two passes (1x with sprayer and 1x with row-crop cultivator), equivalent weed control can be achieved with just one pass.

» Nutrient mobilisation through soil aeration by hoeing

Hoeing breaks open crusts, brings air into the soil and creates a mineralisation of nitrogen. Only the small area where the row of plants is located is the risky area for weed control. Only in this area is the herbicide or pesticide used economically.

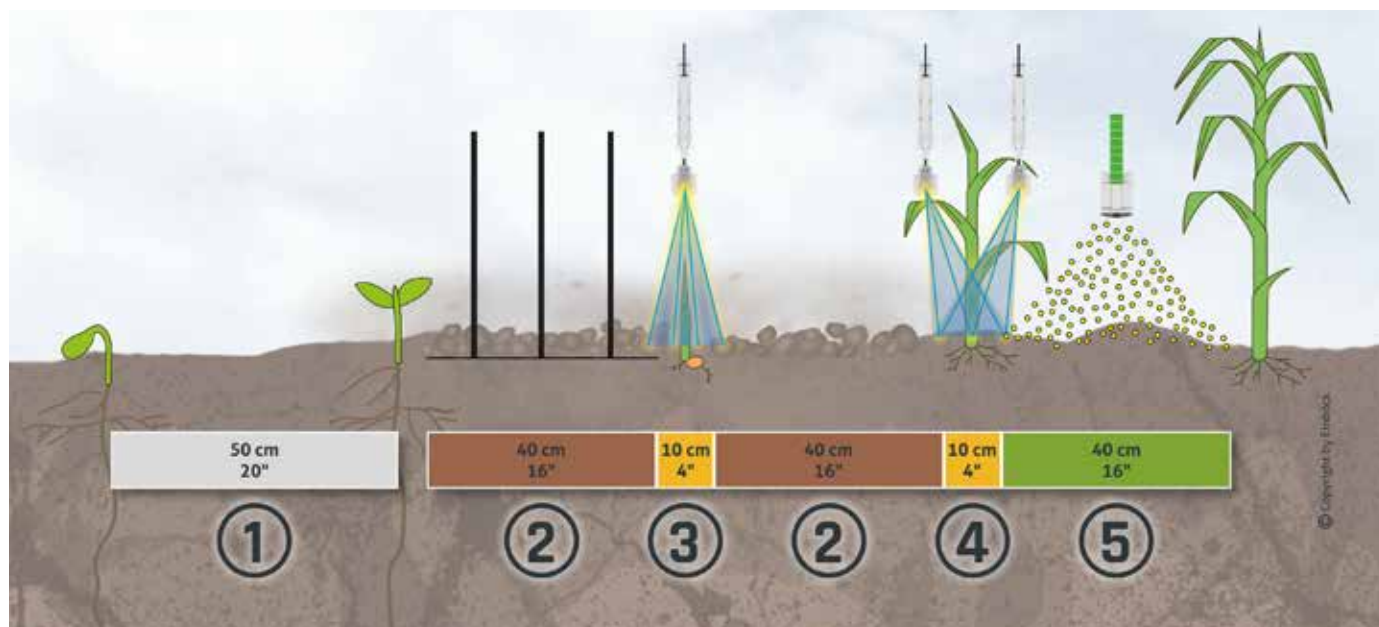
» Creating biodiversity - conserving groundwater

The use of hoeing technology and the concentration of pesticides on only 20-30% of the area creates considerable added value for soil, plants and groundwater. The risk of pesticides being washed into the soil is minimised and spraying only takes place where it is necessary: in the plant row.

» Efficiently designed liquid fertilisation

In combination with the row-crop cultivator, the liquid fertiliser can be placed exactly where it is needed: next to the row. The liquid fertiliser is deposited behind the sweeps in the depot and can therefore be reached by the plant in its entirety.

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



The combination of row-crop cultivator and band sprayer is ideal for Fusion-Farming operations!

Band spraying: The TOP 10

- 1 Efficient and accurate weed control within the row thanks to the band sprayer
- 2 Removal of late weeds between rows with hoeing tool
- 3 Savings on labour and spray costs
- 4 Silt and soil crust is broken up
- 5 Nutrient mobilisation through soil aeration
- 6 Two processes are combined in one pass



Hoeing offers additional benefits such as the break up of silt and soil crust, plus nutrient mobilisation thanks to soil aeration.

7. FUSION-FARMING IN GRAINS

7.1 Preventive culture-specific measures

Crop rotation:

(Winter) cereals are relatively undemanding in terms of crop rotation. The rotation breaks of around 1-3 years should, however, be adhered to so that potential fungal diseases, root diseases and other pests are suppressed from the outset. In addition, the proportion of cereals in the crop rotation should not exceed 60%. Where possible, stalk and leaf crops should also be rotated and incorporated in the crop rotation. Alternating between humus- and N-consuming crops and N-increasing crops is sensible to ensure both humus and nitrogen are balanced.

Sowing:

The sowing date is an important consideration in cereal cultivation. It also determines the variety choice. The sowing date primarily depends on the crop before and the crop rotation set out. As a general rule: the earlier the seeds are sown, the higher the potential yield. If cultivation begin too early however, there is a risk that the crop will overgrow or be attacked by viruses and other diseases. Sowing conditions ultimately determine the exact date as many years of experience have shown. In general, the sowing period runs from mid-September to mid-November, with most sown between the end of September and the end of October.

7.2 Systems and appliances

Broadcast sowing with the classic seed drill is in widespread use for cereal cultivation currently. When using this method for cultivation, only the tined weeder is available for mechanical weed control. The effect of the tined weeder is mainly based on burying and pulling out the small weeds present at this time. At this point, the weeds are at the tube and cotyledon stage. Efficiencies of over 80 per cent per pass can be achieved. However, when the weeds grow larger and have better roots, the desired success diminishes very quickly. Once weeds become too tall, the tined weeder stands little chance of getting them under control. A second, rather uncommon method in arable farming is to sow grain in rows so that the hoe can be used as

a regulating tool for the crop. To do this, a row spacing of 25 cm (9.80") has been successful in recent years, and this corresponds to double the 12.5 cm (4.90") row spacing used for drill sowing. By using the hoe, you gain more flexibility in terms of the sowing date and you can better manage weeds that have taken root. When used in combination with the tined weeder, efficiency significantly improves as FiBL trials from the 1990s show.



7.3 Examples and field reports

Avoiding herbicides is easier with cereals than with any other crop. Weeds are quite easily suppressed by the narrow row widths and the shade cast by the cereals. Normally, one or two passes with the tined weeder are enough to effectively suppress weeds. If there are issues with problem weeds such as black grass in cereals however, the tined weeder used in isolation will quickly reach its limits. Chemical methods are similarly quickly exhausted and do not achieve the desired effect. It is precisely in these circumstances that what can be achieved by a tined weeder and a herbicide when used in combination should not be underestimated.

Tined weeders can support herbicidal measures extremely effectively in autumn and spring. Despite this, and particularly if you have potentially resistant weeds, the herbicide application rate should not be reduced, and the active ingredient group should not be changed. The tined weeder acts as an additional tool to support the herbicides in poor weather conditions. In other words, in isolation, neither process returns the desired success. An entirely chemical approach cannot achieve optimum results - but neither can an entirely mechanical one. When you combine the two however, you create an extremely effective strategy to counter problem weeds.



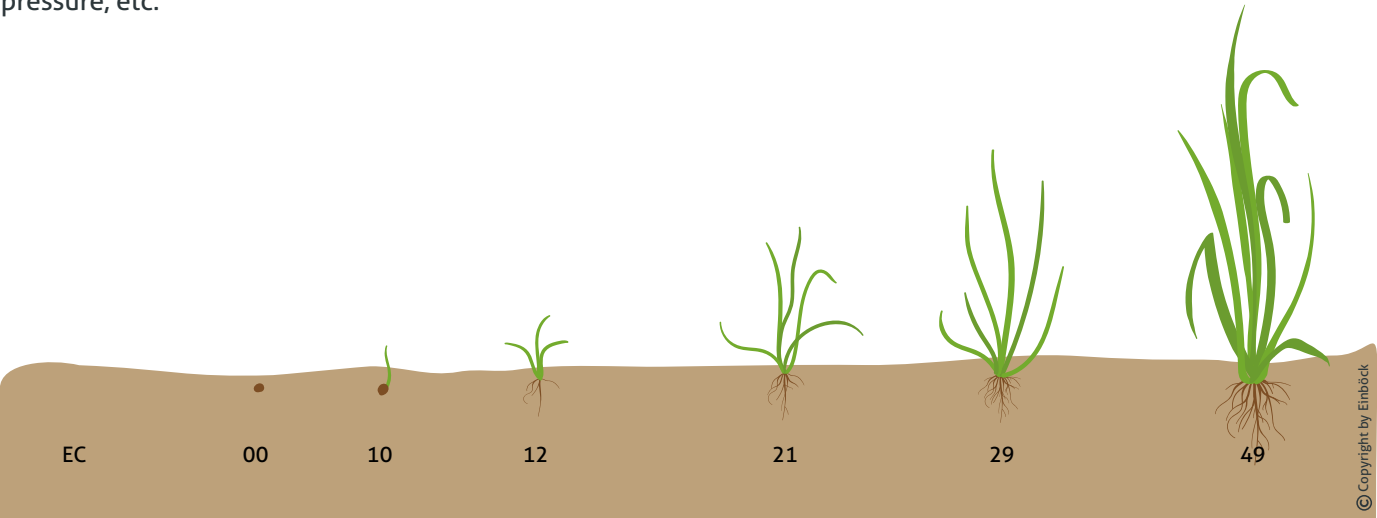
In cereals in particular, mechanical application can increase yields while reducing costs.

For more detail, see Einböck's
Organic Farming Handbook.
www.einboeck.at/en/know-how



7.4 Fusion-Farming cultivation options for grains


The strategies for cereals vary greatly according to the climate region, crop rotation, most common weeds, weed pressure, etc.



Option 1

Tined weeder			
Chemical plant protection			1-2 passes
Rotary hoe			 1-2 passes
as required	Recommended		

Option 2

Tined weeder			
Chemical plant protection			
Rotary hoe			
as required	Recommended		

Option 3 Rotary hoe

Chemical plant protection		
Rotary hoe		
as required	Recommended	

Option 4 Purely mechanical

Tined weeder		
Rotary hoe		 1-2 passes
as required	Recommended	

7.5 Grains Fusion-Farming: The TOP 10

- 1 Maintain growing breaks of 1-3 years (reduces disease pressure)
- 2 Cereal content must not be higher than 60% in the crop rotation. Stalk and leaf crops should be alternated
- 3 The sowing date depends on the variety - the earlier the seeds are sown, the higher the potential yield
- 4 Cereals can be both seed drilled and in rows (e.g. double drilled seed row 25 cm / 9.80")
- 5 Cereals can be weeded or, if grown in wide rows, also hoed
- 6 If there is a lot of organic matter, grain can be worked mechanically with a rotative weeder or a rotary hoe whilst "avoiding pulling the matter together"
- 7 Do not weed during periods of night frosts
- 8 In winter cereals, the rotary hoe breaks the soil crust in spring and offers a jump-start
- 9 Well-rooted weeds can be removed using the hoe
- 10 Using the tined weeder and herbicides in combination is a very effective solution when managing problem weeds (e.g. black grass)

For more detail, see Einböck's
Organic Farming Handbook.
www.einboeck.at/en/know-how



Fusion-Farming strategies for cereals vary greatly across farms!

8. FUSION-FARMING IN RAPESEED

8.1 Preventive culture-specific measures*

Crop rotation:

Rapeseed demands relatively little of the preceding crop. Nevertheless, there are certain important factors to consider. Above all, it is crucial that the preceding crop is quite early to leave enough time before sowing. Next, it is important that 3 to 4 yearly rotations are adhered to, and that care is taken to separate crops susceptible to sclerotinia, such as soy and sunflower.

If a catch crop is planned in the crop rotation, crops such as mustard, oil radish or turnip rape should not be included in the mix. These belong to the cruciferous family, just like rapeseed, therefore increase the risk of disease. Sugar beet should not be grown together with rapeseed, because it acts as a host plant for beet nematode.

8.2 Systems and technology

There are two different sowing techniques that are used in rapeseed cultivation. First, there is the classic broadcast sowing method, second, rows can be sown with spacings of 25 to 50 cm (9.80-19.70").

Mechanical weed control in rapeseed is quite demanding. It is often impossible to use the tined weeder or only with limited effectiveness. The extremely shallow sowing depth makes it difficult to blind weed, while weeding too early in the post-emergence period can damage the plants. The tined weeder can only be used with very low pressure on extremely young plants, meaning that the effect is often inadequate. This is why the tined weeder is rarely used.

Sowing:

Rapeseed is generally sown between mid-August and the beginning of September. The earlier it is sown, the better the autumn development. Unfortunately however, this also increases pest pressure and the risk of above-ground growth increases i.e. it will be in the rosette stage going into winter. This crop should be planted in a levelled and finely crumbled seedbed with sufficient fine soil. The sowing depth should be between 1 and 2 cm (0.40 and 0.80"), while in dry areas, they should be sown a little deeper (3-4 cm / 1.20-1.60"). Particular attention should be paid to rapid juvenile and spring development to achieve complete ground cover quickly.

When rapeseed is sown in rows, mechanical weed control using a hoe is possible. This technique is especially recommended for heavier soils with higher weed growth. Weeds and weed grasses between rows can be efficiently managed with the hoeing unit alone. When the hoe is used in combination with a band sprayer, management can also be carried out within the row.



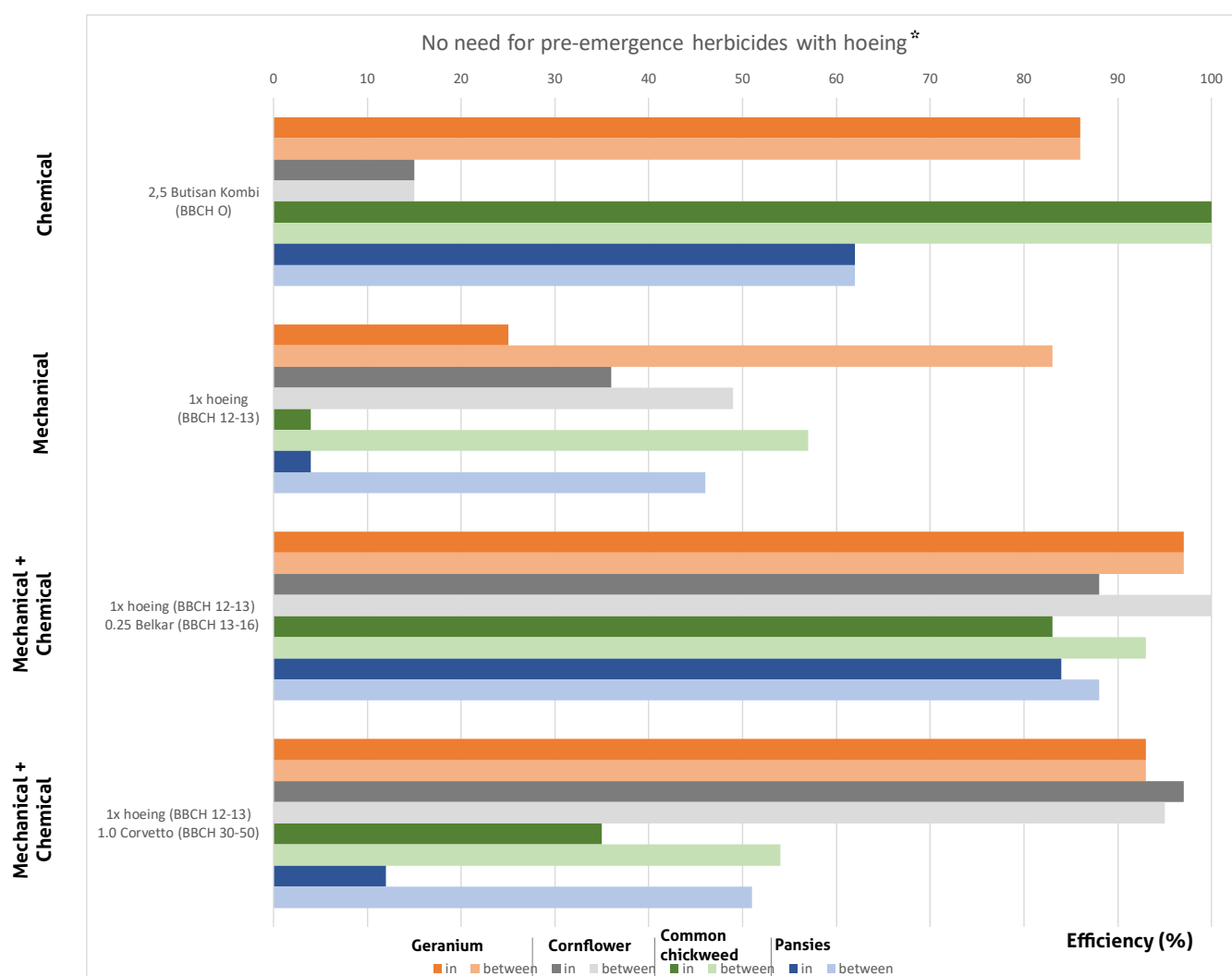
* Source: KWS: The sowing method in rapeseed - Sowing - Advice - KWS Austria Saat GmbH

8.3 Examples and field reports*

Trials were carried out in Thuringia, to evaluate whether the widely popular pre-emergence spraying could be replaced by mechanical processing. During trials, pre-emergence spraying was replaced by a hoeing pass. Between the rows, results were good, however within the row, results were inconclusive.

For this reason, the trial combined mechanics with chemistry. A band sprayer was mounted on the hoeing machine so that the hoe could be used between rows and chemicals could be used within the row. This made it possible to avoid further chemical treatment in post-emergence areas with relatively low weed growth. The

single hoeing pass was sufficient. Accordingly, hoeing in combination with a band sprayer is a good way of controlling the first weeds, weed grasses and lost crop seed, without the need for pre-emergence herbicides. An additional benefit to this approach is that it can also be used to control volunteer rape emerging between rows.

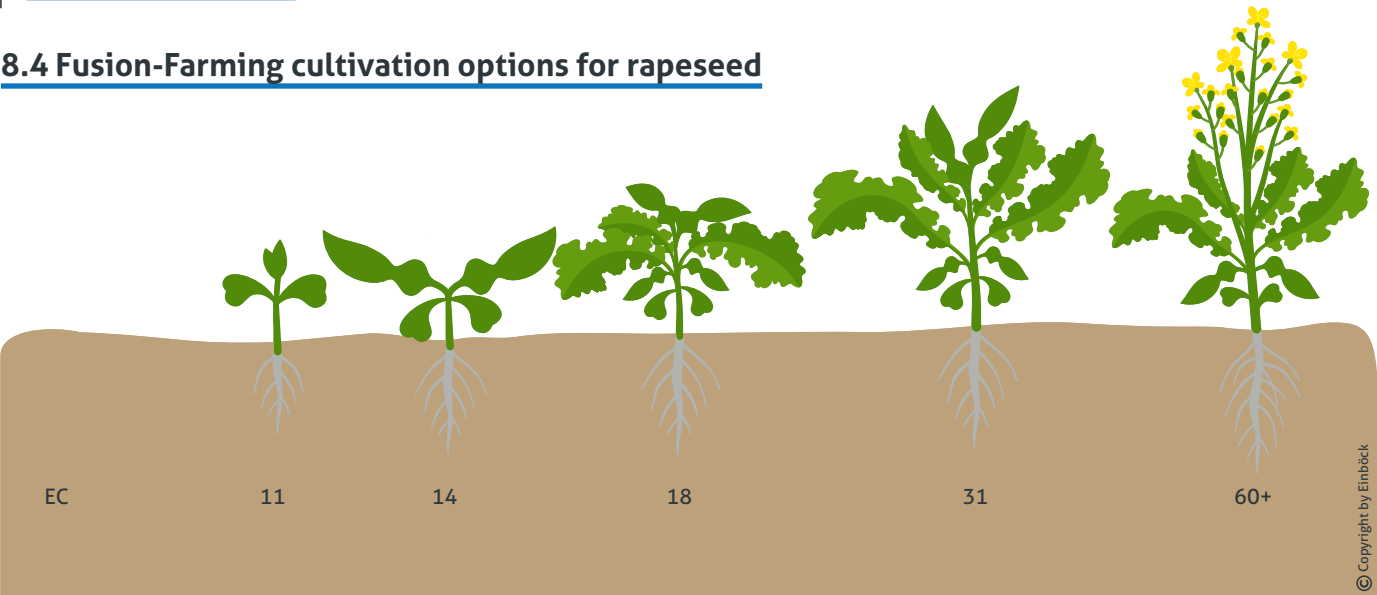


Application rates in litres/ha; comparison of selected variants for controlling weeds in winter oilseed rape, Thuringian trials 2020 to 2022, n = 2 to 4, in = in the row, between = between the row; source: Ewert, TLLLR



Rapeseed is difficult to weed, however it is all the better for hoeing.

8.4 Fusion-Farming cultivation options for rapeseed



Option 1



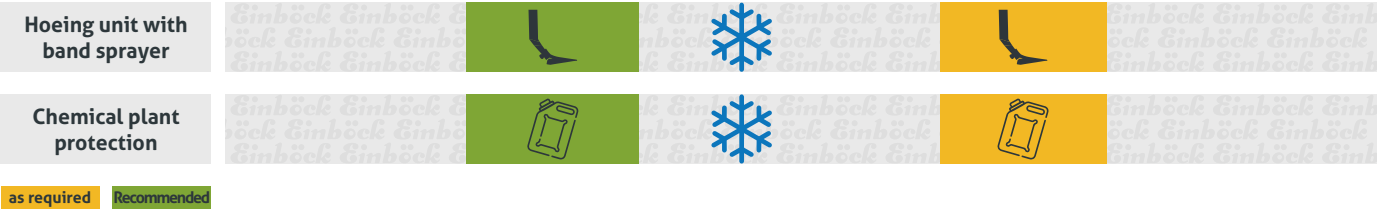
Option 2



Option 3



Option 4 Band spraying



8.5 Rapeseed Fusion-Farming: The TOP 10

- 1 Adhere to crop rotation breaks
- 2 Do not include cruciferous plants in the crop rotation
- 3 A fine, levelled seedbed is important
- 4 Broadcast sowing is more demanding than row sowing
- 5 Rapeseed cannot be blind weeded
- 6 Use the tined weeder with caution
- 7 Hoeing achieves good results between rows
- 8 In-line working is possible, when in combination with a band sprayer
- 9 Pre-emergence spraying can be entirely avoided by using the hoe and band sprayer in combination
- 10 Rape seedlings can be effectively controlled between rows (this is not possible with chemicals)

For more detail, see Einböck's
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Strategies can change during the season and sometimes need to be adapted depending on the weeds.

9. FUSION-FARMING IN SOY

9.1 Preventive culture-specific measures

Crop rotation:

The soy bean makes few demands on the preceding crop. Crops that effectively suppress weeds that love warmth, such as winter cereals or sugar beet, are particularly suitable as preceding crops. Pests and diseases caused by crop rotation are also extremely rare. Nevertheless, a break of at least 2 years is recommended. A break of 3-4 years should be maintained with other legumes. A low proportion of nitrogen content in the soil is also important. This makes field forage mixes with legume content (clover) that are ploughed in spring unsuitable as a preceding crop.

Sowing:

The soy bean has a number of requirements: in addition to a need for high temperatures from May to September, it also requires a light soil that warms quickly. Heavily weeded soils should be avoided at all

costs as the soy bean is not very competitive. Due to its high temperature requirement, it should only be sown when the correct soil temperature of approx. 10 °C has been reached. It needs plenty of warmth from May to September as well as a good water supply (especially from June to August).

Between sowing and when the plants have grown the first leaves, the soy bean must be protected from bird damage. Crows and pigeons sometimes peck the seeds out of the soil or pull germinated plants out of the ground. This can cause serious damage. Early deterrence should therefore be carried out. Once plants have grown larger birds no longer cause damage, but attention must then be paid to potential damage from deer or hares.

9.2 Systems and technology

When soy is chemically treated, a pre-emergence herbicide is usually applied. However, if this is not effective due to unsuitable weather conditions, a post-emergence treatment can still be carried out. It is important to note that growth depression can occur in soy after chemical treatment, however. Depending on the weather, this can be more or less significant and can delay soy development for up to a week.

Mechanical means can keep soy can be kept relatively clear, however. It can be weeded or, if sown in rows, hoed. This has the advantage that even well-rooted weeds can be treated effectively. To achieve this, row widths of up to 50 cm (19.70") have proven successful. When rows are wider (e.g. 70 cm / 27.60" for maize), it takes too long to close the row meaning weeds

continue to return, and are difficult or impossible to remove from the crop. When sown with a classic drill, the hoe is not used and only the tined weeder remains. Drill sowing, however, offers the benefit of faster row closure. The fact that there is no growth depression speaks definitively in favour of mechanical weed control. This can be particularly advantageous in autumn, because the soy can be harvested earlier and dry, often making subsequent processing and sowing easier.





9.3 Examples and field reports*

In co-operation with Manfred Steindl, a farmer from the Braunau district, Maschinenring Oberösterreich set up a practical trial. They established four plots, each processed using different methods. The first plot was sown at 50 cm (19.70") in rows, then hoed. The second plot was also hoed, but with a row spacing of 70 cm. The third plot was planted with the drill and cultivated with the tined weeder. The fourth plot was also planted with the drill, plus the traditional method of using chemical-synthetic pesticides. The sowing rate and time were the same for all four plots. Results showed that the weeded and hoed plots were extremely effective at 50 cm (19.70") and were in no way inferior to the chemical method. The hoed plot with 70 cm (27.60") row spacing was unconvincing,

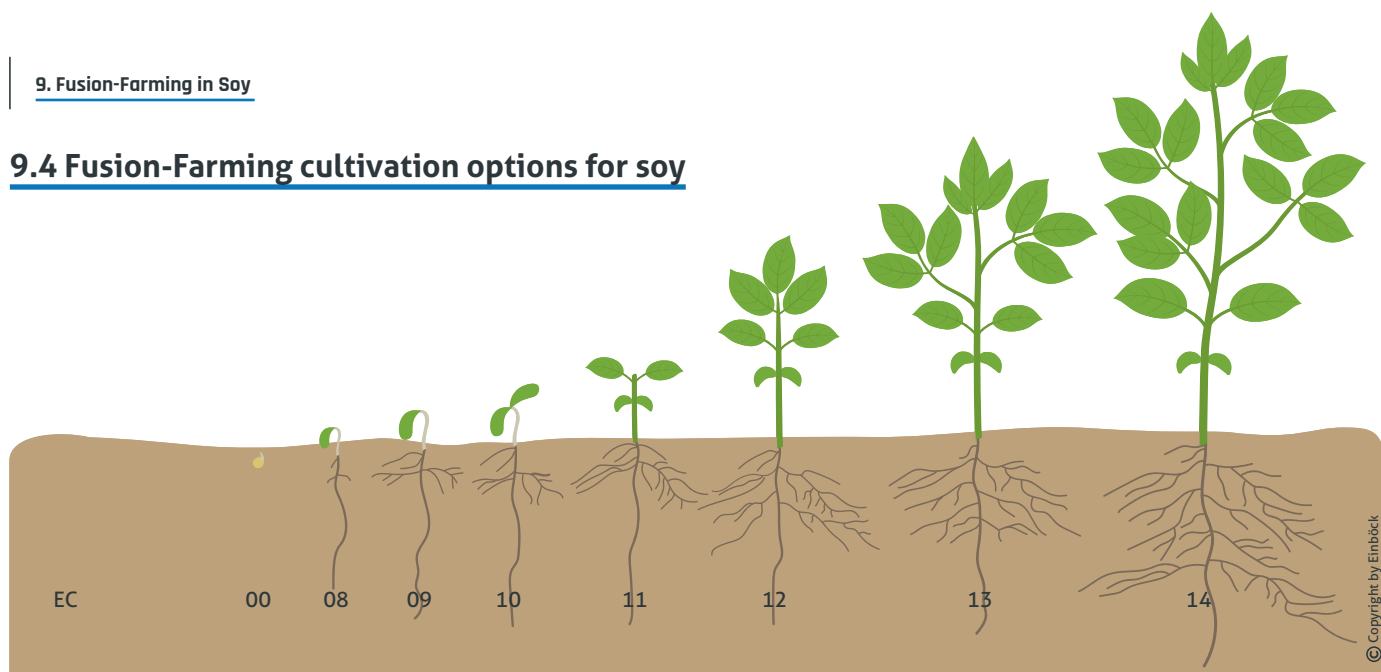
as row closure occurred very late and the attempt to eliminate the weeds with a late hoeing pass failed. The trial demonstrated that avoiding chemical pesticides in soy cultivation had no significant effect on yield. It did offer the advantage of having no growth depression, as was observed on the plot which had been chemically treated.

An evaluation carried out after the harvest revealed the following yields *








Cultivation variant	Yield in kg	Area in m ²	Moisture yield in kg/ha	Moisture in %	Dry yield in kg/ha	Pruning in %	Final yield in kg/ha
Standard	728	2847	2557	13.6	2539	0	2539
Hoe 70 cm (27.60")	794	2847	2789	15.2	2718	30	1903
Hoe 50 cm (19.70")	753	2847	2645	12.7	2654	5	2521
Weeding	716	2847	2515	13	2515	0	2515

* Source: Roman Braun, „Sojaanbau ohne Chemie – geht das?“, in Maschinenring Zeitung Oberösterreich, issue 05 – March 2023, page 26-27

9.4 Fusion-Farming cultivation options for soy



Option 1 Purely mechanical

Tined weeder		 gentle	 1-2 passes
Rotary hoe			
Hoeing machine		 incl. finger hoe or rotative weeder	 Hilling
as required	Recommended		






Option 2

Chemical plant protection		
Rotary hoe		
Hoeing machine	 incl. finger hoe or rotative weeder	 Hilling
as required	Recommended	

Option 3 Chemical and weeding (row sowing)

Tined weeder		 1-2 passes
Chemical plant protection		
as required	Recommended	

Option 4 Band spraying

Tined weeder		 1-2 passes
Chemical plant protection		
Hoeing unit with band sprayer		 Hilling
as required	Recommended	

9.5 Soy Fusion-Farming: The TOP 10

- 1 Adhere to crop rotation breaks of 2-4 years. Nitrogen content in the soil should be low
- 2 It is relatively weak in competition (not suitable for heavily weeded areas)
- 3 Growth depression can occur with chemical treatment
- 4 Observe soil temperatures and definitely inoculate seeds
- 5 Soy can only be weeded when broadcast sowing. It can be weeded AND hoed in row sowing
- 6 Blind weeding is extremely effective the first days after sowing
- 7 If the soil is compacted, the rotary hoe can break up the crust and aerate the soil
- 8 Soy can be buried in the 2-leaf stage
- 9 Aggressive work can be carried out within the row using a rotative weeder or finger hoe, as the soy plant is well rooted in the later stages
- 10 Weeding and hoeing produces the same yields as an entirely chemical treatment

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Soy is easy to manage mechanically, so pesticides can be avoided.

10. FUSION-FARMING IN MAIZE

10.1 Preventive culture-specific measures

Crop rotation:

Maize makes no specific demands when it comes to crop rotation. It is one of a range of crops that is self-compatible, so it can be integrated into both grain crop rotations and rotations with a high proportion of leafy crops. Maize is particularly useful in crop rotations heavy in cereals, as it does not transmit crop rotation diseases of the main cereals.

We advise caution when following maize with wheat in a crop rotation. Any maize crop residue must be well hoed and good rotting must be ensured. If this does not take place, the Fusarium pressure will increase sharply after wheat.

Sowing:

When you sow maize, take care to ensure that the soil temperature is at least 8-10°C. Sowing too early can mean that young plants develop too slowly and that weed pressure becomes great. Later sowing results in quicker juvenile development, so that maize can suppress any weeds better. Later sowing can be normally be compensated for, and does not result in a loss of yield. If necessary, crops that ripen earlier can be used when adopting Fusion-Farming to ensure that the crop matures satisfactorily.

10.2 Systems and technology

Maize is a traditional row crop. It is usually sown at 70-75 cm (29.50") row spacing, but can be sown closer together. If you plan to use a hoe, it is important you adopt a sowing technique and a hoeing technique that are compatible.

Maize is a crop that is relatively easy to process mechanically. The tined weeder is well suited to this

crop, while the hoe also results in weed-free fields. For example, maize can be blind weeded shortly after sowing, weeded again after emergence and then worked with a hoe.



A blind weeding pass is particularly beneficial in maize and we fully support its use for this crop.





10.3 Examples and field reports*

Several trials have been carried out in recent years to find out whether and how it would be possible to reduce the use of plant protection products in maize. Various combinations have been trialled. Four treatment strategies were compared in trials in Bavaria and Baden-Württemberg (Germany). The first strategy

was entirely chemical, the second mechanical, the third and fourth strategies were combinations of a pass with a broad-spectrum herbicide at a reduced application rate and subsequent hoeing as required.

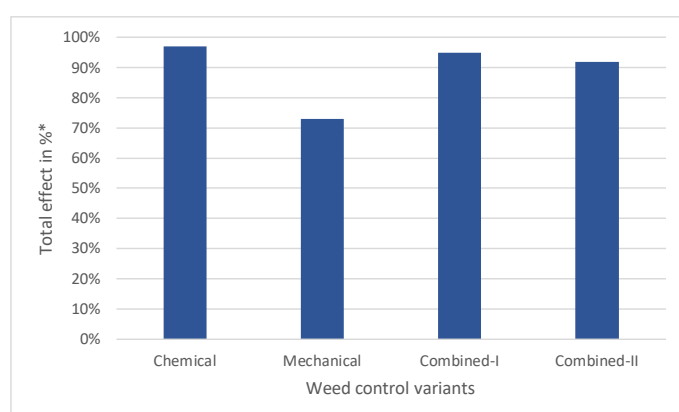
Comparison of treatment applications

Chemical	Mechanical	Combined 1	Combined 2
Standard herbicide treatment according to site-specific requirements in the post-emergence phase.	Use of tined weeder and hoe technology according to site-specific requirements from pre-emergence to row closure.	Use of a broad-spectrum herbicide (Adengo) at a reduced rate (0.25 l/ha) pre-emergence to early post-emergence. Mechanical follow-up (hoeing) as required.	Band treatment with tank mix (Spectrum Plus + MaisTer power) at a reduced application rate (2.5 + 1.0 l/ha) in combination with mechanical weed control (hoeing) as required.

The trial demonstrated that the chemical option and the two combined methods were equal regarding their weed control ability. They performed well to very well. In terms of yield protection, the combined methods showed superior performance. This facilitated even

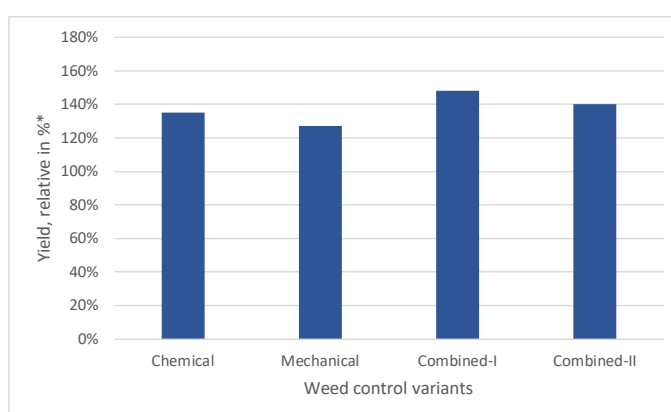
better results when using the chemical option. This is potentially due to the beneficial effect of the hoe on soil mineralisation.

Total weed control of regulatory variants



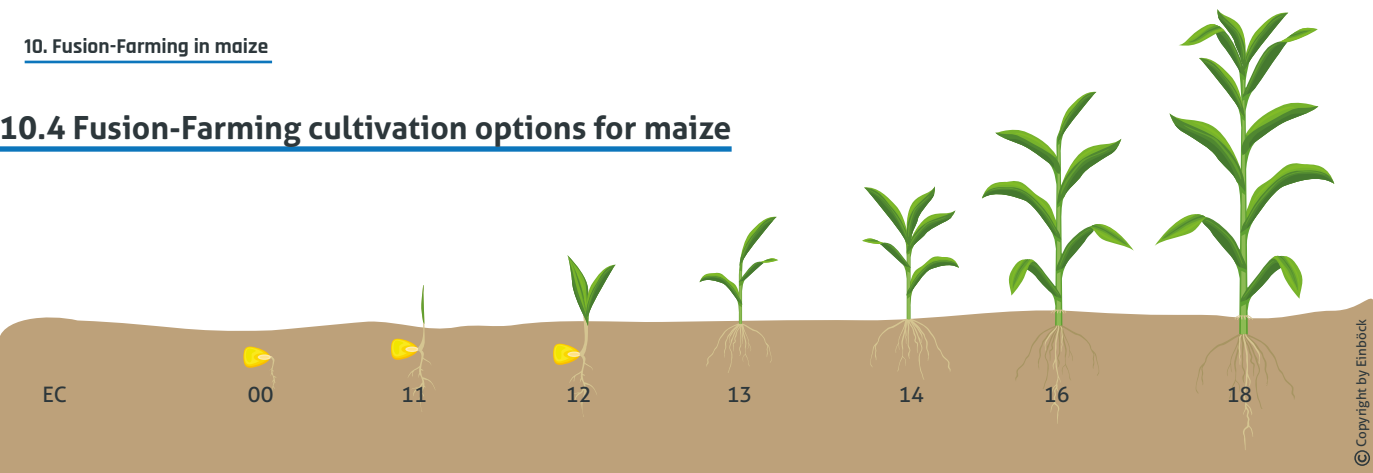
*Mean value and standard deviation, 19 field trials, Bavaria and Baden-Württemberg, 2020-2022

Yield protection of regulatory variants



*Mean value and standard deviation, 19 field trials, Bavaria and Baden-Württemberg, 2020-2022

10.4 Fusion-Farming cultivation options for maize



Option 1

Chemical plant protection		
Rotary hoe/tined weeder		
Hoeing machine		
as required	Recommended	

Option 2

Chemical plant protection		
Rotary hoe/tined weeder		
Hoeing machine		1-2 passes
as required	Recommended	

Option 3

Chemical plant protection		
Rotary hoe/tined weeder		
Hoeing machine		1-2 passes
as required	Recommended	

Option 4 Band spraying

Chemical plant protection		
Rotary hoe/tined weeder		
Hoeing unit with band sprayer		
as required	Recommended	

10.5 Maize Fusion-Farming: The TOP 10

- 1 Crop rotations can be more relaxed with this crop.
- 2 Maize does not transmit crop rotation diseases of the main cereal crops
- 3 Maize rotting management is very important due to the risk of Fusarium in the subsequent crop
- 4 When sowing maize: better a week late, than a week early
- 5 Sowing and hoeing must be coordinated (i.e. 6-row cultivation = 6-row hoeing)
- 6 Maize is suitable for (blind) weeding and hoeing
- 7 The rotary hoe can provide a "head start" for maize in the early stages (especially if the soil is crusted)
- 8 Finger hoes are very effective when controlling weeds in rows of maize
- 9 Hoeing maize offers many other crop benefits in addition to weed control (e.g. tilling and hilling crusts)
- 10 Yield protection is enhanced when a "chemical treatment with reduced application rate" and mechanical process are combined, as opposed to an entirely chemical process

For more detail, see Einböck's
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Additional tools such as band sprayers, heaping tools and seed boxes for nurse crops are particularly suitable for maize.

11. FUSION-FARMING IN BEETS

11.1 Preventive culture-specific measures

Crop rotation:

Sugar beet is subject to high demands and therefore requires a great deal of crop management expertise. It is generally a good preceding crop as it roots deeply and leaves behind well-rooted soil. In addition, the leaves left behind by the beet supply nutrients to the following crop. Very little mineral nitrogen is left behind by beets, which is positive as this would be very prone to leaching.

Despite all these advantages, some crops should be grown with caution or avoided entirely when in rotation with sugar beet, including maize, rapeseed, potatoes and some legumes. Some of these crops act as host plants to diseases and pests which can significantly reduce sugar beet yield.

11.2 Systems and technology

Sugar beet is traditionally considered a root crop and is usually sown with row spacings of between 45 and 50 cm (19.70"). The tined weeder & rotative weeder are row-crop cultivators that are used for weed control. Blind weeding proves very difficult however, as the beet lays very flat and is therefore easily disturbed and damaged during blind weeding. Using the tined weeder is also very difficult as it takes around two weeks for plants to emerge. During this relatively long period, weeds can grow which cannot be immediately weeded as this would damage or destroy the beet plants. As a result, the weeds are already relatively well developed by the time the tined weeder can be used. It therefore struggles to keep them under control at this stage. In these situations, the hoe can easily control the weeds

Sowing:

When sowing sugar beet, seedbed preparation is vital to keep up with the beet's high demands. Although sowing should take place as early as possible, this must not come at the expense of the quality of the seedbed. A fine, levelled seedbed that has not been cultivated too deeply is important to minimise moisture loss. It is also essential that the beet is distributed on a firm sowing horizon so that it can utilise capillary water rise.

For beet to grow quickly, a soil temperature of 10-12°C is optimum. Beets are very susceptible to frost, particularly in the cotyledon stage.

between and sometimes within rows. Nevertheless, the tined weeder does have its uses as it loosens soil, stimulating plant growth.

Band spraying is another way to effectively control weeds in the row. This can be combined with one or more hoeing passes between rows, with the herbicide applied over the top of the rows. This significantly reduces the crop protection agents required, while still ensuring a healthy beet crop.





11.3 Examples and field reports*

In recent years, many trials have investigated how the use of herbicides can be reduced effectively and economically when growing sugar beet. Trials conducted by Nordzucker AG and ARGE Nord, found that hoeing three times in combination with band spraying slightly improved the sugar yield and resulted in more reliable weed suppression. Furthermore, depending on the bandwidth to be treated, a herbicide reduction of 50-70% could be achieved, leading to significant cost savings.

Several years of herbicide/hoeing trials have shown

that the 3x herbicide treatments combined with a single hoeing pass always result in fewer weeds than when a chemical agent is applied in isolation. A hoeing pass shortly before row closure, also slightly increased the beet's yield every year the trial was run.

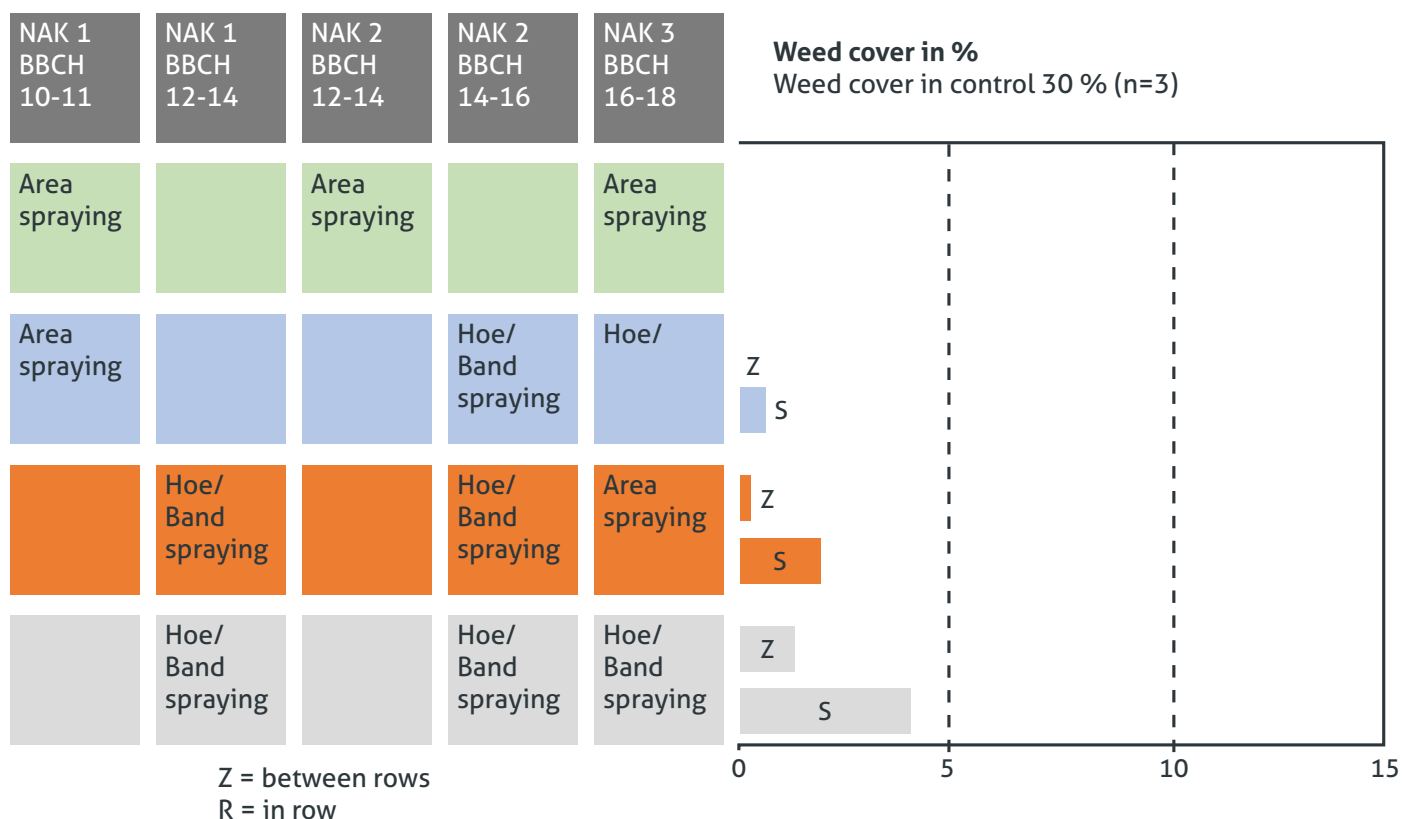
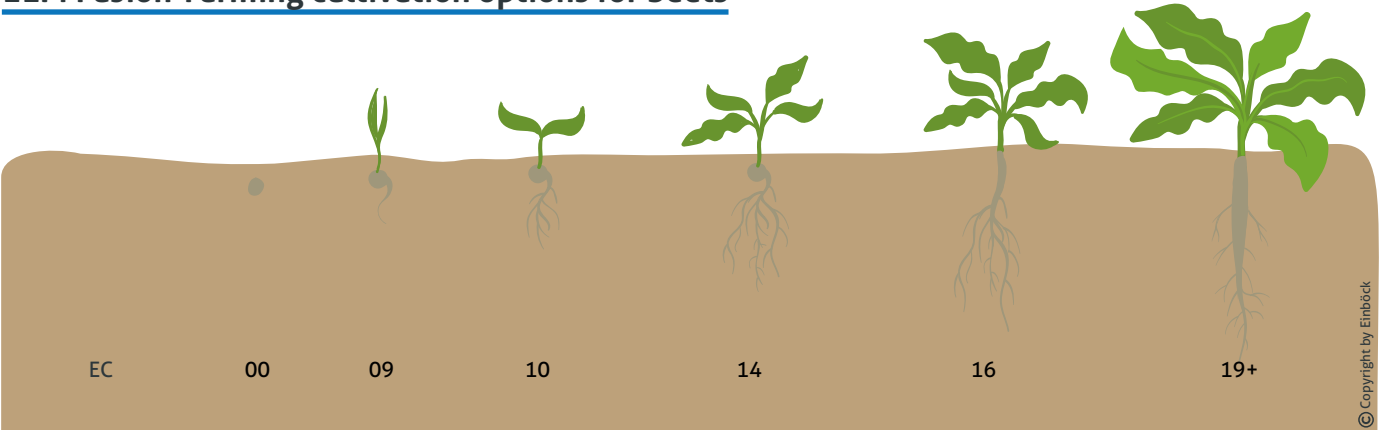


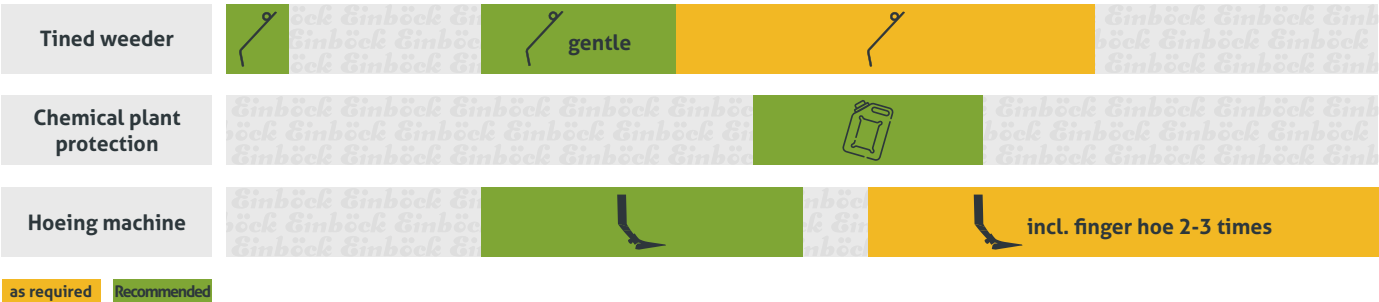
Fig. 2: Results of mechanical-chemical weed control trials using hoeing machines plus band sprayers in sugar beet (N = 3, trials in Eimbeckhausen, Sehnde, Dorstadt) 2016

*Source: LOP 11/2021, article Using the hoe and tined weeder correctly, Fig. 2

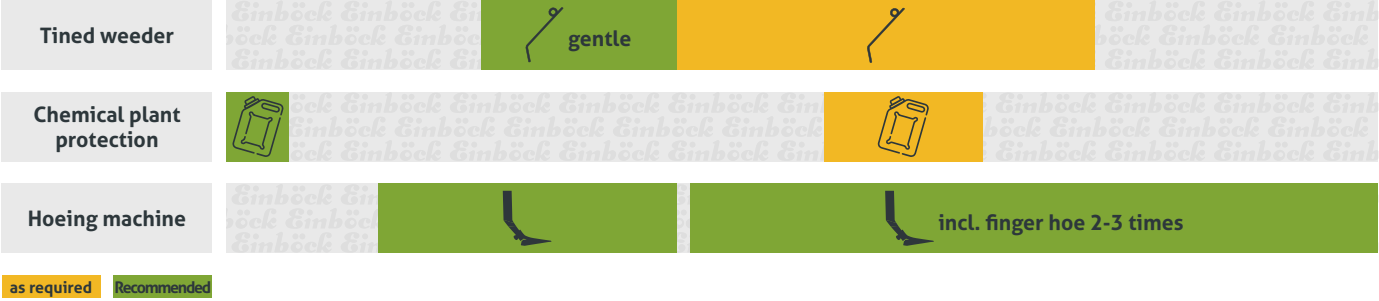
11.4 Fusion-Farming cultivation options for beets



Option 1



Option 2



Option 3



Option 4 Band spraying



11.5 Beets Fusion-Farming: The TOP 10

- 1 Sugar beet is a good preceding crop (it roots deeply and the leaves provide nutrients, etc.)
- 2 Beet leaves little mineral nitrogen behind
- 3 Take care when growing in crop rotation with oilseed rape, maize, potatoes and some legumes
- 4 Sow as early as possible (avoid sowing when there is a chance of frost) - soil temperatures are optimum between 10°C and 12°C
- 5 A fine-crumbled and levelled seedbed is very important - this is more important than the sowing date
- 6 (Blind) weeding beets is challenging. Being gentle is key
- 7 First weed, then hoe.
- 8 Finger hoes can effectively pull out or bury weeds in the row
- 9 Band spraying ensures a high reduction in herbicide usage
- 10 A combination of mechanical and chemical treatment increases beet and sugar beet yields

For more detail, see Einböck's
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When using a band sprayer, beet can be worked mechanically and chemically simultaneously.

12. SUMMARY

12.1 The key factors in Fusion-Farming

The Fusion-Farming Handbook provides a comprehensive insight into the principles, methods and practices of combined weed control when used for conventional arable farming. It is a source of valuable knowledge for farmers interested in healthy soil and sustainable and environmentally-friendly farming methods. The techniques described here aim to improve soil health, maintain stable yields, and prevent resistance while reducing chemical usage.

Soil care:

Fusion-Farming places particular emphasis on maintaining and improving soil health. This includes aspects such as crop rotation, organic fertilisation and avoiding soil compaction. Healthy soil is the foundation for high-yield and sustainable harvests.

Varied crop rotations:

Fusion farmers promote field diversity by incorporating many different crops into rotations. This supports balance in the soil and creates stable yields long term.

Sustainability:

Combined arable farming attaches great importance to reducing use of chemical fertiliser, herbicides, pesticides, etc. Water conservation is another key objective.

Mechanical weed control:

Fusion farmers rely on innovative mechanical approaches for weed control. This is one of the most efficient cultivation methods in modern arable farming. This is primarily thanks to tined weeder and hoeing technology that is increasingly precise, plus detailed hands-on experience regarding when to use them.

Overall, the handbook offers practical advice and guidance to help farmers cultivate their fields more efficiently, sustainably and with higher yields. It is a valuable tool for anyone looking for long-term success, while promoting sustainable agriculture.



Don't be scared of weeds! If a field is worked mechanically, it does not have to be 100% weed-free.



12.2 Fusion-Farming: The TOP 10

- 1 This solution offers an answer to the challenges faced by conventional agriculture, such as plant protection, loss of active ingredients, resistance problems and new legal framework conditions.
- 2 The benefits of traditional and organic farming methods are combined. Farms can use tools from both approaches, choosing what works best for them.
- 3 Preventive measures to reduce weed pressure in the main crop are achieved thanks to targeted measures such as crop rotation, adapted tillage and catch crops.
- 4 Preventive measures reduce weed pressure in the main crop so that the use of chemical crop protection is reduced.
- 5 Mechanical weed control should be promoted wherever possible - chemical pesticides should only be used as a supplement.
- 6 It is essential to monitor fields actively and precisely so that prompt action can be taken when needed, such as blind weeding.
- 7 Mechanical weed control is only successful if used in good time and in a well-planned manner. Just a few hours can be the difference between success and failure.
- 8 Flexibility is key. Chemical pesticides may be needed in the event of unfavourable weather conditions or time constraints.
- 9 Band spraying in row crops reduces costs and offers other positive benefits for the crop.
- 10 Fusion-Farming manages weeds more effectively, reduces the environmental impact and reduces the need for chemicals.

For more detail, see Einböck's
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EINBÖCK



Einböck GmbH
Schatzdorf 7
4751 Dorf an der Pram
Austria

+43 7764 6466 0
+43 7764 6466-390
info@einboeck.at

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