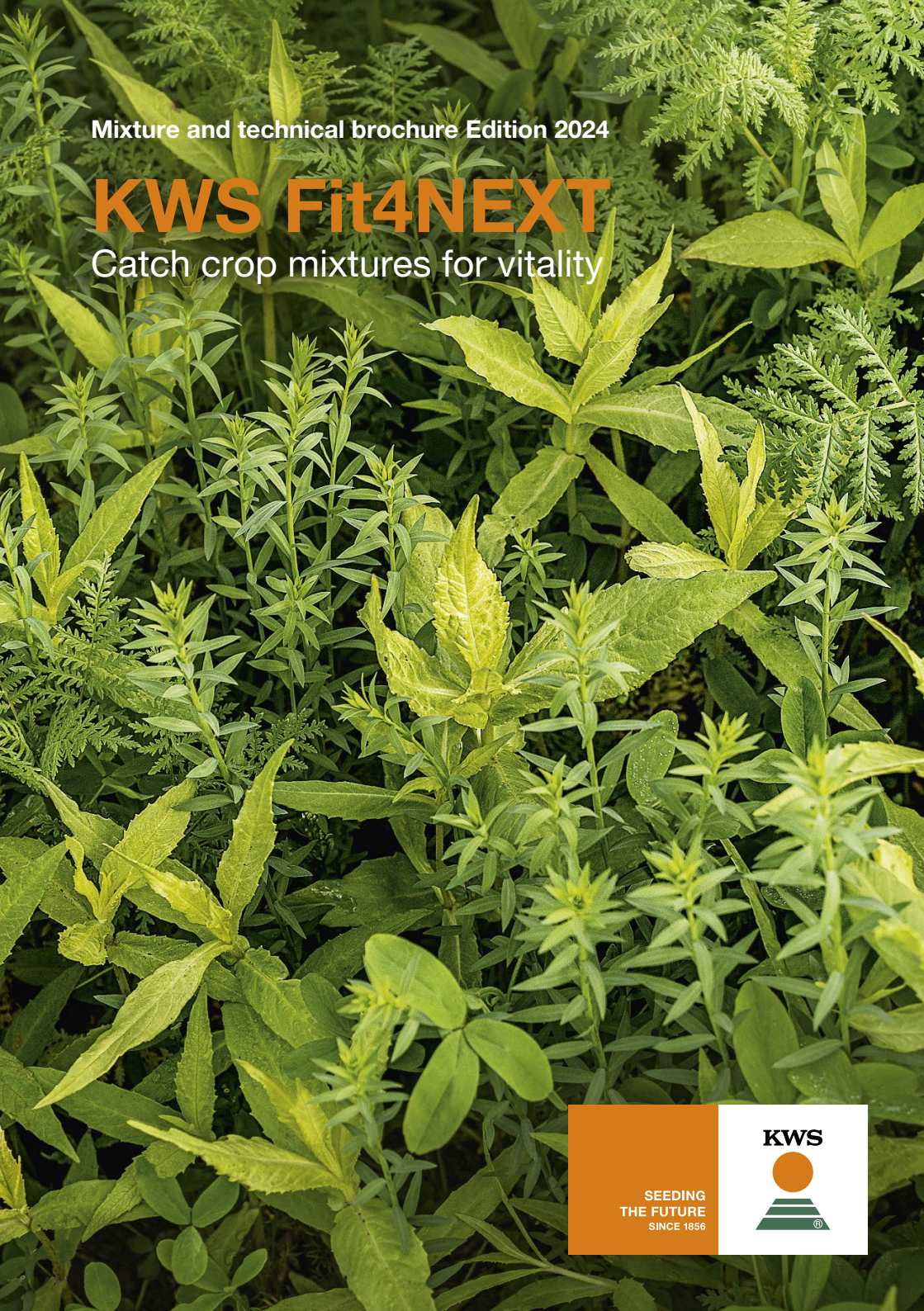

Mixture and technical brochure Edition 2024

KWS Fit4NEXT

Catch crop mixtures for vitality

SEEDING
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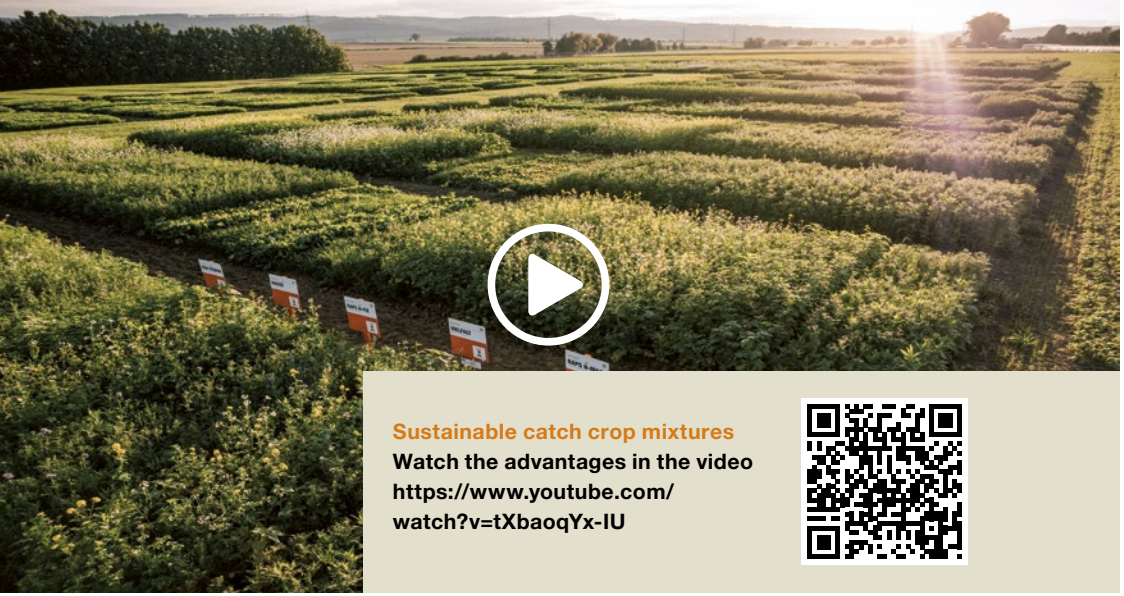
Content



Sustainable catch crop mixtures
Watch the advantages in the video
https://www.youtube.com/watch?v=tXbaoqYx-IU

What is KWS Fit4NEXT?

KWS Fit4NEXT is the product range for catch crop mixtures from KWS. For decades, KWS has been breeding, producing, and distributing the most important field crops and catch crops worldwide. Our goal is to offer you the opportunity to supplement your crop rotation with site-adapted and high-performance varieties from KWS to achieve the ideal catch crop mixture. With the right mixture, you can make your crop rotation even more sustainable, and successfully meet the challenges of field crop cultivation as well as political and social requirements.

Our many years of experience with catch crops contribute to the component selection, making it possible to integrate the right species into the mixtures with regards to phytosanitary and cropping aspects for different crop rotations. Thanks to the intense trial system, it was possible to develop ideal mixture compositions and define cropping recommendations over the course of several years. The mixtures and mixture partners were selected and tested based on their characteristics, such as youth development, blooming time, biomass growth, freezing behaviour, and root systems.

Your advantages with KWS Fit4NEXT

- A one-stop shop
- Clear and focussed portfolio
- Use of components from in-house breeding
- Premium component quality
- Mixtures and components tested in field trials
- Contributes to creating sustainable and socially acceptable field crop cultivation

Advantages of KWS Fit4NEXT catch crop mixtures

- Easy integration in **various crop rotations**
- Good rooting of the soil thanks to the combination of **tap roots and tuft roots**
- Strong youth development and rapid crop closure for better and faster **soil coverage** and **weed suppression**
- Diversified crop rotation and increased **biodiversity**
- Promotion of **soil organisms**
- **Humus formation**
- Additional **CO_2 sequestration**
- **Nutrient conservation** and **mobilisation** as well as **nitrogen fixation**
- Reliable crop establishment under different weather conditions
- High **biomass growth** over a longer period of time
- **Control** of pests such as **nematodes** thanks to a longer vegetative phase

Catch crops – breeding and testing at KWS

For many decades, KWS has been breeding a wide variety of catch crop species. Just like for our main crop, we rely on many years of experience and know-how.

In addition to cruciferous plants such as winter turnips, false flax, white and brown mustard, our activities also focus on oil radish, phacelia, and Tartary buckwheat. More crops are available from other KWS breeding programmes, such as sunflowers.

The main breeding objectives for all species are rapid soil coverage, fast youth development development, a dense crop that suppresses weed growth, and an adapted, rather late flower formation. The development of late-blooming varieties is the declared breeding objective of KWS, particularly for mustard, oil radish, and Tartary buckwheat, since late blooming offers more flexibility in terms of earlier sowing dates and reduces the risk of shedding seeds. Plants with a longer vegetative phase can also grow longer and therefore absorb more nutrients. At the same time, late blooming also ideally complements the main breeding objective for white mustard and oil radish – nematode resistance towards beet cyst nematodes (see p. 24/25).

We perform standardised greenhouse tests for nematode resistance with mustard and oil radish before approving the varieties. In addition, we use the test to verify the seed lots from our propagations.

For more information about the breeding of nematode-resistant mustard and oil radish, watch the video:
www.kws.de/zuechtung-zf

Greenhouse nematode test with mustard and oil radish in Einbeck

For other species, early blooming is actually desired – for example with phacelia and sunflowers. Both species play an important role in bee pastures.

The desired characteristics of new potential varieties are tested on a yearly basis in field trials with two sowing dates (early after winter barley and late after winter wheat). Our mixtures are also tested on several sites under different field conditions. In addition to pure evaluation and observation, we also determine the biomass of the species and mixtures. Biomass is a significant factor in achieving the objectives: nutrient conservation, humus formation, and CO_2 storage. At the same time, we evaluate the nitrogen content of the vegetation to better assess nitrogen uptake from the soil and fixation from the atmosphere.

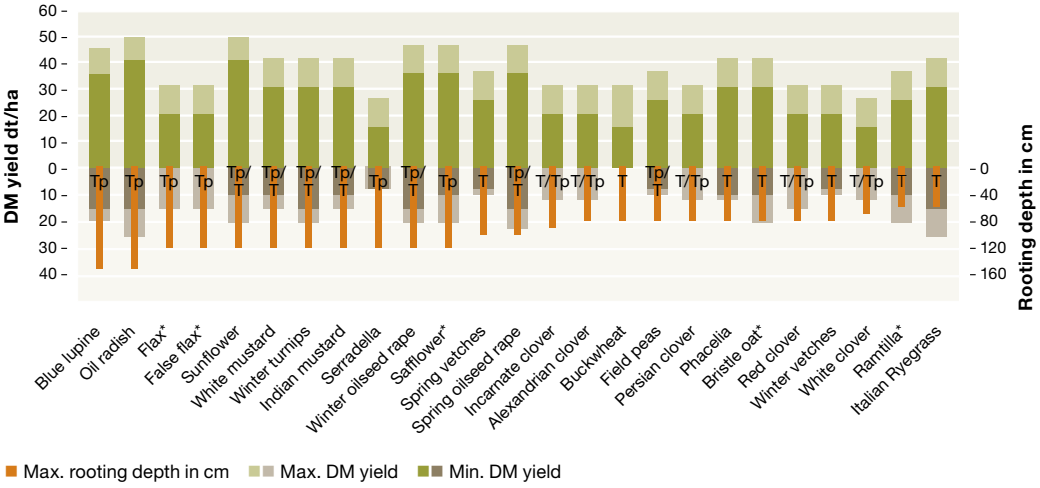
Most of the catch crop species we breed are cross-pollinated, where insects can contribute to a strong exchange of pollen among the plants. The breeding lines must therefore be elaborately separated from each other for breeding purposes. Later during multiplication as well, the required isolation distance from other varieties of the same species must be strictly observed to ensure that the desired characteristics (e.g. nematode resistance) are maintained.

Root systems of various species

One of the most significant advantages of catch crop mixtures is the possibility to combine different types of roots and characteristics on one field. The root systems are divided into tap and tuft roots. Depending on the plant species, one or the other system can predominate or be combined. The topsoil and subsoil can be optimally exploited with a diverse mixture. Nutrients can be conserved, the formed biomass serves as a basic food resource for soil organisms and for humus formation. Root channels that are left behind improve the air and water absorption capacity and are used by the subsequent main crop for root development. Lupines and oil radish even break up soil compaction with their strong tap roots. Species such as phacelia or Tartary buckwheat can mobilise phosphorus through their root exudates. One of the reasons is also the capacity of many catch crop species to form symbioses with fungi, so-called mycorrhiza. The responsible fungi interact with the fine roots of e.g. clover species, flax, or bristle oats, thereby increasing the root surface and improving nutrient absorption.

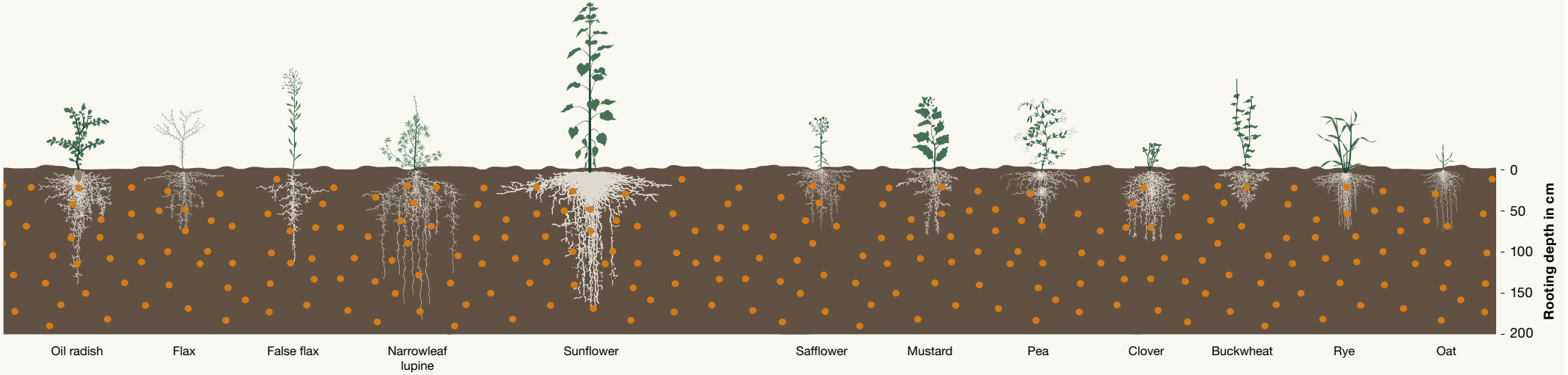
For more information, watch the video on our website: “A glance below the surface”
www.kws.de/fit4next

Root development and biomass potential of different catch crop species



* Rooting depth/DM yield based on first-hand experience. T = Tuft root system; Tp = Tap root system
Source: Zwischenfruchtpass Landwirtschaftskammer NRW (Catch Crop Booklet by the Chamber of Agriculture NRW), M. J. Kanders, Dr. C. Berendonk, 2013

Different species mutually improve root development and nutrient absorption



Schematic representation of root development in the soil and nutrient absorption, own illustration based on Kutschera et. al., 2009 (KWS LOCHOW, 2022)

When is the planned sowing date?

The **cultivation time** frame for winter catch crops after harvesting summer cereals is often strongly determined by external factors: on the one hand, by the harvesting date of the previous crop, but also by many other factors such as thorough stubble cultivation, various maintenance and (basic) fertilising measures, water availability, subsequent crop, and also significantly by other work on the farm needing to be done around the same time, and therefore by the capacities of labour and technology. Another factor in the selection of the sowing date can be the risk of seed formation, which can be more or less significant depending on the species and variety. Political guidelines also determine the cultivation of catch crops.

For more information on the sowing date trial, watch the video:
www.kws.de/aussaat-zf

Catch crop sowing date trial at the Einbeck site in 2021/2022 with early, medium, and late sowing date (each block from the bottom left to the top right).

No matter which reason has the highest priority, we constantly focus on the question regarding the **effect of the sowing date on catch crop cultivation**. How do KWS Fit4NEXT catch crop mixtures and the individual species develop with different sowing dates? The focus is on comparing the mass development of the crops, soil coverage, winter freezing behaviour (p. 22/23), and the amount of fixed nitrogen in the **aerial** above-ground growth. We look at characteristics such as florescence and ultimately also seed maturation of the different species and varieties.

Maximum vegetation time vs. generative growth

From an economic and usually also from a crop production point of view, intercropping in summer should ideally maintain a green population until the end of vegetation – without switching to generative development with flowering and seed formation. Depending on the species and variety, catch crop mixtures can be designed to allow a long period of vegetative growth. However, depending on sowing date, water and nutrient supply, this alternation cannot always be avoided. Late flowering is less dramatic in this regard. Only a few species still have the potential to form germinable seeds. One example is the Tartary buckwheat.

There are enormous differences in the choice of varieties for many species. In white mustard in particular, we rely on very late-flowering varieties such as SIMPLEX, SINEX or SIBELIUS from KWS' own breeding program. With these varieties, seed formation in the fall is rather unlikely.

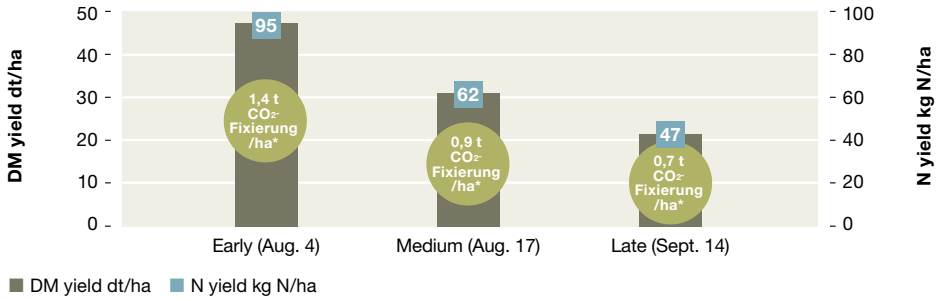
Ground coverage

An early **sowing time** generally always has **advantages in terms of soil cover** and thus **reducing erosion and water evaporation**. Even during later seeding times, a good level of cover can still be achieved. Here, however, mixtures with fast-growing crucifers such as mustard or oil radish have a clear advantage or generally also species that tend to provide rapid, extensive cover such as Phacelia or Tartary buckwheat. Bristle oat can also be very competitive, especially under dry conditions.

Sowing earlier benefits the field more

One day in July is like one week in August, and is like the whole month of September – this popular wisdom is well-known and particularly true for the cultivation of catch crops. It is clearly demonstrated in our trials. In the three sowing dates we selected, at the beginning and middle of August as well as mid-September, the advantages of early sowing dates on the dry mass development of aerial plant growth are evident. The **higher** the **dry matter**, the **more nitrogen is fixed per hectare** in the **plant mass**. This applies both for the quantities absorbed from the soil and generally also for the quantities fixed by legumes from the atmosphere.

An earlier sowing date increases the chances for more biomass as well as more fixed N and CO_2 per hectare!



Dry mass and nitrogen yield of the KWS Fit4NEXT catch crop mixtures depending on the sowing date. In-house results of the catch crop sowing date trial in Einbeck in 2021/2022. (KWS LOCHOW, 2022)

CO_2 fixation through catch crop mixtures

What is true for nitrogen also applies for **carbon**. When a catch crop forms more dry matter, it also fixes **more CO_2 per hectare**. Increased fixed carbon results in a greater **potential** for **higher humus accumulation** thanks to the organic catch crop residues. This has a positive effect on increasing soil fertility.

In terms of **soil coverage**, it was demonstrated that a good degree of cover can also be achieved with the later sowing dates. In this case, however, mixtures with fast-growing crucifers such as mustard or oil radish have a clear advantage as well as species that tend towards rapid

full-area coverage, such as phacelia or Tartary buckwheat. With early sowing dates, all species generally reach the flowering stage. Only a few species still have the potential of forming viable seeds. One such is Tartary buckwheat. Here are generally huge differences in the variety selection. Particularly with white mustard, we also use very **late-blooming varieties** such as SIMPLEX, SINEX, or SIBELIUS from the KWS in-house breeding programme. Seed formation in the autumn is rather unlikely with these varieties.

CO_2 sequestration through Catch crop mixtures

What applies to nitrogen also applies to **carbon**. With more dry matter formed, a catch crop also binds **more CO_2 per hectare**. This means that the **potential** for **higher humus enrichment** through the organic catch crop residues is also increased through more bound carbon. This has a positive effect on increasing soil fertility. If the above-ground growth of a catch crop is analysed for carbon, the values vary depending on the cultivation conditions, stage of development and also the composition of the mixtures. From analyses of KWS Fit4NEXT catch crop mixtures harvested by us, we assume an average of 40 % carbon in the above-ground biomass. This means that **0.4 tonnes of carbon** are sequestered **per tonne of dry matter** (DM). If we continue to calculate on this basis, **around 1.5 tonnes of CO_2** are fixed per tonne of dry matter through the cultivation of catch crops.

Longer vegetation periods promote biomass formation and CO_2 sequestration

* Comparison of plant development and above-ground [1)] DM yields of the catch crop mixture KWS Fit4NEXT KARTOFFEL N-FIX at the Einbeck site, 8 November 2021. Sowing dates from left to right: 04 August, 17 August, 14 September. Calculation of above-ground CO_2 fixation based on own analysis results (C content = 40 %). [2)] Assumption that carbon remains fixed in up to 20 % of the above-ground DM biomass in the longer term. Conversion via molecular weights. (KWS LOCHOW, 2023)

This is where a significant lever lies in the DM yields per hectare. This in turn can be positively influenced by many factors – the described factor of sowing time and thus vegetation period probably has the greatest effect.

In the majority of cases, the catch crop serves as green manure. However, it is not possible to bind 100 % of **the bound CO_2 in the soil** in the **long term**. The accumulation and release of CO_2 are also subject to dynamics here. According to estimates by the Thünen Institute in Braunschweig, **up to 20 %** can nevertheless be stabilised in the long term when considering the carbon sequestration in the soil that goes hand in hand with the build-up of humus.

Although this assumption is also subject to fluctuation, **catch crop cultivation** as a **CO_2 sink** can still make a **significant contribution** to **climate protection** and CO_2 sequestration in the agricultural sector. According to studies by the Thünen Institute, catch crops currently still have considerable potential to increase this contribution. This relates to both the area under cultivation and the cultivation management.

Click here for the interview

with PD Dr. Axel Don, Deputy Director of the Institute of Agricultural Climate Protection at the Thünen Institute in Braunschweig:

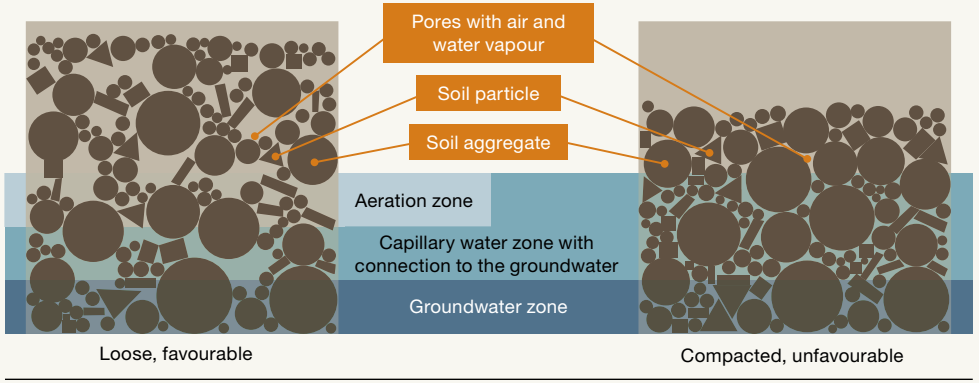
Catch crops: Nitrogen, erosion control, humus build-up

Reducing soil erosion by cultivating catch crops

Soil erosion is the displacement of soil particles at the soil surface by wind and water, and it is associated with reduced soil fertility. The prevention of soil erosion still remains one of the main purposes for cultivating catch crops.

Wind erosion mostly occurs in regions with light soils and/or landscapes with few trees and shrubs (high proportion of large open areas). The finest soil particles are picked up by the wind, transported over a distance of several metres, and accumulate in front of hedges and field trees. Wind erosion is particularly problematic in spring when the soil surface is dry and the spring crops have not yet grown enough coverage. The mulch layer produced by catch crops can reduce the risk of erosion in these cases.

Stabilising the soil structure with catch crops



Own illustration according to "A guide to better soil structure", National Soil Resources Institute, Cranfield University, 2001 (KWS LOCHOW, 2021)

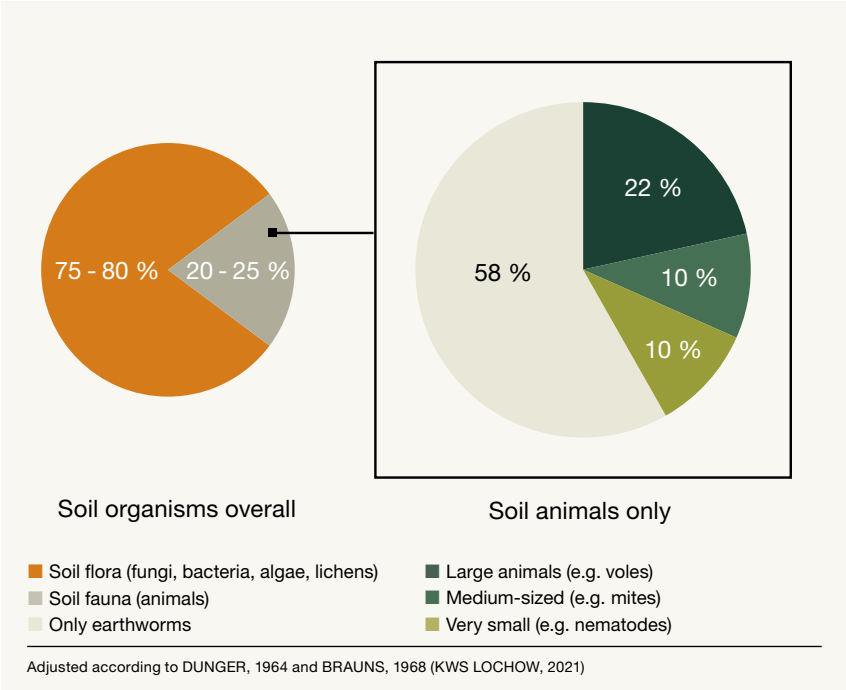
On slopes, strong or persistent precipitation can cause water erosion. The impact of raindrops can destroy soil aggregates, and the water can then pick up and transport small soil particles and cause surface sealing. These types of erosion usually occur on bare fields. Continuous plant coverage and a mulch layer consisting of dead catch crops are suitable countermeasures, which also apply for cross-compliance (CC land). The faster a catch crop can become established, the lower the risk of soil erosion.

Wind and water erosion on arable fields in spring

What influences the decomposition of catch crops in spring?

Decomposition of the catch crop biomass is accomplished by the soil flora (mainly fungi, bacteria, algae, and lichens) and fauna (animals), which are grouped together as the so-called edaphon. The cultivation of catch crops promotes their activity, and therefore also activity in the entire crop rotation.

Classification of soil organisms



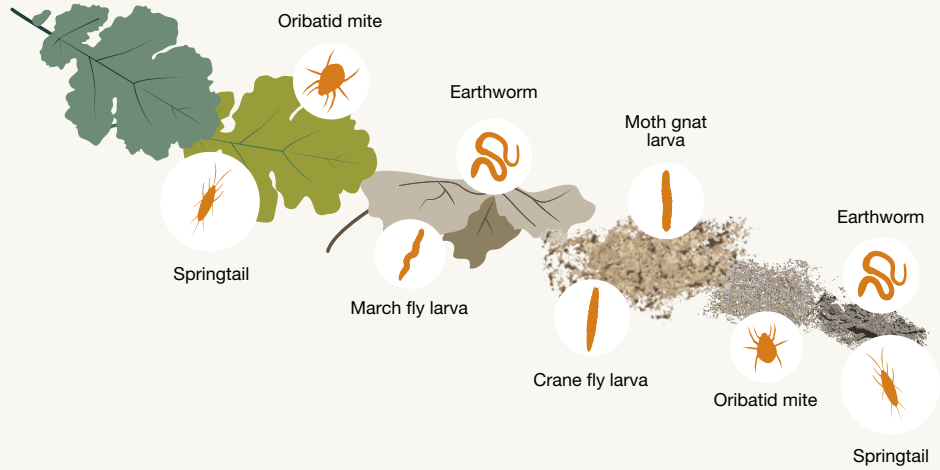
Adjusted according to DUNGER, 1964 and BRAUNS, 1968 (KWS LOCHOW, 2021)

A food supply with a narrow carbon and nitrogen ratio (C/N ratio) has a positive effect. This ratio provides an indication of how fast plant material can be decomposed by the soil organisms (mineralisation). As a general rule, the narrower the ratio, the faster the decomposition. Nutrients that come from plant material with a narrow C/N ratio are then more readily available to the subsequent crop. However, the ratio not only depends on the plant species, but also on the growth stage.

Older plants that have already formed more fibrous tissue (lignification) generally have a wider C/N ratio than young plants.

Due to their very short vegetation period, catch crops have a very narrow C/N ratio of approx. 30:1. In contrast, cereal straw has a very wide C/N ratio of approx. 100:1. However, there are also differences among catch crops, which can be influenced by crop management and species selection. In addition to nutrient supply, crop management also includes the growing date of the catch crops. With regards to species selection, legumes are decomposed more rapidly, while cruciferous plants or phacelia are decomposed more slowly. By mixing these different species, nutrients are gradually released from the catch crops for the subsequent crop in spring.

Decomposition of an oil radish leaf



Adjusted according to SCHÄCHTER, 1988 (KWS LOCHOW, 2021)

Enlarged view of forage pea roots (*Pisum sativum L.*) with root nodules.

Habitat and food sources for organisms

Catch crops are used as a habitat and food source for a wide variety of organisms. In the aerial leaf mass, for example, birds can hide from their predators. The vegetation serves food for hares, rabbits, insects and wild animals. The soil organisms, in contrast, feed on dead catch crop residues, on organic material, plants roots, faeces from other animal groups, as well as bedding and harvest residues, living both at the soil surface and underground.

For example, the anecic earthworm (deep burrowing) comes to the surface looking for food, pulls dead plant residues down into the ground, and uses them as a food source in addition to the soil. At the same time, the excretions of this worm are a highly concentrated fertiliser, containing 5 times more nitrogen, 7 times more phosphorus, and 11 times more potassium than the surrounding soil (Pfiffner et al., 2013).

Legumes as a nitrogen source in catch crop mixtures

As a result of the reduced use of organic and mineral nitrogen fertilisers, cropping systems used in agriculture must be further optimised in terms of nutrient efficiency. Legumes are currently regaining importance within the scope of the revised Fertiliser Ordinance. They can form a symbiosis with nitrogen-fixing bacteria (rhizobia) in their root nodules and therefore fix atmospheric nitrogen.

This puts you in line with the times, considering the high cost of mineral nitrogen and an overall favorable CO2 footprint. This nitrogen can be incorporated in the cropping system. Legumes primarily supply themselves autonomously with atmospheric nitrogen and can thus reduce nitrogen absorption competition with non-leguminous plants in a catch crop mixture. To a certain extent, legumes can also share atmospheric nitrogen with non-leguminous mixture partners.

The mode of operation without additional nitrogen fertilising is illustrated in the figure below, and shows a possible relationship between nitrogen absorption from the air, the soil reserves, and the distribution within a clover/grass mixture. In this example, the clover was able to share approx. 1/5 of the bound atmospheric nitrogen with the grass. Additional nitrogen fertilisation generally results in decreased atmospheric nitrogen reduction by the legumes.

Improvement of the nitrogen balance based on the example of a grass/white clover mixture

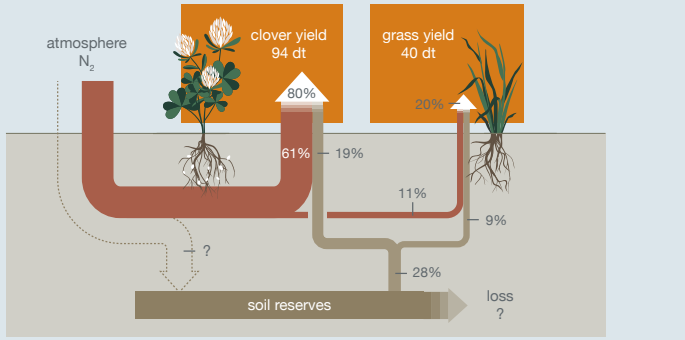


Illustration of the nitrogen fluxes (kg/ha) in a grass/white clover crop without N fertilisation in a main production year, adjusted according to B. Boller, 1988(KWS LOCHOW, 2021)

Nutrient conservation and mobilisation by catch crops

Catch crops are essential in current and future cropping systems to support the nutrient cycle in crop rotations in a sustainable, economically expedient way. Three main aspects are relevant in this context: conserving nutrients from the soil in the plant mass, mobilising poorly available nutrients in the soil, and fixing of atmospheric nitrogen by nodule bacteria.

Especially the micronutrients nitrogen, phosphorus, potassium, and sulphur can be conserved thanks to the cultivation of catch crops, and made available to the subsequent crop. In addition to these purely crop-related reasons, the European Water Framework Directive has a decisive effect on the cultivation of catch crops and particularly the conservation of nitrogen. The objective of modern agriculture is to protect nutrients against leaching with seepage water into deeper soil layers or loss through surface runoff. This is part of the guidelines for good agricultural practice.

P
Phosphorus

Mobilise phosphorus

Since phosphorus is not very mobile in the soil solution, plant roots must actively grow towards it. An important prerequisite for optimum phosphorus supply is therefore to ensure a sufficient supply of plant-available phosphorus in all layers of the soil. Particularly with non-inverting soil tillage, there is a risk that the nutrient concentration strongly increases in the upper soil layer, since this is where mineral and organic fertilisers are added. The concentration can be much lower in deeper soil layers if the nutrients are not incorporated deeply enough. Due to the poor mobility of phosphorus, this produces an imbalance in the soil layers. Although the topsoil often has a good supply, there is a risk of desiccation in case of longer periods of drought, which inhibits plant growth. The cultivation of a catch crop mixture that is specifically matched to the subsequent crop can help in this case. Recent research has confirmed that catch crops per se have a positive effect on phosphate availability. One of the reasons is the promotion of mycorrhiza, i.e. the symbiosis of plant roots and fungi. Catch crops such as lupines, buckwheat, and phacelia are particularly well suited to improve phosphorus availability.

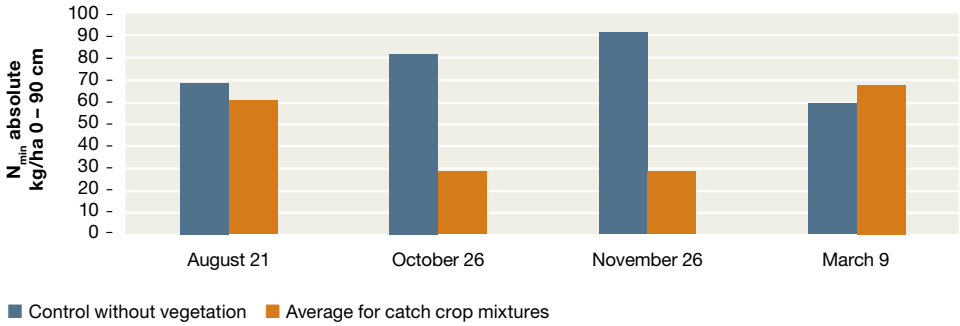
N
Nitrogen

Efficient nutrient storage

In regard to nitrogen, there are essentially two tasks that an catch crop mixture should fulfill, depending on the composition of the mixture partners: the conservation from the previous crop into the following crop rotation and, if legumes are included, also the fixation of atmospheric nitrogen in the root nodules with the help of nodule bacteria, which are usually native to the soil (pp. 20 - 21).

Particularly on light, sandy soils, there is a very high risk that mineralised nitrogen in the soil will be transported into the groundwater as a result of autumn and winter precipitations. During the sometimes very long cultivation pauses between the cereal harvest in summer and the spring sowing of the subsequent crop, catch crops and catch crop mixtures can feasibly conserve 100 kg of nitrogen per hectare in the plant mass, depending on the development conditions, species, and composition. The majority of this nitrogen is then available again in the nutrient cycle and/or accumulates in the soil as humus. Catch crops can thus make an active contribution to **water conservation**.
In our scientific trials on a Luvisol site, we compared the nitrogen absorption by the catch crop mixture from sowing in summer until the end of winter to a barren control plot (comparable to stubble or bare fallow). The figure shows that regardless of the mixture composition and the presence of legumes in the mixture, a catch crop mixture can reduce the N_{min} content to a level equal to or lower than 30 kg/ha before winter, whereas in the barren control plot in this example, there is about 90 kg N_{min}/ha in the soil solution before winter, which can potentially be transported. The final sampling in March shows that a portion was transported and that bound nitrogen from the catch crop mixture was already mineralised for the cultivation of the subsequent crop. The degree of mineralisation is generally influenced by the degree of conversion of the biomass, and proceeds faster when mechanical shredding, frost, or similar effects have broken down the material.

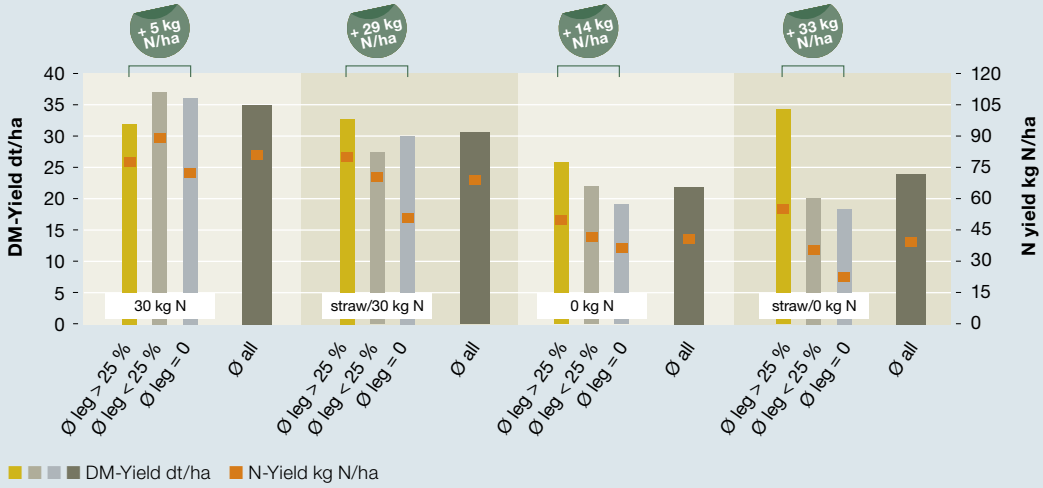
Better with than without – catch crop mixtures conserve nitrogen



Comparison of N_{min} contents in the 0–90 cm soil layer on fields without vegetation and with catch crop mixtures (average from the mixtures KWS Fit4NEXT BEET, OILSEED RAPE N-FIX, and OILSEED RAPE N-MAX). Scientific plot trial on a Luvisol site in South Lower Saxony. Sowing date for the catch crop mixtures: 18 August. (KWS LOCHOW, 2021)

Sowing nitrogen and reducing fertilizer costs

Nitrogen availability promotes catch crop mixtures if there is a nitrogen deficiency, leguminous mixtures are recommended!



Above-ground DM yields and N yields kg/ha in the nitrogen fertilisation trial at the Einbeck site, in each of the four tested variants with straw & without N fertilisation (S/0), with straw & with N fertilisation (S/30), without straw & with N fertilisation (30) and without straw & without N fertilisation (0). N fertilisation (S/30), without straw & with N fertilisation (30) and without straw & without N fertilisation (0). Average values grouped according to freezing Fit4NEXT catch crop mixtures with legume seed content > 25 % (n=4), < 25 % (n=3) and 0 % (n=6) (KWS LOCHOW, 2023)

In a separate exact trial, we tested the influence of nitrogen availability and nitrogen deficiency in combination with various KWS Fit4NEXT catch crop mixtures.

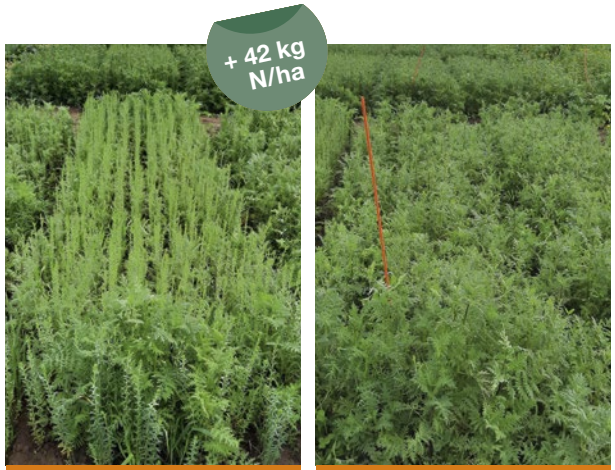
The general advantages of legumes in a catch crop mixture with regard to nitrogen have already been described on page 45. The question behind this trial has become more and more important due to various factors.

On the one hand, due to the designation of nitrogen limited areas, catch crop cultivation is only possible without additional fertilisation, and on the other hand, for economic reasons and the increased prices for nitrogenous fertilisers, there is great interest in reducing fertiliser costs in the intercrop, but also in the subsequent crop.

All catch crop mixtures were grown both fertilised (30 kg N/ha from KAS) and unfertilised and in one half of the trial the straw from the previous crop, winter barley, was removed. As the straw residue generally also binds nitrogen, there are different levels of nitrogen availability from fertilised without straw (30 kg N) to unfertilised with straw (straw/0 kg N).

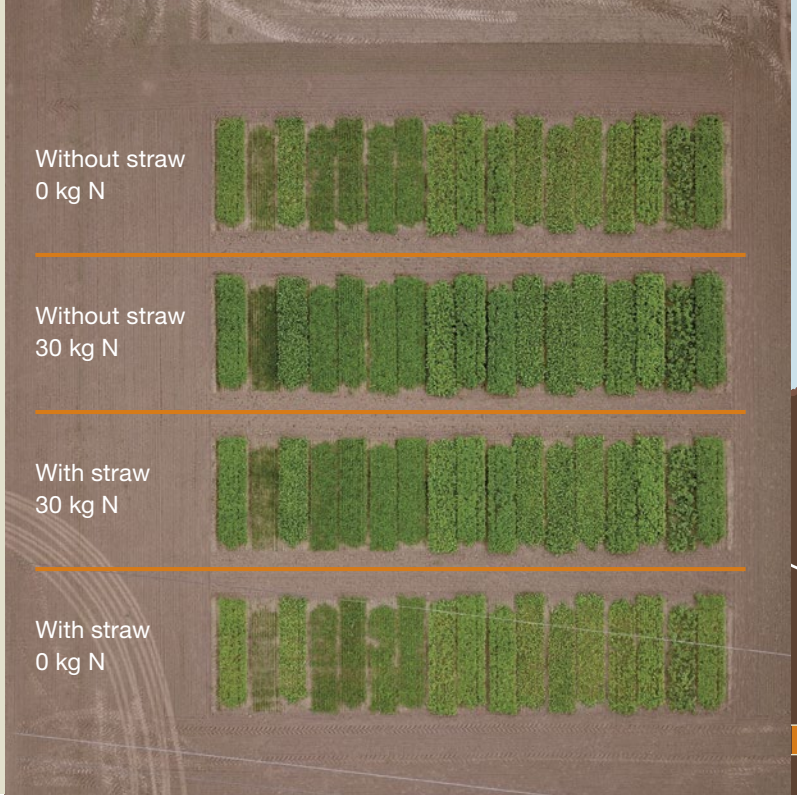
The dry matter (DM) and nitrogen (N) yields in kg/ha from the above-ground biomass clearly show **the advantage of legume-containing catch crop mixtures when N is in short supply**. Under these conditions, KWS Fit4NEXT catch crop mixtures with a higher proportion of legumes such as VIELFALT, RAPS N-MAX, RÜBE N-FIX or KARTOFFEL N-FIX can still form a good crop and thus fulfil the diverse functions of a catch crop mixture. This can be seen very clearly in a direct comparison of similar mixtures using the example of RAPS N-MAX.

Comparison with and without legumes



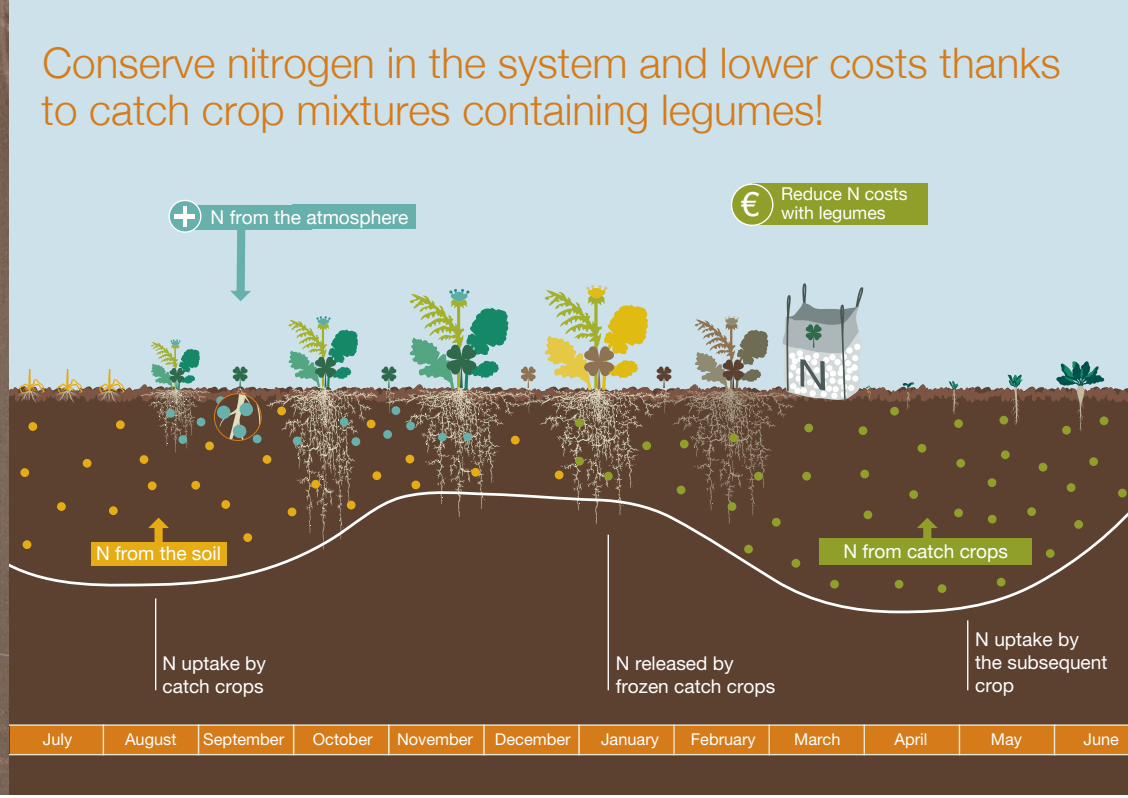
Comparison of the catch crop mixtures KWS Fit4NEXT RAPS (legume-free) and KWS Fit4NEXT RAPS N-MAX (62 % legume seed content) in terms of DM and N yield in above-ground growth, with straw & without nitrogen fertilisation, in the trial in Einbeck. (KWS LOCHOW, 2023)

Check out the video from within the N fertiliser trial:
www.kws.de/zwischenfruchtversuch



Aerial photos of the N fertiliser trial at the Einbeck site on 24 September (KWS LOCHOW, 2022)

Conserve nitrogen in the system and lower costs thanks to catch crop mixtures containing legumes!



Schematic course of nitrogen (N) dynamics in a cereal-root crop rotation using the example of maize with the cultivation of freezing legume intercrop mixtures between the cereal harvest and maize sowing (KWS LOCHOW, 2023)

If nitrogen is available, this type of mixture still achieves good results, although less legume-rich and completely legume-free catch crop mixtures can also score well here. It has also been shown that a **diverse species composition** can have a **good buffering effect and adaptability** to different conditions.

The additional nitrogen provided by the legume-containing catch crop mixtures benefits the catch crop and the subsequent crop. It therefore directly benefits the catch crop and can also **reduce the N fertilisation costs per hectare** in the crop rotation. In the system as a whole, the use of biologically fixed nitrogen makes farming **more CO_2-efficient** and at the same time further reduces the **CO_2 footprint in the crop production process chain** thanks to the additional CO_2 savings.

> The main task of catch crops is to store nutrients, primarily nitrogen of course!

Tobias Schröder
Farm manager at Agrarhof Veelböken eGz

Freezing behaviour for catch crop mixtures

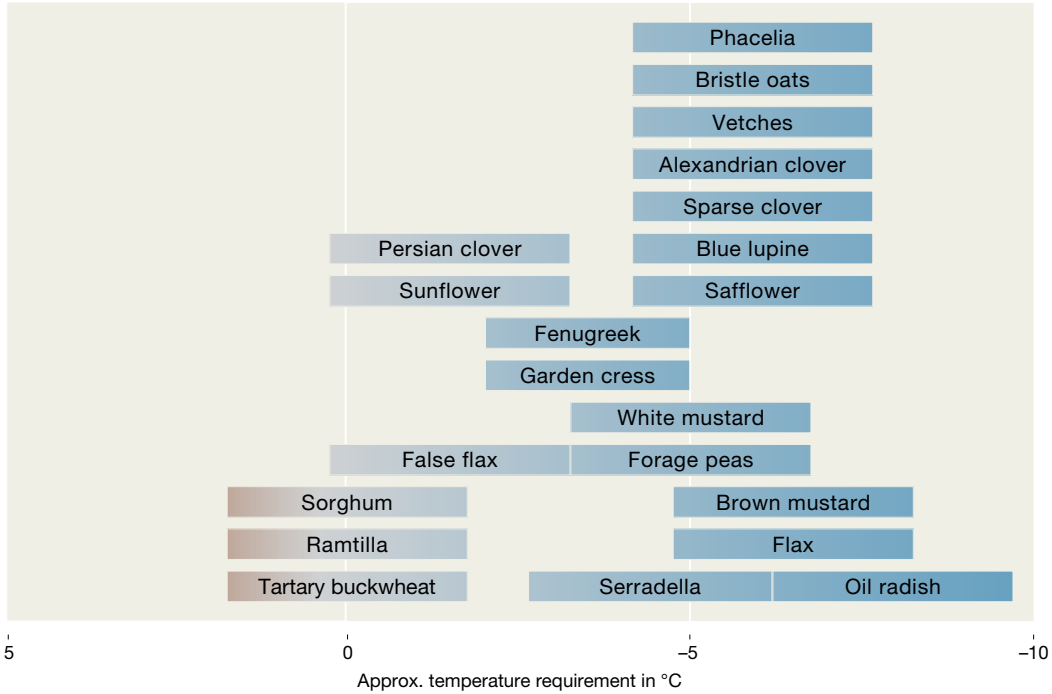
How effectively a catch crop mixture is freezed depends on various factors, some of which you can control.

1. Species and variety selection

Among common catch crop species, the range of frost sensitivity is quite broad. The illustration shows how the species generally react. This evaluation is performed at a development stage that focuses more on the mass and where all species are about equally developed. Tartary buckwheat or ramtilla already react with cellular death at low, one-digit, above-zero temperatures. Minor frost events reliably ensure freezing of these two species. Many other species, such as false flax, flax, or white mustard react adequately to frost. Other species, such as oil radish, require longer and/or stronger single frost events. There are also differences among the varieties within a species. In extreme cases, they can also go beyond the ranges specified here. With mustard and oil radish, for example, this can also be associated with youth development or early blooming.

Once-off frost events in combination with regeneration phases at temperatures that allow growth do not lead to the desired freezing. This is evident during mild winters. The plants can recover and continue to grow. Time periods of several nights with frost or also longer periods with freezing temperatures are reliable.

Comparison of the freezing behaviour of different non-hardy catch crop species



Assessment based on results from in-house trials (KWS LOCHOW, 2022)

2. Seedbed preparation and crop establishment

After selecting the species, here too you can lay the foundation early on for the later, easier “disappearance” of the catch crop mixture. A good start, which ensures good development and a homogeneous crop, also improves the freezing behaviour. This includes the elimination of volunteer grain, oilseed rape or competing vegetation, site-adapted primary soil tillage, as well as sowing technique. The more effort is invested in the start of a catch crop mixture, the more likely good results can also be achieved with the freezing.

Different radish development due to different crop densities (KWS LOCHOW, 2020)

3. Sowing density

Unlike the cultivation of main crops, higher sowing densities and therefore crop densities can offer many benefits – denser crops and weaker development of the individual plants. Weaker development is not a disadvantage in this case. It generally ensures increased frost sensitivity. The best example is with oil radish. If the sowing density is too low and the individual plants grow vigorously, the stem and radish body can be very strongly developed.

Pictures 1 – 6: Freezing behaviour using the example of the KWS Fit4NEXT OILSEED RAPE N-FIX mixture with different sowing dates

Pictures of the catch crop mixture trial 2019/2020 at the Einbeck site (KWS LOCHOW, 2020)

Both the massive stems and particularly the large radish may impede or even prevent freezing in the event of insufficient frost. As a result, this otherwise excellent catch crop species falls from grace, because later elimination with herbicides is also difficult. This is where a higher sowing density helps.
If the field is trafficable, an additional roller pass during the winter season can be worthwhile. It breaks and damages the stem, and later frost events help to kill the entire plant.

4. Sowing date

A very impressive effect can be achieved by selecting an adapted sowing date. This is supported by long-term scientific trials. The same mixture and individual species were sown in the trials at different dates (early: beginning of August; middle: mid-August; late: beginning/mid-September). It was demonstrated that early or timely sowing results in good and massive development of the crops. These well-developed crops react more sensitively to frost events, particularly if the plants have already reached the blooming stage. Moreover, larger plants are more susceptible to mechanical loads such as snow. Of course, an early sowing date must fit into your operational schedule, and the previous crop and soil moisture must cooperate. With extremely early sowing, there can be a risk that individual species or plants still form seeds.

5. Mechanical cultivation

In cultivation areas without reliable frost and with mild winters, an intermediate or subsequent mechanical cultivation of the catch crop mixture can make sense. Where applicable, the timing or technological specifications must be observed here. Use of mulchers or Cambridge rollers (high area efficiency) ensure good results. Measures with soil tillage (e.g. disc harrow, cultivator) can be used (during greening, only after 15 February).
In addition, please also observe the requirements of the Common Agricultural Policy (CAP). **In any case, the trafficability of the field is decisive!**

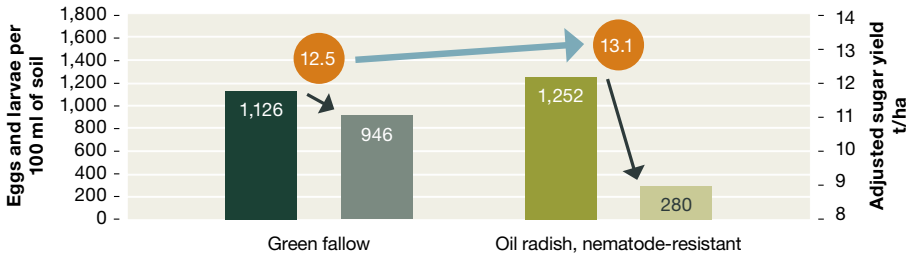
Nematode-resistant catch crops – an important component in nematode management

Beet cyst nematodes (*Heterodera schachtii*) damage the root system of sugarbeet. If there is an infestation, water and nutrient absorption is significantly limited, which can cause yield losses (picture on the right).

The cultivation of nematode-resistant catch crops is an important biological control method to prevent the build-up of high nematode population densities in tight sugarbeet rotations or to reduce existing high populations. In addition to choosing nematode-resistant sugarbeet varieties, the cultivation of nematode-resistant catch crops is a decisive factor in nematode management. This was demonstrated in recent years both by numerous trials and in practice. Nematode-resistant catch crops are capable of significantly reducing the population density of beet cyst nematodes and even enable a positive yield effect on the adjusted sugar yield in the following sugarbeet crop (illustration below).

The principle of action consists in interrupting the development cycle of *Heterodera schachtii*. Just like the host plants, nematode-resistant catch crops stimulate hatching of the nematode larvae, attract them with the promise of a rich food supply, and allow them to penetrate into their root system.

Effect of nematode control on the yield of a nematode-resistant sugarbeet variety with the catch crops “Green fallow” and “Nematode-resistant oil radish”



Biological control of beet cyst nematodes *Heterodera schachtii* Source: Figure based on Heinrichs, 2010 from ”Gesunde Pflanzen” (2011) 62:101–106.

Sugarbeet crop with nematode infestation nest w and dormant beet

Unlike the susceptible host plants, the nematodes cannot establish an adequate nurse cell system in the resistant host plants. The nematodes then starve to death. While a female-male ratio of almost 1:1 is observed in susceptible host plants, it reaches 100:1 in resistant plants. The nematode females require 40 times more food than the males, so that the development cycle is only completed in isolated cases. This leads to a reduction in the nematode population. The nematode-reducing effect of resistant catch crops drops considerably after the beginning of flowering. Cultivation of early sowing-compatible **varieties with long vegetative development and a low tendency to bloom** or **late blooming** is recommended. Hatching is stimulated where the nematodes come into contact with the root system of the catch crop. The seedbed must therefore be prepared such that the plants germinate uniformly and good root development is ensured later on. A plant density of more than 160 resistant plants/m^2 is ideal to reduce the populations of *Heterodera schachtii*. The varieties of oil radish and mustard used both have the best resistance grade of 1 or 2.

You can find more information about nematodes at **www.kws.de/nematodenmanagement**.

Weed suppression

From today's perspective, weed suppression is a goal that is gaining importance in the cultivation of catch crops. Although undesirable weeds and grasses as well as volunteer grain or oilseed rape should germinate, their growth should be suppressed by the rapid development of the catch crops, so that they die before flowering and developing seeds and do not serve as a green bridge for diseases and pests in the crop rotation.

Effective weed suppression can be achieved with catch crop species that have strong youth development, rapid soil coverage, and high biomass growth. The weed suppression achieved by many cruciferous species, such as oil radish, white mustard, and Tartary buckwheat is per se higher than, e.g. clover species and flax.
The reason is their rapid youth development and formation of leaf mass. In addition to the species combination, of course, factors such as the **sowing density**, **sowing date**, **nutrient** and **water supply**, as well as **seedbed preparation** and **sowing technology** play an important role for success.

The better a crop is established, the greater the probability that the desired effect will be achieved. Crops with gaps, which can also occur due to varying freezing behaviour of the mixture partners during the course of the catch crop season, can leave space for new waves of weed growth. Species that like warmth, such as ramtilla, sunflower, or also most legume species, can achieve good effects, but always taking account of the adapted sowing date.

Excellent weed suppression with KWS Fit4NEXT BEET

KWS Fit4NEXT BEET
44% mustard and 56% oil radish

Test mixture
with 8% mustard and 6% oil radish

Efficient water utilisation by the catch crops

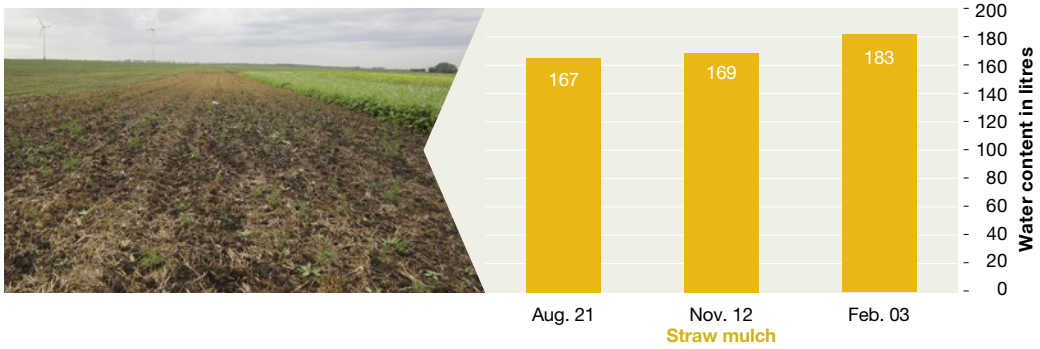
In recent years, the topic of water availability has been significant not only in classic arid areas. The declared goal is to offer the main crop the best possible development conditions. Time and again, the question arises as to whether a catch crop, due to its water use, is detrimental to the growing conditions for the following spring crop. In most cases, one can say: no, a catch crop tends to even have more of a positive effect! What are the reasons for this?

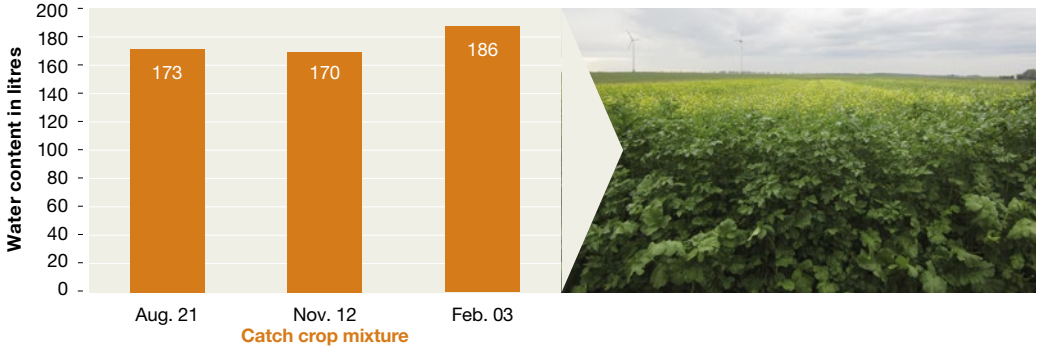
Several areas must be considered when addressing the water requirement and therefore the water use of a catch crop. First of all, it is important to know whether the absence of vegetation (e.g. bare fallow or stubble fallow) saves water compared with vegetation with a catch crop. Numerous trials by the German Meteorological Service (Böttcher et al.), by official Austrian facilities (Bodner et al.), and in-house trials by KWS were performed on this subject. In all cases, the soil water content down to a depth of 60 or 90 cm/100 cm was analysed after harvesting the previous crop/seeding the catch crop until the end of the winter/seedbed preparation for the main crop.

Based on the example of our arid site in Klein Wanzleben, it becomes apparent that the subsequent sugarbeet crop was offered the same starting conditions both with straw mulch and with freezed catch crop. In both cases, the water reserves in the soil were about the same over the entire period.

How can this be explained? The water quantity consumed by the catch crop for the developed biomass is lost in the scenario with straw mulch through other factors, mainly evaporation and seepage water. The most important correlations and the influence of the catch crop are summarised in the table on page 19. A well-developed catch crop ensures better absorption of precipitation thanks to the additional creation of soil pores and because the leaf/mulch cover reduces surface evaporation. As a result, a **catch crop uses water very productively**! In the case of snow, particularly in areas with drift, a well-developed catch crop also reduces “snow erosion” and is additionally beneficial to the water balance of the surface.

Determination and comparison of the soil water contents – straw mulch compared with catch crop mixture





Determination and comparison of the soil water contents in mm down to a depth of 1 m from August 2014 to February 2015 after winter barley as the previous crop at the Klein Wanzleben site. Straw mulch (repeated tillage until winter) compared with a catch crop mixture (sown on 11 August) before sugarbeet. The winter precipitation amounted to 71 litres. (KWS SAAT SE & Co. KGaA, 2021)

Mixing consultant

Find the right mixture for your crop rotation. This is also possible with our "variety advisor" for intercropping mixtures. The result is a mixture tailored to your crop rotation, site requirements and sowing time.

www.kws.de/mischungsberater

You would like to know more?

The KWS advisors for cereals / catch crops will be happy to help you.

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