Factsheet

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Multi-species swards in crop rotations

Building climate resilience

Integrating multi-species swards into the ley phase of organic crop rotations offer farmers a powerful strategy for building climate resilience while improving soil quality, controlling weeds, and supporting livestock nutrition. Success depends on careful mixture design and management, but the benefits extend well beyond the ley phase itself. These swards combine grass, legume and herb species, each of which provides complementary functions, while enhancing biodiversity and supporting climate resilience on the field, particularly within integrated crop-livestock systems. Careful planning of mixture composition, sowing time and management is essential.

Forage production can be substantially reduced by climate change, particularly due to ever-more-frequent and extreme summer droughts alternating with more intense rains. This situation jeopardises livestock feed supply security and undermines the resilience of animal husbandry systems. Faced with these challenges, incorporating multi-species swards into the rotation appears to be a promising adaptive strategy.

Temporary grasslands or grassland leys, which incorporate diverse grasses, herbs and legumes into crop rotations on arable land, can result in higher yields and mitigate the yield risks associated with extreme weather events. Multi-species swards form the foundation of sustainable organic farming systems offering a practical, farm-scale management action to enhance the sustainability of intensive grassland production. Other than providing feed for livestock, they reduce weeds and pests and improve the soil fertility and quality.

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Why integrate multi-species swards into the crop rotation?

Improved soil quality and fertility

Rotating arable land with multi-species grassland benefits soil in several ways. After prolonged arable use, soil organic matter and soil nitrogen (N) availability declines. While pure grass requires N supplementation, legumes, like clover, fix atmospheric N through rhizobium bacteria, reducing fertiliser needs and boosting protein production.

Temporary grassland periods enhance soil quality through organic matter accumulation, improving soil structure, biological activity, and water retention. When ploughed in, this organic matter has a low C:N ratio, mineralising rapidly and releasing substantial N for subsequent crops. This reduces fertiliser requirements while increasing yields compared to continuous arable cultivation.

Info box 1. Defining grassland leys or temporary grasslands

Ley, lea or lay (also sward) is described as arable land temporarily laid down for grass as part of a crop rotation. These temporary grasslands are composed of annual, biennial, or perennial forage species that are usually cultivated for only a few years. In the EU, temporary grassland is defined as grassland included as a part of a normal crop rotation, for at least one crop year and for no more than five years grassland[1]. According to EU definitions, therefore, all temporary grasslands are leys.

Reduced weed and pest pressure

Multi-species grasslands disrupt arable weed and pest cycles. Dense, competitive swards prevent most weeds from establishing, depleting soil seed banks and supporting lower weed populations than pure grass[2]. Upon return to arable production, reduced weed pressure decreases both herbicide use and mechanical weeding time.

The rotation also breaks disease cycles of continuous cropping systems. Pathogens like cereal cyst nematodes and fungal root diseases decline without host plants, while livestock grazing reduces pest populations through trampling and habitat disruption. This natural suppression supports healthier crops with fewer interventions, benefiting both farm economics and environmental sustainability.

Forage yield potential

Multi-species grasslands enhance forage production compared to monoculture grass swards. Herb species like chicory demonstrate high yield potential, often outperforming traditional grass species. The diverse plant species offer complementary rooting depths and growth patterns, optimising resource use throughout the growing season. Legumes contribute protein-rich forage

while fixing atmospheric nitrogen, reducing fertilizer requirements. This diversity creates resilient swards that maintain productivity under varying weather conditions while supporting the arable rotation's fertility goals.

Nutritional quality and animal health

Multi-species swards provide superior livestock nutrition beyond basic forage yield. Herbs contain higher concentrations of essential minerals—including copper, zinc, and selenium—than grasses, potentially reducing costly mineral supplementation. The botanical diversity also delivers health benefits through secondary metabolites: chicory and bird's-foot trefoil contain condensed tannins that reduce gastrointestinal parasite burdens. These combined nutritional and health benefits improve animal performance relative to grass-only swards.[3,4].

Drought tolerance

Prolonged hot and dry conditions can have harsh economic impacts on intensively managed grasslands. Multi-species grasslands demonstrate enhanced resilience to drought compared to pure grass swards[5]. The variety of plant species creates complementary water-use strategies: deep-rooted herbs, like chicory and plantain, tap into moisture reserves during droughts, while shallow-rooted species capitalise on lighter rainfall events. This maintains consistent productivity across variable weather conditions, enables faster recovery after drought periods, and can increase overall annual yields despite temporary stress.[6,7].

Reduced nitrate leaching

Multi-species grasslands reduce N losses compared to pure grass stands[8] owing to the complementary resource use, with grasses utilising their extensive root systems to better capture nitrate. Deep-rooting herbs like chicory and plantain are particularly effective, with taproots reaching up to one meter and dense fibrous roots in the topsoil that efficiently intercept nitrogen. Higher root biomass in diverse mixtures and especially plantain has the potential to further reduce leaching, protecting water quality while retaining nutrients for subsequent crops in the rotation[9].

Support on-farm biodiversity

Multi-species swards enhance farm biodiversity both above and belowground. Above ground, the variety of flowering herbs and legumes provides diverse habitats and food sources for pollinators, beneficial insects, and other wildlife throughout the growing season. This floral diversity supports populations of natural pest predators, contributing to integrated pest management.

Belowground, clover particularly stimulates earthworm populations by providing nitrogen-rich plant residues that earthworms readily consume[10]. Increased earthworm activity improves soil structure by creating burrows that allow plant roots to penetrate deeper and enhance water infiltration. This enhanced soil biological activity creates a self-reinforcing cycle: better soil struc-

ture supports more diverse plant communities, which in turn sustain richer soil life and greater above-ground biodiversity.

What kinds of farms can benefit?

Multi-species leys suit mixed arable-livestock farms and collaborations between specialised farms. Dairy and beef operations growing fodder crops (silage maize, other cereals for whole-crop silage and fodder beets) can integrate diverse leys, while arable farms can establish leys for neighbouring livestock operations or contract grazing[11]. The diversity of species and management flexibility makes them adaptable to many systems.

On a larger scale, arable farms may sell the harvested herbage for use as fodder or biomass, or leys may be grown under contract by companies responsible for cultivation and harvesting. This is practised, for example, with lucerne, which is artificially dried and used as a concentrate or in other livestock feeds. On the other hand, mixed farming systems, also referred to as integrated crop-livestock systems (ICLS), have been reintroduced to promote more climate-resilient, sustainable and economically viable farming systems, compared to those specialised and intensive systems (see Info box 2)[12].

How best to integrate multi-species sward into the crop rotation?

Along with grasses and clovers such as red and white clover, various herbs can be included in productive grassland mixtures. The most common of these are ribwort plantain and chicory, although other herb species can also be included depending on the location and regional conditions.

Sowing time and previous crop

Multi-species swards containing grasses, legumes and herbs should ideally be sown in late summer or early autumn, though the optimal timing varies by climate.

In **Northern Europe**, the preferred sowing window is August to early September. A preceding crop of winter grain or early potatoes works well due to harvest timing. If sowing is delayed beyond early September, young clover and herb plants may not develop sufficiently before winter and can be lost in February or March.
In **Mediterranean climates**, the sowing window shifts to October–November, timed to

Info box 2. Climate adaptation in the Netherlands – cooperation of dairy and arable farms

In the Netherlands, a growing number of organic arable and dairy farmers are collaborating through 'partner farms': mixed farming systems that integrate crop and livestock operations across separate farms. In this partnership, the arable farms grow short term grass clover leys for one to two years, as fodder for dairy farms in exchange for resources such as manure. This helps to overcome some of the major disadvantages of specialisation for organic farmers: it extends the crop rotation of the arable farms, primarily by facilitating N-fixation and weed suppression. At the same time, it ensures a steady supply of high-protein, digestible fodder for livestock farms at relatively low cost.

Spring 2025 was very dry again in the Netherlands and the dairy farmers involved in the OrganicClimateNET Project observes this partnership as an important climate adaptation measure. The dairy farms in this partnership are mostly located on drought-sensitive sandy soils, while the arable farms are situated on a clayey soil with better water availability. For dairy farmers, this concept provides insurance that there will be enough fodder for winter.

coincide with the first reliable autumn rains. Here the key risk is the opposite: rather than insufficient winter hardening, the danger is sowing into soils that are still too dry and warm, leading to erratic germination. If maize is the preceding crop—which is often harvested later under hot, dry Mediterranean conditions; choose an early-maturing variety to allow sowing as early in autumn as possible. In continental-Mediterranean areas, sowing beyond November risks insufficient establishment before either winter cold or the dry spring period.

Regardless of climate, adequate soil moisture after sowing is more critical for multi-species swards than for grass leys alone. Clover and herb seeds are particularly sensitive to surface drying: seeds can absorb moisture from dew and begin germinating, only to be killed if the soil surface dries out again during the day. In Mediterranean transition periods and warm autumns, this risk is especially pronounced.

From a climate adaptation perspective, the autumn sowing window is expected to become shorter and less predictable in both regions as rainfall seasonality shifts. Building flexibility into rotation planning,e.g. identifying alternative preceding crops or irrigating during establishment, will become increasingly important.

Mixture design

The composition of multi-species swards varies by region and according to the main motivations or target ecosystem services. The most productive swards combine species from three functional groups—grasses, legumes and herbs—with a legume proportion of 30–70% delivering the greatest drought resilience[5].

Grasses such as perennial ryegrass are widely used for their versatility across silage, hay, and grazing systems, their high digestibility for livestock[13], and their positive effects on weed suppression and soil structure[2,10]. However, perennial ryegrass is drought-sensitive and may underperform during prolonged dry periods. In drier regions or under climate projections anticipating more frequent summer droughts, more drought-tolerant grasses such as tall fescue and cocksfoot are better suited as the primary grass component (see Table 1).

Research consistently confirms that plant diversity boosts productivity, stability, and drought resistance—a finding of particular relevance as more frequent and intense summer dry periods are projected across Europe by 2050[5]. Importantly, diversity also confers resilience under wetter conditions: species with high waterlogging tolerance such as timothy, meadow foxtail, and greater birdsfoot trefoil can maintain sward productivity during wet spells and on heavier soils (see Table 1). Designing mixtures with both drought- and waterlogging-tolerant species therefore represents a robust climate adaptation strategy.

Each country has commonly used regional mixtures, and farmers are advised to consult their local seed supplier for locally tested options. As a general starting point, a basic mixture per hectare could include:

- 20–30 kg grass seed (perennial ryegrass or substitute tall fescue/cocksfoot in drier regions)
- 5–6 kg red clover
- 3 kg white clover
- 1 kg ribwort plantain
- 1 kg chicory

Seed rates and species composition should be adjusted to local soil conditions, rainfall and intended use. In Mediterranean climates, the grass component in particular warrants reconsideration—drought-tolerant species are strongly preferred, and the proportion of red clover relative to white clover should be increased. If sowing in late autumn, add an additional 1–2

kg of clover seed; however, in Mediterranean conditions late sowing carries more serious establishment risks than adjusting seed rate alone can compensate for.

Table 1. Species selections for multi-species swards: drought and waterlogging tolerance, Category: Legumes

Species						
Latin name	**Common name**	**Drought tolerance**	**Sowing notes***	**Waterlogging tolerance**	**Soil preferences**	**Key benefits / notes**
Category: Legumes						
Trifolium pratense	Red clover	★★★	+1–2 kg if late sowing	★	Wide range; well-drained preferred	Strong taproot; stays green in dry summers; high protein
Trifolium repens	White clover	★	Standard rate; reduce in dry climates	★★	Fertile, moist loams	Persistent in moist conditions; variable drought tolerance
Lotus corniculatus	Birdsfoot trefoil	★★★	Inoculate seed; slow to establish	★★	Wet, acidic, peaty soils	Fixes nitrogen in wet/acidic conditions where other legumes fail
Onobrychis viciifolia	Sainfoin	★★★	Spring or early autumn; large seed	★	Calcareous, well-drained	Excellent drought tolerance; palatable; reduced bloat risk
Lotus pedunculatus	Greater birdsfoot trefoil	★	Spring sowing preferred	★★★	Wet, acidic, peaty soils	Fixes nitrogen in wet/acidic conditions where other legumes fail

*= assuming dry conditions conducive to sowing.
Note: Drought tolerance ratings apply to established swards. All species require adequate moisture at establishment. In Mediterranean climates, species with ★★★ drought tolerance are strongly preferred for the grass and herb components. Waterlogging tolerance ratings reflect resilience to temporary or seasonal saturation.

Table 1. (contin.) Species selections for multi-species swards: drought and waterlogging tolerance, Category: Grasses

Species						
Latin name	**Common name**	**Drought tolerance**	**Sowing notes***	**Waterlogging tolerance**	**Soil preferences**	**Key benefits / notes**
Category: Grasses						
Festulolium	Festulolium hybrid	★★★	Standard autumn	★★	Most soils	Combines ryegrass quality with fescue stress tolerance
Festuca pratensis	Meadow fescue	★★★	Standard autumn	★★★	Clay to loam; low fertility	Deep-rooted; matches ryegrass productivity on lower fertility soils
Lolium arundi-naceum	Tall fescue	★★★	Standard autumn	★★	Wide range, including heavy	High drought toler-ance; persistent under grazing pressure
Poa pratensis	Kentucky bluegrass	★★	Spring or early autumn	★	Well-drained, fertile	Dense, palatable, tolerates dry conditions and traffic well
Dactylis glomer-ata	Cocksfoot	★★★	Standard autumn	★	Well-drained, incl. light sandy	Highly drought-tol-erant; productive alongside ryegrass
Festuca rubra	Red fescue	★★	Standard autumn	★★	Poor, sandy, acidic soils	Good on low-fertility soils; persistent in dry conditions
Phleum pratense	Timothy	★	Standard autumn	★★★	Heavy, moist soils	Excellent for heavy/ wet soils; stabilises sward structure
Alopecurus pratensis	Meadow foxtail	★	Autumn preferred	★★★	Heavy clay, wet low-lands	Very early spring growth; suited to wet, poorly drained fields
Glyceria maxima	Reed sweet-grass	★	Spring or autumn	★★★	Waterlogged, riparian	Tolerates prolonged waterlogging; useful in wettest corners

*=assuming dry conditions conducive to sowing.
Note: Drought tolerance ratings apply to established swards. All species require adequate moisture at establishment. In Mediterranean climates, species with ★★★ drought tolerance are strongly preferred for the grass and herb components. Waterlogging tolerance ratings reflect resilience to temporary or seasonal saturation.

Table 1. (contin.) Species selections for multi-species swards: drought and waterlogging tolerance, Category: Herbs

Species						
Latin name	**Common name**	**Drought tolerance**	**Sowing notes***	**Waterlogging tolerance**	**Soil preferences**	**Key benefits / notes**
Category: Herbs						
Plantago lanceo-lata	Ribwort plantain	★★★	+1–2 kg if late sowing	★★	Wide range	Deep-rooting; boosts drought resilience and mineral content
Cichorium intybus	Chicory	★★★	Avoid water-logged sites	★	Well-drained; does not tolerate wa-terlogging	Deep taproot; drought toler-ance; minerals; animal and soil health
Achillea mille-folium	Yarrow	★★★	Standard autumn; small seed	★★	Poor, dry soils	Drought-hardy; deep roots; medicinal prop-erties; attracts beneficials
Sanguisor-ba minor	Salad burnet	★★★	Standard autumn	★	Calcareous, well-drained	Deep-rooted; palatable; drought-tolerant; mineral-rich
Succisa pratensis	Devil's bit scabious	★	Autumn or after cold stratifica-tion	★★★	Wet, neutral to acidic	Thrives in wet conditions; high biodiversity and pollinator value

* = assuming dry conditions conducive to sowing.

Note: Drought tolerance ratings apply to established swards. All species require adequate moisture at establishment. In Mediterranean climates, species with ★★★ drought tolerance are strongly preferred for the grass and herb components. Waterlogging tolerance ratings reflect resilience to temporary or seasonal saturation.

Establishment: sowing and first-year managament

Timing and seed rates

Sow in spring (March–May) or late summer (August) when soil temperatures exceed 8°C and moisture is adequate. Typical seed rates range from 25–35 kg/ha, adjusted based on species composition and establishment method.

Soil preparation

Before sowing, ensure:

- Adequate phosphate and potassium is especially critical for root development under dry conditions
- Target pH-H_2O 6.2-6.5 or pH-KCl 5.2-5.5, though this varies by region and soil type
- Where permitted, a light slurry application (10–15 m³/ha) can be applied before sowing, but avoid heavy applications on dry seedbeds (compaction risk) or wet heavy soils (run-off risk).
- Futher nitrogen fertilisation is not required as legumes will fix their own nitrogen; excess N suppresses clover

Sowing depth and seedbed

Multi-species swards should be sown at maximum 1.0–1.5 cm depth, as small-seeded herbs and clovers cannot emerge from greater depths. In drier climates:

- Sow toward 1.5 cm depth
- Consolidate the seedbed firmly with a roller to improve moisture access
- Maintain some surface roughness to prevent rain-induced crusting

In northern climates, avoid very shallow autumn sowing on light soils to prevent frost damage.

First-year expectations

The establishment period presents challenges due to slower initial growth compared to pure grass:

- Careful weed management is essential in the first 6–8 weeks,
- Light grazing or a conservation cut at 8–10 cm helps control annual weeds without damaging establishing seedlings,
- Avoid heavy grazing or cutting; prioritise root development over forage yield,
- Full productivity typically arrives in year 2, though grasses establish quickly while deep-rooted herbs like chicory need a full season to develop their root systems. Plan for reduced first-year output (60–75% of mature sward yield) when budgeting feed requirements.

Weed control after sowing

Weed pressure after sowing is usually managed with an early first mowing, allowing slower-establishing herbs and clovers to compete more effectively. When sowing after a grain stubble, this can often be completed before winter growth slows—though timing varies by region and season.

If soils are too wet to mow without causing compaction or rutting, delay until conditions allow. In mild or wet autumns, weed growth can be rapid, so monitor closely. In Mediterranean climates, the first flush of autumn weeds often coincides with the establishment window, and an early mow may be needed before dry conditions return in spring.

Winter management after sowing

Especially with autumn sowing, it is important that multi-species swards enter the winter period at a low sward height which allows greater light penetration to the base and promotes tillering. Herb species such as chicory can be sensitive to grazing in wet conditions, especially late in the year when damage caused by poaching and treading is more likely.

Target length of a temporary grassland period

A three-year temporary ley period is optimal, as the soil has time to recover and rebuild sufficiently after three years of arable use. Additionally, the costs of sowing multi-species swards can then be spread over three years. However, longer periods (>3 years) swards are not desirable because of N build up that cannot be optimally utilised in the subsequent crop, which can lead to nitrogen leaching. Shorter periods (<3 years) may not allow deep-rooted species, like chicory to fully establish or provide maximum soil benefits.

Management during the ley phase

Multi-species swards require more careful management than grass monocultures, as each functional group responds differently to cutting height, grazing frequency, and fertiliser inputs.

- **Nutrient timing:** Apply slurry early in the season to stimulate grass before clover and herbs become active.
- **Cutting and grazing heights:** Maintain minimum residual height of 6–7 cm to protect the higher growth points of red clover and herb species. Cutting too short damages these species disproportionately. In dry conditions, raise this threshold further to help swards retain leaf area and recover effectively.

- **Grazing strategy:** Rotational grazing is strongly preferred over continuous grazing, allowing recovery periods between passes. Sheep selectively graze clover and herbs more than cattle, significantly reducing their proportion over time; continuous sheep grazing is particularly damaging to diversity. Under variable rainfall, extend rest periods during dry spells to maintain sward composition. Lush, legume-rich swards carry bloat risk for cattle and sheep, particularly early season—monitor closely.
- **Mediterranean climates:** Summer management should shift from productivity to preservation. Reduce grazing or cutting pressure well before the dry season to allow plants to build root reserves for autumn recovery.

Costs and return on investment

Multi-species seed mixtures typically cost 2-4 times more than simple ryegrass-clover blends, with prices varying by species diversity and seed source. A diverse 6-8 species mixture may cost €150-250/ha compared to €60-100/ha for conventional ley seed. However, this higher up-front cost should be weighed against multiple benefits:

- reduced fertiliser requirements through legume nitrogen fixation
- improved drought resilience reducing yield variability
- enhanced soil structure benefiting subsequent crops, and
- potential reductions in veterinary costs through improved animal health.

The nitrogen left for following crops can be substantial—a legume-rich ley may provide 80-150 kg N/ha. Most farms report the investment pays back within the first rotation cycle.

Termination methods

Terminate the ley 4–6 weeks before sowing the next crop to allow decomposition and nutrient release. Best methods depend on system:

- **Plowing:** 15–20 cm depth incorporates biomass effectively; deeper plowing (>20 cm) buries organic matter too deeply for optimal mineralisation,
- **Shallow cultivation:** Multiple passes with disc harrows or cultivators (10–15 cm) suitable for organic systems; may require several operations to kill perennial species,
- **Timing:** Autumn termination allows winter decomposition; spring termination provides shorter interval before cash crops.

Managing the nitrogen flush

A legume-rich ley provides 80–150 kg N/ha to the following crop—valuable but requires careful management:

- Match the following crop to expected N availability (winter cereals, maize, or brassicas work well)
- Avoid crops with low N demand or those vulnerable to lodging from excess N
- In high-rainfall areas, terminate in late summer/early autumn and establish cover crop immediately to capture N and prevent leaching

- Time spring crop planting to coincide with peak N mineralisation (typically 3–6 weeks after termination)

Recommended following crops

The best following crops would have higher N requirement, to capitalise on N credit and improved soil structure:

- Winter wheat or other cereals (moderate-high N demand)
- Brassicas (high N demand)
- Potatoes (benefits from disease break and structure)

Avoid legumes as the immediate following crop, as they cannot utilise the N credit effectively.

Planning considerations

Integrating multi-species swards into arable rotations requires more upfront planning than conventional leys, but offers substantial benefits in return.

Species selection should align with farm priorities: deep-rooting herbs improve soil structure and drought resilience, while early-flowering species support pollinators. However, diverse seed mixtures cost 2–4 times more than simple ryegrass-clover blends, and management complexity increases with diversity.

Rotation length requires flexibility. Many herb species have relatively short lifespans—chicory rarely persists beyond 3–4 years—making multi-species swards well suited to 2–4 year leys rather than permanent pasture. Climate variability may require adaptive management: a drought-thinned sward may warrant early termination, while a thriving sward could be extended. Balance productive lifespan against soil nitrogen accumulation and the needs of your rotation sequence.

System fit matters more than following rigid guidelines. Multi-species leys excel in mixed crop-livestock systems where grazing is integrated into the system, or through livestock-arable farm collaborations. Success depends on matching mixture complexity to management capacity and measuring performance against specific goals—whether drought resilience, soil improvement or forage quality.

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Further information

- Including diverse leys in arable rotations: organic-farmknowledge.org/tool/44457
- Temporary ley mixtures with added herbs: organic-farmknowledge.org/tool/55491
- Including diverse leys in arable rotations: organic-farmknowledge.org/tool/44457
- Ley termination with shallow ploughing or cultivators: organic-farmknowledge.org/tool/30994
- Undersowing leys in cereals: organic-farmknowledge.org/tool/41887
- Living Mulches hub and technical guide: organic-farmknowledge.org/tool/55988

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About OrganicClimateNET

The project is running from February 2024 to January 2028. The overall goal of OrganicClimateNET – A pilot network for organic climate farming – is to act as a model for the European organic sector to enable farmers to integrate climate farming, thereby enhancing their capacity to mitigate and adapt to climate change.

Project website: organicclimatenet.eu

Social media:

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