Benefits of intermediate crops, and bottlenecks to their development

With recommendations for practical certification guidance

studio gear up

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Executive summary

Background

Intermediate crops are crops planted and harvested between main crops in a crop rotation scheme. They offer an additional volume of feedstock for the bioeconomy on top of existing food and feed farm output without requiring additional land. Their inclusion within the Annex IX of the Renewable Energy Directive makes them an interesting feedstock for meeting renewable fuel subtargets of the Renewable Energy Directive, the ReFuelEU Aviation and the FuelEU Maritime.

The technical potential to grow intermediate crops in the EU is large, and indispensable for meeting EU renewable fuel targets. But the adoption and scale-up to reach the full potential of this option takes at least 15 years. A timely and effective contribution therefore depends on a (1) an immediate and long-term market perspective and (2) a prompt finalisation of practical rules for certification and compliance.

To promote the role of intermediate crops in the European biobased economy, several industry stakeholders have convened and formed an ad hoc industry Coalition (hereafter: the Coalition). They have asked studio Gear Up to assess the benefits of intermediate crops, to assess the bottlenecks to their development and deployment, and to provide recommendations for certification of these crops in the frame of the Renewable Energy Directive.

Benefits

Intermediate crops have gained increasing interest across Europe due to their multiple benefits and their potential to contribute to union objectives in energy, climate, agriculture, industry and broader biobased economy. Beyond providing additional volumes of sustainable biomass feedstock (for renewable energy and reducing greenhouse gas emissions), intermediate crops can contribute to climate resilience of farmland, add to increasing soil organic matter, generating additional income and market for farmers, which in turn benefits the rural economy. The coproduction of animal feed and biofuels assists European protein self-sufficiency. Also, an increased land-use efficiency can reduce pressure on natural ecosystems by reducing demand for additional agricultural land elsewhere.

Bottlenecks

Despite the many potential benefits of intermediate crops, their large-scale implementation and development also face several challenges. The most important challenge is the lack of certification guidance, which makes stakeholders hesitant. But the value chains cannot be built overnight. Farmer contracting and an optimal integration of intermediate crops at a farm requires at least two to three cultivation seasons. The farmer also faces unknown cost aspects, due to requirements that may change and possible interference with Common Agricultural Policy rules and subsidies. At the same time, further seed development is required for large-scale roll out in Europe. In parallel, crushing and conversion capacity must be developed. In sum, time is of the essence.

Therefore, this large-scale rollout and further development of new intermediate crop varieties take precious time. At the same time, the farmers and the industry face uncertainty about the demand for (and the value of) these intermediate crops as Annex IX feedstock for biofuels. The current formulation of targets and categorisation of eligible feedstocks in the legislative and regulatory framework are stimulating the development of intermediate crops for aviation, but have not given the immediate incentive to use the road sector mandates to build up the volumes.

Recommendations

We recommend to introduce a definition of intermediate crops that focuses on the role they have in providing additional feedstock volumes compared to the existing practice at a farm,

and that relates to their position in the rotation scheme. Our more detailed recommendation can be found in Appendix A of this report.

To ensure a large and timely contribution of intermediate crops to renewable energy targets in transport and potential mandates for chemical markets, we recommend that the European Commission widens the optionality in the Annex IX definitions by either (1) allowing intermediate crops to count for Annex IX A subtargets in all transport sectors, or (2) lifting the cap on Annex IX B, so that intermediate crops become a next cost-attractive option besides waste vegetable oils.

We also recommend that the Commission swiftly finalises and publishes practical certification guidelines for intermediate crops in Regulation (EU) 2022/996:

- We recommend that the certification method is crop-agnostic because many crops may be made suitable as intermediate crops and no option should be ruled out.
- We recommend that compliance with requirements should be proven at the farm-level, because the options may differ from farm to farm – we therefore also recommend that the certification method is region-agnostic.
- The method should rely on farm-based strict documentation of the existing/previous practice and how intermediate crops are inserted.
- Intermediate crops can be inserted between main crops (outside of the primary cropping season) or use fallow land in break years.
- By documentation of existing farm practice, it can be proven that the intermediate crop does not displace main crops or (indirectly) expands arable land elsewhere.
- Use observation and documentation to prove that soil-organic matter is maintained without soil sampling.

We furthermore recommend aligning rulesets for intermediate crops with the Common Agricultural Policy (such as catch and cover crop subsidies) and the Carbon Sequestration and Carbon Farming regulation where possible, to limit competition between incentive frameworks and to align the administrative efforts for the farmers.

Finally, we find that the discussion on intermediate crops should be extended beyond their contribution to renewable fuels and climate targets. A more efficient land use benefits the production of food, feed, as well as (green chemical) materials and energy for the European bioeconomy and the European protein autonomy.

Table of Contents

1 Introduction

Intermediate crops can generate more feedstock for the biobased economy

Intermediate crops are crops planted and harvested between main crops in a crop rotation scheme. They represent an important option to produce additional feedstock for the biobased economy, alongside food and feed crops, and without expanding (global) agricultural land. As such, they offer increased feedstock flexibility for sustainable biofuels needed to meet 2030 and beyond policy mandates in transport.[1] Specifically the recent (2024) inclusion in Annex IX of the Renewable Energy Directive makes intermediate crops an interesting feedstock for meeting subtargets in the Renewable Energy Directive and the ReFuelEU Aviation Regulation.[2] The integration of these crops in existing agricultural practices, producing additional volumes within existing land use, and combined with a mandated demand, can create an interesting additional business case for farmers.

The technical potential of intermediate crops that can be grown, in Europe, is considerable: the European Commission (hereafter EC) has estimated that up to 27 Mtonne of vegetable oils (plus proteins) could be produced via intermediate crops, as well as a further 159 Mtonne of starch and lignocellulose biomass.[3] Therefore, intermediate crops may be an indispensable feedstock option to produce the required volumes of sustainable biofuels for the obligated parties in the transport sectors to meet their 2030 transport sector mandates. Nonetheless, its rollout and scale-up to reach the full potential takes at least 15 years, see Figure 1, next page. Intermediate crops can only timely contribute to achieving renewable fuel targets if the regulatory framework is attractive and offers a long-term perspective, and if the certification framework is finalised soon.

Intermediate crops are indispensable for meeting EU renewable fuels targets

The existing production capacity of biofuels from other lipid feedstock options are either more restricted in volume or face regulatory limits. This could potentially create a problem for obligated parties to contract the required volumes of renewable fuels that they need to meet their mandated goals in 2030 as shown by Figure 2.

First of all, the ReFuelEU, FuelEU Maritime and the Renewable Energy Directive require a large amount of Annex IX biofuels in 2030 and beyond. The European Commission projected that the total demand for Annex IX biofuels in 2030 is likely between 24 and 30 million tonne.[4] This volume may consist of various fuel types, including bioethanol and biomethane.

Considering that new production facilities for advanced biofuels on basis of technology platforms that can process lignocellulose feedstock, and for drop-in e-fuels, are developing slowly, a new feedstock base that can increase the Annex IX biofuel production volumes via existing conversion facilities and commercially available technologies provides important options for the market for meeting the mandates in the road sector.

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[1] Such as the policy mandates laid down in the revised Renewable Energy Directive (EU) 2018/2001, ReFuelEU Aviation (EU) 2023/2405, the FuelEU Maritime (EU) 2023/1805, as well as stimulated by the Emissions Trading Scheme 2003/87/EC which has recently been expanded to include aviation, shipping and road transport.

[2] Commission Directive (EU) 2024/1405 introduced intermediate crops in Annex IX of the Renewable Energy Directive. When used to produce biofuel for aviation they fall under Part A, otherwise under Part B of the same Annex IX. This currently implies a limitation of their deployment in broader transport, as discussed in Chapter 4.

[3] The theoretical potential for vegetable oils produced via intermediate crops in the EU is based on EC DG Research and Innovation 2024, Development of outlook for the necessary means to build industrial capacity for drop-in advanced biofuels.

[4] EC DG Research and Innovation 2024, Development of outlook for the necessary means to build industrial capacity for drop-in advanced biofuels.

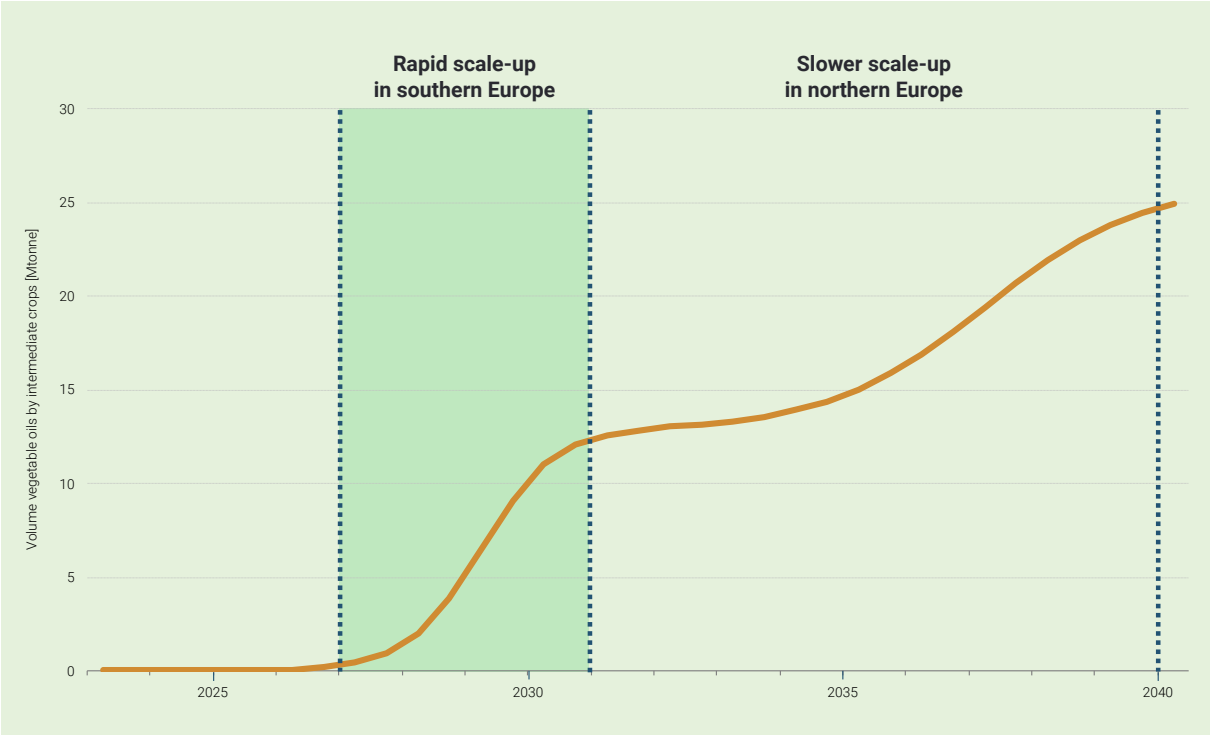

Figure 1. Possible development of the potential of vegetable oils from intermediate crops in the EU. The European Commission[3] estimates that the total technical potential for intermediate crops is about 186 Mtonne, including about 27 Mtonne of vegetable oil. In a first stage, it would require about 2 – 3 years to roll out intermediate crops in regions where existing varieties can be integrated in existing crop rotations. The development of varieties for colder regions, towards northern Europe, takes 10 – 15 years. We assumed that finalization of certification guidelines by the end of 2025 can initiate investments from 2026 onwards, leading to first production in 2027. More detailed considerations on this timeline are discussed in Chapter 4. Obviously, overseas sourced intermediate crops can also contribute.

Further considering the current and near-term fleet compositions, and the constricted fuel specifications for ethanol in petrol cars, most of the renewable fuels used for road, aviation and maritime fuels will be diesel-type fuels.

This context requires an expansion of current production capacity with more flexibility in the lipid feedstock base. For aviation, the only commercially available biofuel is HEFA, also based on lipids. Alternative technology pathways in the SAF-market, such as for e-SAF, are under development but are not expected to contribute before 2030.

While Annex IX A and B of the Renewable Energy Directive contain a wide range of feedstock options, most do not currently have a great potential to produce affordable biofuels. The most significant current options are shown on the right-hand side of the figure:

- The global potential for Palm Oil Mill Effluent (POME) ranges between 1.5 and 3 Mtonne.[5]
- The global potential for Crude Tall Oil (CTO) ranges between 1.6 and 2.5 Mtonne.[6]
- The global potential for other acid oils and refinery fatty acids ranges 2.1 to 7.5 Mtonne.[7]
- The global potential for used cooking oil is about 6 Mtonne.[8]

For intermediate crops, the European Commission calculated a 27 Mtonne technical supply of vegetable oils from these crops and presents this as a share within a larger potential of intermediate crops (186 Mtonne) also including starch and lignocellulose crops.

[5] T&E estimates that the global potential for POME is 1 – 1.5 Mtonne [T&E 2025, Palm oil in disguise?]. ISCC estimates that the maximum potential is 3 Mtonne [ISCC 2025, Understanding POME context and controversy (website news item)].

[6] Ecofys estimates a global potential of 2.5 Mtonne CTO, and cites an estimate by Pöyry of 1.6 Mtonne [Ecofys 2017, Crude tall oil low ILUC risk assessment].

[7] Based on confidential study by studio Gear Up, involving interviews with experts and stakeholders in lipid residues industry.

[8] IEA 2023, Liquid biofuels – feedstock forecast.

This may make intermediate crops an indispensable option, if two important bottlenecks, further discussed in Chapter 4, are solved:

1. The contribution of intermediate crops outside the aviation sector is limited by the 1.7% cap on Annex IX B feedstocks. This will strongly limit the role for intermediate crops in maritime and road transport in the frame of the Renewable Energy Directive. Member States may want to allow higher Annex IX B volumes, above the cap, for these sectors.
2. The timely development of intermediate crops requires a quick adoption of credible and practical certification guidelines via the implementing act. In Chapter 4 of this report, we discuss the timeline to integrate intermediate crops in the agricultural practice.

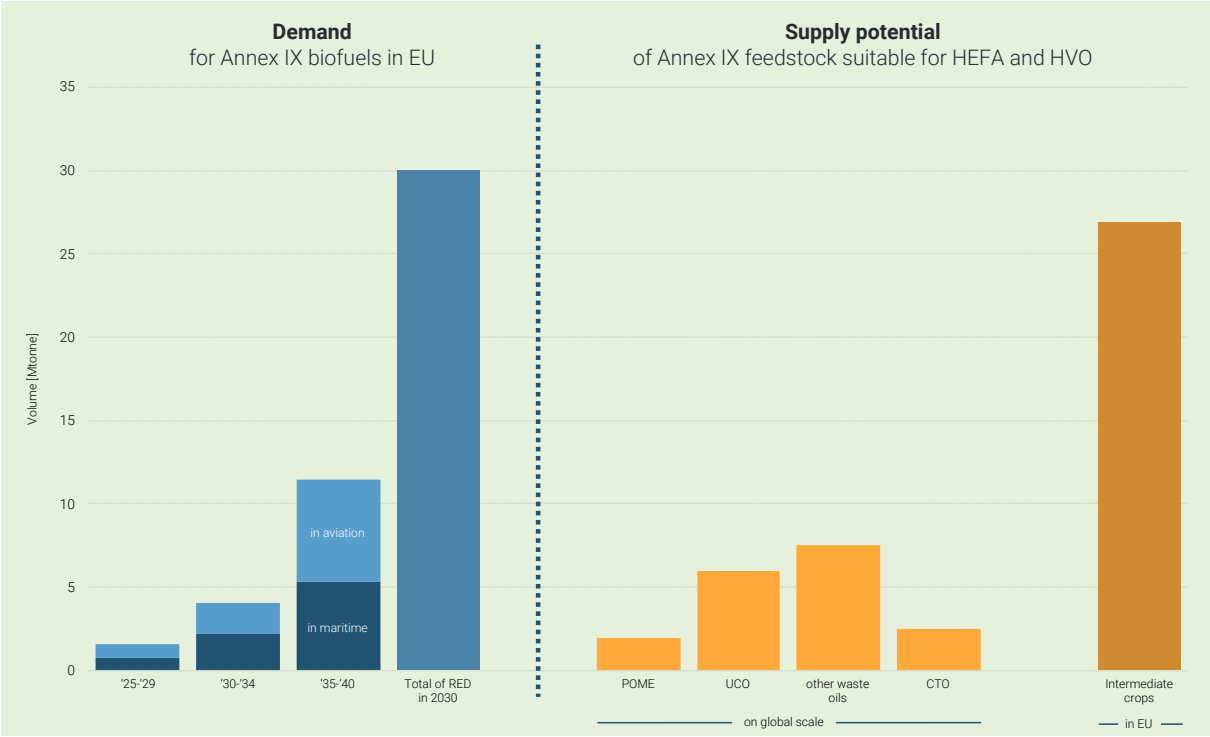

Figure 2. Demand for Annex IX fuels by the ReFuelEU aviation regulation, the FuelEU Maritime regulation, and the Renewable Energy Directive (left). Potential supply of likely Annex IX feedstock for SAF and renewable diesel in the same timeframes (right). Demand was calculated as follows: ReFuelEU can only be fulfilled by Annex IX or RFNBO (e-SAF), with a target of 2% until 2029 (assume a negligible share of e-SAF), 6% during 2030-2034 (assume about 1.5% e-SAF in line with subtarget), 20% during 2035-2040 (assume 5% e-SAF in line with subtarget). FuelEU Maritime sets targets for emission intensity reduction of 2% for the period 2025-2029, 6% for 2030-2034, 14.5% for 2035-2039. This has been translated to renewable fuel demand. The FuelEU Maritime de facto excludes food and feed crop-based biofuels and therefore implicitly requires mainly Annex IX biofuels. Total demand for Annex IX by RED from EC study, see main text and footnote 4. Potential supply of palm oil mill effluent (POME), other waste vegetable oils and refinery fatty acids, crude tall oil (CTO), and vegetable oils via intermediate crops are based on literature, explained in the main text.

Study objectives

Several industry stakeholders have convened and formed an ad hoc industry coalition (hereafter: the Coalition)[9] to promote the role of intermediate crops in the European biobased economy. The Coalition asked studio Gear Up to assess the benefits of intermediate crops, to assess the bottlenecks to their development and deployment, and to provide recommendations for the certification of these crops under the Renewable Energy Directive.

This study is based on knowledge and expertise from studio Gear Up, literature research and complemented with interviews with companies involved in the Coalition. In Chapter 2 we summarise the context. In Chapter 3, we review potential benefits of intermediate crops. Chapter 4 assesses the major bottlenecks to their timely development. Finally, in Chapter 5 we provide recommendations to support a successful scale-up of intermediate crop application in Europe.

[9] See colophon in this report.

2 Context

Intermediate crops contribute to union objectives for energy, climate, agriculture and industry

Europe faces challenges with the energy and climate crises, global competition, farmers livelihoods, ecosystem degradation and biodiversity decline.[10] To address these various hurdles, the European Commission has set several ambitious objectives which are addressed in various policy frameworks. The Fit for 55 package, Clean Industrial Deal, European Green Deal and the Vision for Agriculture and Food, all provide long-term plans to promote the resilience and sustainable prosperity of Europe. With 2040 Climate targets and the announced Omnibuses for Simplification, the Bioeconomy Strategy, and the Climate Resilience and Risk Management Initiative, new objectives will be added. The European Commission is thus tasked with a complex balancing act to pursue the different objectives of the Union.

Beyond providing additional volumes of sustainable biomass feedstock (for renewable energy and reducing greenhouse gas emissions), the development of intermediate crops can also contribute to regenerative farming, by providing considerable benefits for soil health, biodiversity and climate change mitigation through soil carbon sequestration, and provides additional income and market to farmers, which in turn benefits the rural economy. The coproduction of animal feed assists European protein self-sufficiency. Also, an increased land-use efficiency can reduce pressure on natural ecosystems by reducing demand for additional agricultural land.

In this setting, intermediate crops have been gaining increasing interest across Europe due to their multiple benefits and their potential role to produce feedstock for fuels and chemicals in the biobased economy, and how they may contribute to Union objectives and address some of the challenges noted above.

This also means that several legislative and regulatory frameworks related to agriculture, feedstock production or climate action, create a role for intermediate crops. It is necessary that the subsequent targets and instruments, for instance in the Common Agricultural Policy, the Carbon Reduction and Carbon Farming Regulation, and the Renewable Energy Directive, do not contradict each other.

Transport mandates lead the way

Europe seeks to reduce emissions in the transport sector with a strategy that combines support for a rapid electrification of transport with policy support for renewable fuels to replace fossil fuels. Especially in aviation, biofuels remain the most cost-efficient and scalable solution. The Renewable Energy Directive, the Fuel EU Maritime and the ReFuelEU Aviation, create increasing mandates to deploy biofuels and other renewable fuels in the national transport sectors and in the international aviation and maritime sectors.

Over the past decade, these European biofuel mandates have led the way in shaping demand markets for biomass feedstock. Fuel producers must secure sufficient volumes of sustainable feedstocks to comply with the mandates. As a result, the interest in establishing reliable, long-term feedstock supply chains, including a range of feedstock types is increasing.

Feedstocks can be categorised by their physical characteristics, or in regulatory context.

From a physical point of view, we note that the European Commission projects that transesterification and hydrotreatment conversion capacity for lipids (vegetable oils and

[10] von der Leyen 2024, Political Guidelines for the next European Commission 2024-2029.

animal fats) will increase by 2030 and for hydrotreatment also beyond 2030.[11] Lipids are also important to provide green feedstock for green chemical manufacturing.

From the regulatory point of view, we should note that the EU has limited the share of "food and feed crops"[12] in biofuels, introduced submandates to support the development of advanced biofuels and e-fuels, and stimulates biofuels produced from residues and waste streams. The desired feedstocks are listed in Annex IX of the Renewable Energy Directive.

In 2024, intermediate crops have been added to this list of feedstocks, however with a distinction between their use in the aviation sector on the one side and in the maritime and road sector sectors on the other side. In this way the use of intermediate crops is incentivised for aviation, but it is capped as a biofuel option in the road and maritime sectors. This adds a complexity because production facilities often produce not only aviation fuels but also fuels for the road or maritime sector, as well as other chemical building blocks such as green naphtha. Either way, the use of intermediate crops as feedstock option will contribute to increased feedstock flexibility in the production of sustainable biofuels. This has further increased their interest, but the current formulation of Annex IX creates some bottlenecks to their deployment. If these bottlenecks could be removed, then the mandates for renewable fuels could become a more important driver for the development of intermediate crops.

[11] Analysis by the Dutch Platform Renewable Fuels, on basis of data in [EC DG Research and Innovation 2024, Development of outlook for the necessary means to build industrial capacity for drop-in advanced biofuels].

[12] 'Food and feed crops' is a legal term which is defined in the Renewable Energy Directive (EU) 2018/2001 as "starch-rich crops, sugar crops or oil crops produced on agricultural land as a main crop excluding residues, waste or ligno-cellulosic material and intermediate crops, such as catch crops and cover crops, provided that the use of such intermediate crops does not trigger demand for additional land".

3 Benefits

Intermediate crops offer a wide range of potential benefits, see Figure 3. Their integration in agricultural practices create opportunities for additional income for farmers and an instrument to improve the resilience of their soil to changing climate conditions. By promoting crop diversification and increasing land productivity, intermediate crops bring many agronomic benefits in a way that is aligned with regenerative agriculture practices such as maintaining soil organic matter. In addition, they provide an opportunity for farmers to generate additional income. On the other hand, intermediate crops are a crucial feedstock type providing more flexibility to scale up the production of renewable fuels necessary to reach climate targets.

Figure 3. Overview of the key benefits of intermediate crops as discussed in this chapter.

Feed and fuel synergy

The incorporation of intermediate crops maximises the land use efficiency without compromising on existing agricultural production or advancing into nature: it allows to produce a food or feed crop during the primary season, and feedstocks for the bioeconomy during the otherwise fallow, idle or unproductive periods.[13,14,15]

On a systemic level, improved resilience of the EU farm sector and strengthening of EU protein security (both below) also contribute to increased food security. Finally, some vegetable oils of intermediate crops, while intended as feedstock for biofuels, can still be directed to the food sector when necessary (as was observed during high veg oil prices in 2020). The additional feedstock thus provides flexibility to multiple markets.

[13] Alexopoulou 2024, Research on intermediate crops, Webinar Intermediate crops for low ILUC biofuels in the EU.

[14] Barrios Latorre 2024, Managing Soil Carbon Sequestration: Assessing the Effects of Intermediate Crops, Crop Residue Removal, and Digestate Application on Swedish Arable Land. GCB Bioenergy, 16: e70010.

[15] Fallow land is traditionally used for agricultural land left intentionally uncultivated for a period or cycle typically with the intentional of improving soil quality and fertility. Idle land is traditionally used for land suitable for cultivation that has been abandoned or no longer utilised.

Demonstrably additional feedstock for the biobased economy

Since the crops are grown during otherwise fallow, idle or unproductive periods, it can be demonstrated that the harvested feedstock is fully additional to what would otherwise be produced on that land. This ensures that they do not cause any indirect land use change. See Appendix B of this report for ideas on how the additionality and other requirements set by Annex IX can be demonstrated.

Climate resilience

Intermediate crops help to increase the resilience of farms against extreme weather events. Intermediate crops cover the land when the land would otherwise be fallow and exposed in periods of heavy rainfall.[16] In doing so, intermediate crops help retain soil structure, as they usually develop deep rooting systems thereby reducing the risks of soil erosion.[17] The use of intermediate crops species with strong functional root systems can also improve the resilience of the land to droughts by retaining moisture and increasing soil water storage capacity.[18] With a changing climate, intermediate crops can thus help increase resilience to different environmental conditions and provide farmers with flexibility.

Farm economy

Intermediate crops provide additional income for the farmer, against relatively low additional costs, using the same land and the same machinery during a period that these would otherwise be idle, although both cost and revenue will depend on how some bottlenecks are addressed (see Chapter 4).[19] Part of the additional costs may be recovered by improved soil health, which reduces the vulnerability of the land to extreme weather events (droughts and heavy rainfall), as well as a reduced use of fertilizer and pesticides (noted above). The crops also provide diversification to an additional market, which reduces the exposure to volatility in commodity markets.

Economically healthy farms also contribute to their surrounding rural economy, through the involvement of contractors and other suppliers and offtakers.

Increased flexibility in feedstock supply for the production facilities

Unlocking the large potential of intermediate oil crops will allow the HEFA and renewable diesel producing industry to further scale up,[20] certainly when the supply of other feedstocks is capped (food and feed crops) or approaches the supply maximum as indicated in Figure 2 (for POME oil, crude tall oil, used cooking oil and animal fat, and other residue oils). With other technology platforms ramping-up also starch or lignocellulosic containing crops will add to feedstock mobilisation in these pathways in a similar way. In the context of strategic autonomy, and in case overseas supply chains are under pressure, access to a European feedstock base is a relevant asset for the European production facilities.

Intermediate crops grown outside the primary crop season help to more evenly distribute the feedstock supply over the year. This assists the continuity of EU renewable aviation fuel (and animal feed) producing industry.

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[16] This is an important reason for farmers to incorporate intermediate crops (specifically cover crops), even when the crop is not harvested.

[17] Alexopoulou 2024, Research on intermediate crops, Webinar on Intermediate crops for low ILUC biofuels in the EU.

[18] EIP-AGRI Focus group 2021, Sustainable industrial crops.

[19] Svensson et al 2025, Evaluating intermediate crops for biogas production–Effects of nitrogen fertilization and harvest timing on biomass yield, methane output and economic viability. Biomass and Bioenergy, 192, 107497.

[20] Analysis by the Dutch Platform Renewable Fuels on basis of data in [EC DG Research and Innovation 2024, Development of outlook for the necessary means to build industrial capacity for drop-in advanced biofuels].

Further optimization of intermediate crops involves the development of crop types that grow in colder settings (more north and more outside the primary cropping season). The prospect of a significant demand for these crops will boost innovation in seed development, in machines (for seeding, tending, harvesting), and precision agriculture.[21]

European policy targets

Intermediate crops are a cost-effective option for Europe to enable an additional supply of renewable energy and sustainable carbon. As noted in Chapter 1, the theoretical potential is larger than the current demand for Annex IX based biofuels from the ReFuelEU Aviation regulation and the Renewable Energy Directive.

The additional volume of renewable fuels further limits the use of fossil fuels and their climate impacts. The supply chain of intermediate crops will have limited greenhouse gas emissions and may effectively decrease emissions of the primary crop via reduced use of synthetic fertilizer (due to less loss of nutrients) and less loss of crops. At the same time, the soil organic matter fraction and therefore the carbon stocks in agricultural land are maintained.

The European Parliament noted that the EU's current protein import dependency poses risks related to price volatility, global market fluctuations, and trade disruptions, which can threaten EU food security.[22] For each tonne of biofuels produced from intermediate crops such as camelina or brassica carinata, almost two tonne of protein rich animal feed is produced. The development of the indicated potential of 27 Mtonne of vegetable oils via intermediate crop thus implies about 50 Mtonne of animal feed which is almost twice the current EU import of soybean meal.

[21] The boost in innovation by the increasing demand for intermediate crops has been mentioned in several conversations with industry parties supporting the Coalition.

[22] European Parliamentary Research Service 2023, Briefing PE 751.426 on EU protein strategy.

4 Bottlenecks to deployment and scale-up

Despite the many potential benefits of intermediate crops, their implementation and scale-up also faces some challenges. These challenges can be related to the integration in the agricultural practice at the farm level, unknown cost aspects for the farmer, for instance related to (potentially) complex certification rules and Common Agricultural Policy rules, and uncertainty about the demand for (and value of) the crops as Annex IX feedstock. Furthermore, the large-scale rollout and further development of new intermediate crop species take time. The speed of development will depend on how predictable and vast the regulated demand will be, and in how far the bottlenecks discussed below are timely addressed.

Integration in the agricultural practice

Farmers may have concerns about growing a new crop for an uncertain market. While the crop can be grown on land that otherwise remains unused, or in lieu of an existing catch and cover crop, and while it can (largely) use the same machinery, the farmer will still face additional work and costs.

Outcomes can vary by region and season. As the time window for the cultivation of intermediate crops is limited by their definition – between the rather rigid timing of harvest and planting of the previous and the next crop – there is quite a risk that the crop does not achieve sufficient maturity or is lost altogether due to climatic conditions. This is a financial risk for the farmer (or supply chain partners) and adds to the cost of the crop.

An additional barrier to mainstream adoption of intermediate crops by farmers is that the regulatory framework places stricter requirements on intermediate crops than on main crops. If the additional administrative obligations compared to the existing practice are disproportional to the additional revenues and benefits at the farm level, this may discourage farmers from innovating with or scaling up intermediate cropping practices.

Address competition with catch and cover crop subsidies

Many farmers currently already grow catch and cover crops and receive subsidies in the frame of the Common Agricultural Policy (CAP) rules on environmental benefits. The exact rules are nationally defined. Member States may require that catch and cover crops are terminated (i.e. cut and left on or ploughed in the soil), before the next crop is planted. Then, if the crop would be harvested, the farmer could lose the subsidy. So, when an intermediate crop replaces an existing catch and cover crop, the farmer may lose the subsidy. This would effectively increase the cost of the crop at the farm gate. However, since most if not all the catch and cover functions remain the same (see Chapter 4), it should be ensured that the farmer does not lose the subsidy. Since the CAP allows that Member States flexibly implement the rules, the exact rules may differ on a country-by-country basis.

Similarly, after the adoption of certification methodologies for Carbon Removals and Carbon Farming (CRCF),[23] carbon farming schemes may also interfere with the stimulation of intermediate crops. For instance, if carbon sequestered through intermediate crops is not regarded "additional" for carbon farming schemes, or if carbon farming would not allow the harvesting of the intermediate crops. This would then limit the possibility for farmers to generate carbon credits if they harvest intermediate crops, or vice versa.

Lack of definitions and (potential) complexity of rules

The Renewable Energy Directive lacks a clear, operational definition of "intermediate crops". As a consequence, it is uncertain what cropping systems are potentially eligible. Exclusion of

[23] The Carbon Removals and Carbon Farming (CRCF) Regulation (EU) 2024/3012 was published in December 2024 and is not yet operationalised. The Commission plans to establish certification methodologies for different carbon removal activities through delegated acts. Amongst the options mentioned in recital (25) of the regulation are catch crops and cover crops.

specific crop types can make industry adoption slow and limit the process by additional farmer training and field testing. We recommend that the definition remains species-agnostic, because many species could potentially be grown as intermediate crops.

Moreover, the three conditions in Annex IX are hard to apply uniformly: (i) "short vegetation period" is vague and would benefit from clarification; (ii) "no demand for additional land" cannot be directly observed and must be inferred differently; and (iii) "maintain soil organic matter" could be ensured in an easy or complex manner.

In Appendix B of this report we recommend in more detail how the definition and the Annex IX conditions could best be guaranteed by practical certification guidance.

Development time of intermediate crops in EU agriculture

After the certification guidelines for intermediate crops are published by the Commission, we expect that it will take at least another year before Voluntary Schemes have developed their guidance and before the Commission has recognised these guidances. This implies that if the Commission publishes the guidelines in autumn 2025, the certification of intermediate crops could start in 2026 at the earliest. Therefore, a prompt development of certification guidelines is paramount to securing sufficient volumes of intermediate crops to reach mandates.

We propose (see Appendix B of this report) that the guidance includes a documentation at farm-level of land utilisation of several years before the intermediate crop is introduced. Note that it should be allowed to base this on evidence from earlier years (well before 2025), to ensure that the introduction of intermediate crops can start immediately and not wait another three years. Also, we recommend to retroactively recognise initiatives on intermediate crops from 2020 onwards, noting that initiatives with intermediate crops have already started.[24]

European rollout and scale-up of intermediate crops requires multi-year planning even after any certification guidance is issued. Based on experience from the Coalition companies, at least two to three cultivation seasons are required to reach meaningful volumes in regions where intermediate crops can most easily be inserted in the existing crop rotations.

For optimal implementation in more diverse climatic conditions, the complete seed breeding and multiplication programs can take over 10 years (some incremental gains made annually). Coalition companies note this may happen faster (between six and eight years) if new genomic techniques are allowed, see Figure 4.

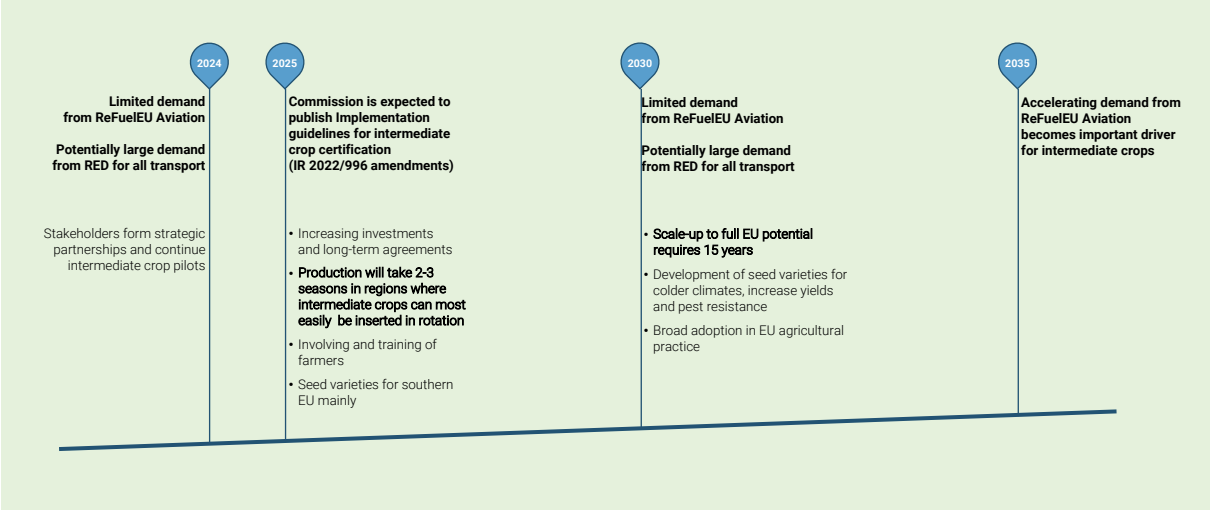

Figure 4. Timeline of the regulated demand for intermediate crops via ReFuelEU and the Renewable Energy Directive, aligned with development and production of intermediate crops.

[24] For instance, voluntary scheme 2BSvs in their standard 2BS-STD-01 of 07/05/2025 includes a definition of intermediate crops "pending clarified guidelines from the EU Commission".

Insufficient market pull in early years

While the technical potential of intermediate crops in the EU is large in the long term (See analysis in Chapter 1), the rollout and scale-up will take considerable time, as explained above. The additional feedstock volume will therefore be limited in the first years after publication of the certification guidance. It is crucial that the regulatory framework provides adequate market incentives from the start, so that supply chains and initial volumes can be developed swiftly, and that in the longer term, the high mandates in aviation can be met.

An important limitation to reaping the potential of intermediate crops seems to be their position in Annex IX A and IX B of the Renewable Energy Directive.

When intermediate crops are used as feedstock for *aviation biofuels*, they are located in Annex IX A. But, as shown in Figure 2, the demand for Annex IX A in aviation is limited in the coming years. Until about 2035 the required volumes for aviation via the ReFuelEU Aviation regulation could be supplied by several waste and residue oils, leaving little early incentive for investment in intermediate crops.

Until about 2035, the road sector presents a much larger demand for Annex IX A fuels. However, intermediate crops that are used for *road fuels* (HVO also known as renewable diesel) fall in Annex IX B. But the contribution of Annex IX B to meeting renewable energy in transport targets is currently capped (by the Directive) to 1.7% of energy in road transport. The required volume can be met with the much cheaper used cooking oil and animal fats.

It is not clear why the placement of the same feedstock in either Annex IX A or B depends on the mobility sector where the fuel will be used. The production of HEFA and HVO largely follows the same conversion pathway, often combined within the same conversion facility. It is even suboptimal for any installation to produce only HEFA and therefore it is always produced in combination with HVO.

To address this, the inclusion of intermediate crops for the road sector in Annex IX A, or not capping their contribution via Annex IX B, would create an earlier market signal and support the immediate development of the production of these crops. As intermediate crops need multiple seasons to reach meaningful volumes and even longer horizons for breeding and seed multiplication, an early start is essential. This would allow sufficient scaling to meet the increasing aviation mandates under ReFuelEU from 2035 onwards. When road transport becomes progressively electrified and consequently its demand for renewable fuels declines, the developed volumes of intermediate crop feedstock can be redirected towards aviation, and very importantly towards the green chemical manufacturing industry, ensuring a long-term alignment with the EU's decarbonisation objectives. Although the last-mentioned sector has not yet a mandate or obligation, these industries likely will also require intermediate crops, for lipid, starch, sugar and lignocellulose feedstock.

5 Recommendations

As shown in Chapter 2, intermediate crops could increase the land use efficiency of agriculture, so that more can be produced on the same land while at the same time they can improve soil quality and reduce inputs.

But value chains cannot be built overnight: farmer contracting and an optimal integration of intermediate crops at a farm requires at least two to three cultivation seasons. At the same time, seed development is required for large-scale rollout in Europe, especially towards the north. Crushing and conversion capacity must be developed in parallel.

To ensure that a sustainable contribution of intermediate crops, to climate and renewable energy targets in transport and to the potentially upcoming demand mandates in the chemical industries, is both large and in-time, we recommend that the Commission incentivises their demand via the Annex IX subtarget for all renewable transport fuels. With the electrification of the road sector, these volumes will be ready for the aviation, maritime and to provide feedstocks for the feedstock transition in the chemical sectors.

We also recommend that the Commission swiftly finalises and publishes practical certification guidelines for intermediate crops in Regulation (EU) 2022/996.

As long as ambiguity persists over what counts as an eligible intermediate crop under Annex IX, investors and farmers will hold back.

In Appendix B of this report, we present recommendations for the certification guidelines, including a workable definition of intermediate crops as well as ideas on how the three conditions of Annex IX of the Directive can best be certified. In short:

- We recommend that the certification method is both crop-agnostic and region-agnostic.
- The method should be farm-based and rely on strict documentation of the existing/ previous practice and how intermediate crops are inserted.
- We suggest rules on where and when intermediate crops can be inserted between main crops (outside of the primary cropping season) or use fallow land in break years.
- We recommend how the intermediate crop can be proven not to displace the main crop or (indirectly) expand arable land elsewhere.
- We recommend what evidence/observation can be used to guarantee that the soil-organic matter is maintained without requiring costly soil sampling.
- Within the EU we recommend aligning the administrative requirements with the CAP where possible, to limit administrative burden for the farmers.

Finally, we find that the discussion on intermediate crops should be extended beyond their contribution to renewable fuels and climate targets. A more efficiency land use benefits the production of food, feed, as well as material and energy for the broader bioeconomy

Appendix A What are intermediate crops?

A.1 Lack of uniform definition

While the EU Renewable Energy Directive includes 'intermediate crops' as a feedstock in Annex IX, it does not provide a precise definition. It provides an example "such as catch and cover crops", and it sets three additional requirements, which we will discuss in Appendix B.3:

> *[…] Intermediate crops, such as catch and cover crops that are grown in areas where due to a short vegetation period the production of food and feed crops is limited to one harvest and provided their use does not trigger demand for additional land, and provided the soil organic matter content is maintained […].*[25]

Major institutions, such as the EC, USDA and FAO, do not provide a firm definition either. Nevertheless, various definitions of "intermediate crops" can be found, which largely overlap, but also differ in details. Some examples are:

- "Intermediate crops are crops that are usually an off-season crop planted after harvesting the cash crop, replacing a fallow period. Usually, those crops are planted to cover the soil rather than for the purpose of being harvested, contributing to system diversification and environmental performance."[26]
- "Intermediate crops are fast growing annual crops that can be cultivated between main food crops or during fallow periods."[27]
- "Intermediate crops are crops that are grown outside the main growing season, such as catch crops and cover crops that are for instance cultivated during winter"[28]
- "Intermediate crops are crops planted between two main crops. They cover the soil between intercropping periods to ensure it doesn't remain bare."[29]
- [Intermediate crops are] "a fast-growing crop planted in a field in a period when no main crops are being grown there, either for market or to prevent the soil losing nutrients".[30]

Often, intermediate crops are described in the context of temporal succession to attain an improved land-use efficiency, where planting takes place in otherwise idle periods between main crop cycles. However, intermediate crops could also refer to crops that are *spatially* planted between main crops – see the discussion on intercrops, below in A.2.

Before we develop a suitable definition in the frame of the Renewable Energy Directive, it is useful to consider the variety of intermediate options that the above definitions could allow and relate to.

A.2 Variations

Intermediate cropping systems described in literature share the core aim of making more efficient use of the available growing season and land, thereby increasing the productivity per hectare in a sustainable way. They do so through different strategies that vary in timing, crop choice, and intended function, with some types not actually intended to be harvested.

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[25] EU Renewable Energy Directive (EU)2018/2001, amended and corrected version of 16 July 2024, in Annex IX Part A(t) and Part B(f).

[26] EIP-AGRI 2021, Focus Group Sustainable industrial crops, Final report.

[27] ETIP Bioenergy 2024, Intermediate crops for low ILUC biofuels in the EU.

[28] Transport and Environment 2024, The advanced and waste biofuels paradox.

[29] French agro-industrial cooperative Avril, 2023, What exactly is an intermediate crop?

[30] E4Tech 2022, Assessment of the potential for new feedstocks for the production of advanced biofuels. That study suggests that the definition is provided by IATE (Interactive Terminology for Europe). In fact, IATE merely collects definitions from other publications and the cited definition could not be found in IATE – it seems to be combined from in turn two other definitions collected in IATE: (1) "fast-growing crop sown between two main crops, whose primary purpose is to capture the excess nitrogen that remains in a field to prevent rainfall from transferring nitrate to the groundwater or to surface water and polluting it", and (2) "off-season crop planted after harvesting the cash crop, replacing a fallow period".

Catch and cover crops

One widely used approach is the planting of catch crops**,** after the harvesting of the main crop. The primary role of catch crops is to quickly absorb residual nutrients from the soil, thus preventing leaching of nutrients into groundwater and reducing nutrient losses. This effectively reduces nitrogen emissions from agriculture that would otherwise cause eutrophication (via ammonia) and climate change (via nitrous oxide). Catch crops are usually not harvested but ploughed back into the field, and in that case also contribute to soil health by adding organic matter.

Closely related are cover crops**,** which are planted with the main goal of protecting the soil surface from erosion, suppressing weeds and spread of pests, and improving biodiversity in the field. While they also contribute to nutrient recycling, their defining characteristic lies in safeguarding soil structure and organic matter content.

In practice, a single crop often performs both the catch and cover function and therefore 'catch and cover crops' are often mentioned as a single concept because it serves overlapping environmental functions.

Note that the Renewable Energy Directive Annex IX includes the sentence part "such as catch and cover crops" when referring to intermediate crops. This addition is somewhat unusual since catch and cover crops are actually not harvested but rather terminated. However, if the same crop would be harvested, it would still largely fulfil the catch and cover function, because the land is covered with the crop for (almost) the same time.

Sequential cropping

With sequential cropping a second crop is sown immediately after the main crop has been harvested, allowing the second crop to reach full maturity. This allows for both crops to be harvested, thereby increasing the combined crop yield of the plot of land. Sequential crops can be incorporated between every main crop or at different intervals in the crop rotation. For example, a farmer might achieve five harvests in four years instead of the usual four. The frequency might depend on climatic conditions, soil recovery needs, and the requirements of specific crops in a rotation. If two crops are grown and harvested within a year, it is often referred to as double cropping.

Note that sequential cropping happens at a significant scale in Brazil, where about 77 million tonne of safrinha (i.e. off season) corn is produced as a second crop after soybean. Note that this corn may not be eligible for Annex IX A of the Renewable Energy Directive, if it is already an existing practice to have these two crops per season.

Relay cropping

While in a sequential cropping system there is no overlap in growth periods between the main and second crop, relay cropping refers to a set-up where the second crop is planted before the first crop has been harvested. This creates a period where both crops are growing simultaneously, which can be advantageous in climates with short growing seasons, because the growth of the second crop can start somewhat earlier than in a pure sequential setting. Thus, relay cropping can help intermediate crops to fit better in the narrow cultivation window.

Relay cropping requires careful planning to ensure that the two crops do not compete excessively for sunlight, nutrients, or water, and adapted machinery to plant/harvest one crop without damaging the other crop.

Intercropping

If two (or more) crops are simultaneously grown on the same plot of land, coexisting for a time so that they interact agronomically, this is called intercropping. Different intercropping set-ups exist, such as mixed, strip or row intercropping. These approaches differ mainly in how the crops are spatially arranged and each set-up offers specific advantages.

Crops are sown and grown together, and their harvest times may or may not coincide. The aim is often to use space, light, and nutrients more efficiently than a single crop could do, to improve pest and disease resilience, and to provide biodiversity benefits.

The simultaneous under-sowing of catch or cover crops is a common practice. This allows for a better development of the catch or cover crop, so that the field is well covered directly after harvest of the main crop. In this case, the growth period of the catch crop for the larger part overlaps with the growth period of the main crop, which implies they (in this case) rather constitute intercrops than intermediate crops.

Intercropping, relay cropping and sequential cropping are an extension of each other. Where the growth periods in sequential cropping are fully separated, in intercropping they largely overlap and in relay cropping they partially overlap.

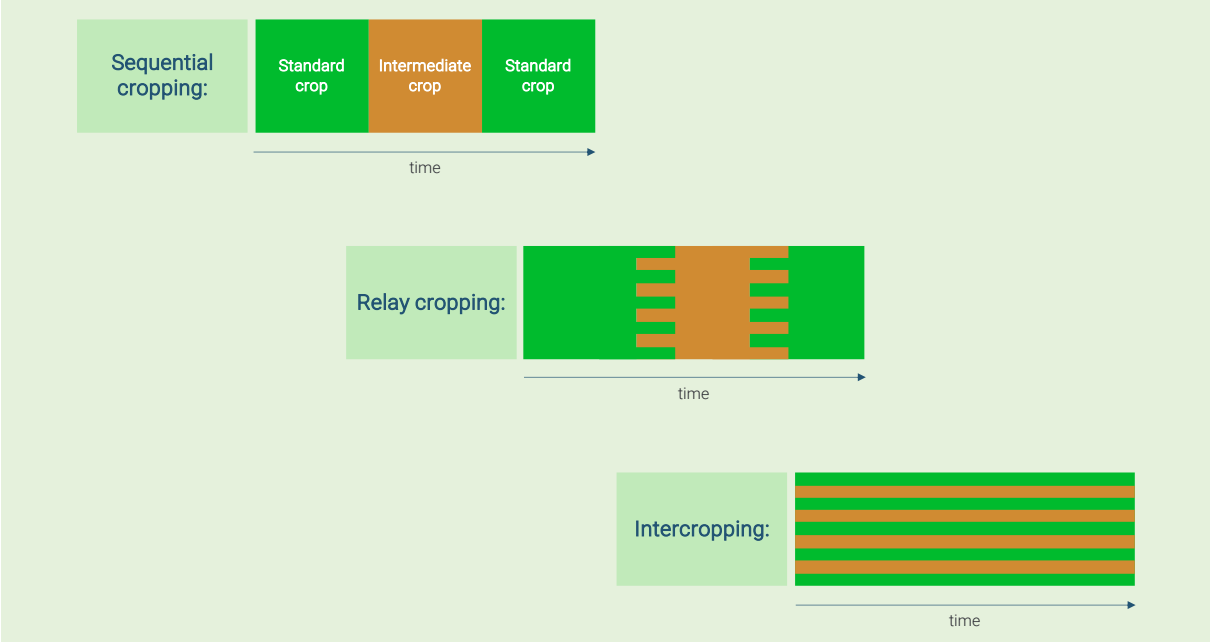

Figure 5. Simplified representation of (left) sequential crops growing separately from each other not overlapping in time, (middle) relay cropping where a second crop is planted before a first crop is harvested on the same field, so that they partially overlap in time (right) intercropping where several crops are planted at the same time which mature simultaneously.

To increase confusion, the term "intercropping" is often used as abbreviation of "intermediate cropping". On the other hand, literature and industry definitions of "intermediate crops" as cited (above, in Appendix A.1) all have a clear focus on crops that are grown outside the growing season of the main crop, and this would exclude intercrops.

A.3 Which of the crops in the field is the intermediate crop?

The definition of intermediate crops in the frame of the Renewable Energy Directive should be unambiguous and practically applicable. One of the main challenges is to distinct intermediate crops from main crops. Since the crops exist in a continuous rotation it may be difficult to define (after a while) which is the first and which is the second crop.

Also, a same plant species can serve in both roles depending on when it is sown, how long it is grown, and the purpose for which it is cultivated. For instance, a farmer might grow oilseed rape as a main crop in one year and as an intermediate crop in another year, because whether the crop is main or intermediate depends on its position in the rotation. This means that classification would depend on timing, management, intent and observation, and not on the physical characteristics of the crop.

In the certification of intermediate crops for the purpose of the Renewable Energy Directive, this could be solved by limiting the intermediate crops eligible for Annex IX to those crops that are clearly newly introduced in a crop rotation, compared to a benchmark of several past years on the same area.

If such clarification is well included in the Directive or in the guidance for certification (via the Implementing Regulation (EU) 2022/996) the overarching definition of the intermediate crops could be kept broader, to potentially include many options that achieve the same goals.

A.4 Inclusive definition of intermediate crops

A broad, inclusive definition of "intermediate crops" is essential to unlock the full potential of this feedstock. The assurance that the crop is truly additional is subsequently arranged by the conditions that are included in Annex IX of the Directive (as discussed in Appendix B). We therefore recommend the following definition:

> *Intermediate crops are crops that are cultivated in the period between the growth periods of main crops in a crop rotation scheme, or during times where the land would be otherwise idle or fallow, or unproductive and that yield additional output material compared to the existing farm practice.*

Appendix B Suggestions for certification of intermediate crops

The goal is to provide credible certification, with a high level of certainty that feedstock identified as intermediate crops meet the Directive's requirements. The method should avoid options for fraud, and be practically applicable, so to reap the real opportunities.

B.1 Overarching principles

Focus on the principle of additionality

We propose a farm based-level, practice-based assessment of past practice by which it can be observed whether the intermediate crop is truly additional to current land-use and that it does not compromise the production of existing crops.

Do not limit options by blanket rules

We recommend that the guidelines focus on proving additionality at the farm level, linked to the local agronomic and economic reality. We advise against limiting options by "blanket rules" on areas or crop types that immediately restrict entire crops or regions without consideration of the individual setting.

The first condition for the eligibility of intermediate crops in Annex IX "[…] that are grown in areas where due to a short vegetation period the production of food and feed crops is limited to one harvest […]" could be read to allow a blanket exclusion of certain regions, for instance by developing maps of blacklisted/whitelisted regions. That would severely limit the opportunities at individual farms, while it would still not relieve those farms from providing farm-based evidence, and it would limit the options for plant breeding innovation to adapt crops to short *remaining* vegetation periods. Also, we foresee that a debate about which regions are excluded, will mainly delay implementation.

Furthermore, note that many crops could potentially function as an intermediate crop. Some companies focus on the development of novel crops specifically as intermediate crops, with shorter cultivation seasons. This concerns amongst others camelina, crambe and brassica carinata and brassicae juncea. However, also several existing crops may function as intermediate crops in some situations, such as sunflower, soybean, safflower and winter rapeseed, or they can be adapted through breeding to be grown as intermediate crops.

It may seem attractive to limit the option of intermediate crops to those crops that have been specifically developed for that purpose, but there are several arguments against this:

- Whether a crop is intermediate depends on their position in the rotation, and whether they are additional to the existing output of a farm. Any crop species could be considered a main crop in some situations and an intermediate in other situations (see Appendix A).
- Existing commodity crops such as winter rapeseed may in some situations be a more efficient and better choice of intermediate crops. If that is the case, their opportunity should not be discarded.
- Crops that today are specifically developed as intermediate crops may often prove equally valuable as main crop, with perhaps a shorter cultivation season. Since many varieties may be developed for widely varying situations, a novel crop is not guaranteed to be an intermediate crop. Especially, when moving forward, when the novel crops are no longer "novel" their position in the rotation may not be fixed.
- If there is a clear demand for intermediate crops, plant breeders can develop intermediate crops that may be based on crops mostly grown as main crops today, such as sunflower, soybean and winter rapeseed.

Therefore, we advise not to identify intermediate crops on basis of any crop-species label.

The Commission should explain carefully how such a crop-agnostic approach can coexist with other rules. Especially, it is thinkable in some situations that soybean would be an optimal intermediate crop candidate. But, if the threshold for the identification of high ILUC-risk crops in Commission Delegated Regulation (EU) 2019/807 would be lowered (as is

discussed between some stakeholders), then soybean could also become identified as a high ILUC-risk crop.[31] However, an intermediate crop by definition has no ILUC-risk.

Include an adequate penalty system to avoid fraud

If the market for intermediate crops becomes attractive, there is an increased risk that fraud will occur, especially when intermediate crops become of equal or higher value than the main crop. This is equal to the dynamics of waste and residue streams: if policy intervention awards a higher value to a material, some people will find ways to fabricate that material.

The rules for certification should therefore be strict and unambiguous. The certification should be strengthened with improved traceability technologies (this is a recommendation for sustainable biofuel certification in general), and enforcement of the certification rules. Also, the penalty in case of fraud should be deterrent and in line with how fraud is penalised in other corners of RED biofuels certification.

In general, we think that in case of group certification more responsibility should be required of the first gathering point.

Simple where possible – thorough where necessary

The reporting requirements should aim at proving the compliance with the three conditions, but not much further beyond. We observe that the guidelines for several certification requirements of the Renewable Energy Directive (for instance monitoring of the e_{SCA} factor, calculation of the nitrous oxide emissions, low ILUC-risk certification) have become so complicated that these important options to demonstrate improved performance are not widely used. We recommend to carefully consider the balance between credibility and practical application, to avoid field measurements where possible, and to connect to reporting in the frame of EU Common Agricultural Policy where possible.

B.2 Three conditions of Annex IX of the Renewable Energy Directive

Annex IX of the Renewable Energy Directive sets three conditions to intermediate crops in Part A(t) and Part B(f):

> *Intermediate crops […]* ***that are grown in areas where due to a short vegetation period the production of food and feed crops is limited to one harvest*** *and* ***provided their use does not trigger demand for additional land*** *and* ***provided the soil organic matter content is maintained*** *[…].*

Requirement #1 […] that are grown in areas where due to a short vegetation period the production of food and feed crops is limited to one harvest […]

This requirement is ambiguous as it does not specify what is meant with "area" and it does not clarify what is a "vegetation period".

In line with our recommendation for a farm-based analysis we recommend that "area" implies a field or a farm.

The mentioning of "food and feed crops" is not fully clear, because any crop that is not a main crop but a second crop, is by definition 2(40) of the Renewable Energy Directive not a food and feed crop. This would imply that in every area the production of food and feed crops is by definition limited to one harvest (within a crop season).

On the other hand, if the Directive meant to say: "crops that are used for food and feed", then this requirement is even more problematic. All intermediate crops can be used for animal feed and often also for food. Even stronger, the co-produced meal from oilseed crops and the distillers' grains from sorghum *will* be used for animal feed. This is essential for the business

[31] As specified in the Commission Delegated Regulation (EU) 2019/807 covering the determination of high ILUC-risk feedstock and the certification of low ILUC-risk feedstocks,

case for those crops as the feed represents over 50% of the mass produced from the processing of the seeds or grains. The suitability as animal feed also contributes to benefits such as reducing land use and increasing protein security. Therefore, if any biological-climate reason such as a "short vegetation period" would limit the production of these crops to one harvest, then this implies that intermediate crops can never comply with the requirement.

Finally, the vegetation period is sometimes defined on basis of plant phenology. For instance, the period could start when certain plants unfold their leaves, and end with the beginning of leaf fall. But it is not clear how the length of a so-defined vegetation period is related to whether the production of crops is limited to one harvest. For instance, the crop cultivation season at both ends often stretches beyond a local vegetation period. In fact, winter wheat is even planted in fall and harvested in spring, so that the cultivation period largely falls outside the phenologic vegetation period.

In short, this condition is confusing. On the one hand, any crop besides the main crop is not a food and feed crop in the frame of the Renewable Energy Directive. On the other hand, if all areas where the climate conditions allow the cultivation of a second crop that can be used for animal feed, are off limits, then no areas remain.

The condition may be based on the concern that in some locations, already two crops are produced per calendar year. This concern is much better covered by the second requirement.

Requirement #2 […] provided their use does not trigger demand for additional land […]

Whether the use of any crop triggers demand for additional land cannot be observed or measured, because it is an indirect effect that involves complex dynamics in international commodity markets.

Nevertheless, it can be made plausible that the use does not trigger demand for additional land if only feedstock that is additional to the observed recent past practice is allowed.

Two potential approaches to this are:

- Observe the crops that were produced in the (recent) past and monitor that their production does not decrease. This is however problematic since (1) very different crops may be produced in rotation, which cannot be combined under a single parameter, (2) the yield of those crops fluctuates from year to year. Moreover, this parameter would not be connected to the "intermediate" aspect of the current purpose.
- Observe the land use to identify when and where current crops are grown and allow that intermediate crops only occupy the time and space between these, or more precisely, that the areas and periods of the existing crops do not decrease. This approach is most directly connected to the "intermediate" aspect and guarantees that there is no demand for additional land.

Thus, the second approach is better. Therefore, we propose that, at farm level, the crop rotation and land use is (or has been) observed and documented for at least three years in a row. For that period, the planting and harvesting times per plot are documented, fallow periods, break years and the use of catch and cover crops.

The crop rotation at farms has two dimensions: time and space:

- On a single field, a crop can be followed by a fallow period, which is followed by a next crop etcetera. During the fallow period, in the existing situation, a catch and cover crop may be grown, which is terminated before planting the next crop. Every several years, a break year is applied to improve soil health by replenishing nutrients, to increase organic matter, to improve soil structure and break cycles of pests. This also often involves a catch and cover crop. See Figure 6.
- The farm may consist of multiple fields on which different crops are grown, in such a way that crops seem to move from plot to plot over time, as shown in Figure 7.

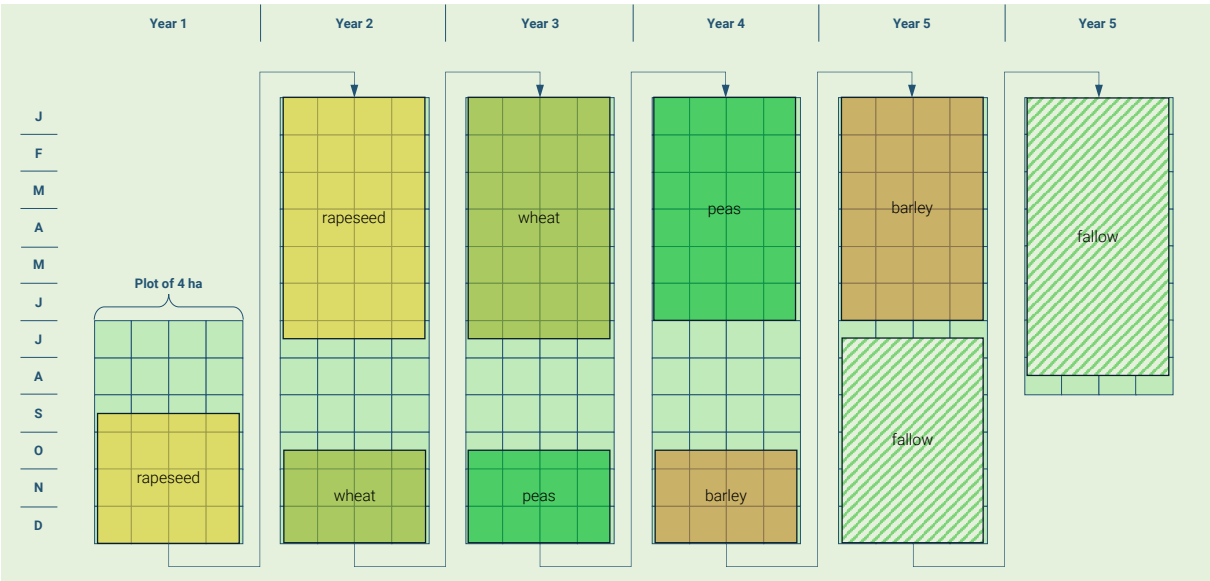

Figure 6. Schematic example of rotation of crops on a single field, followed by a break year in year five.

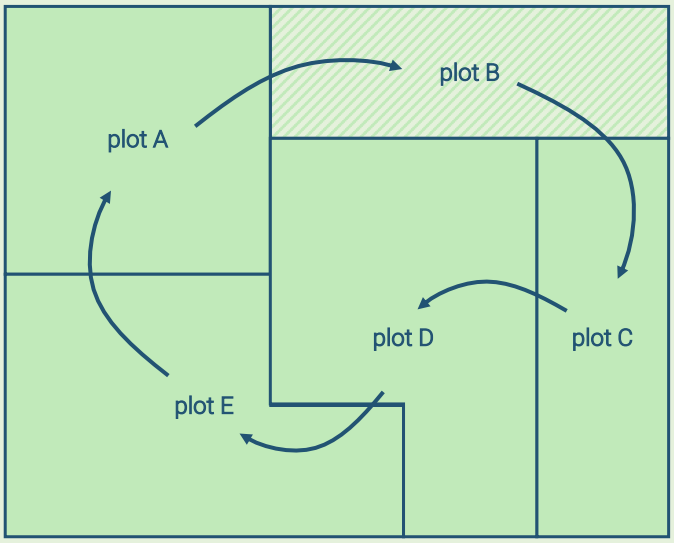

Figure 7. Schematic example of rotation of crops between five fields of a farm. Crops move from field to field. Similarly, the break year, here shown as a striped area in field B, moves to another field every year.

In Figure 8, the rotation of all crops within and between fields is combined in a grand scheme for the full farm. This allows to understand the opportunity windows for inserting intermediate crops. Note that the example scheme is greatly simplified from reality. The farmer will adapt the rotation scheme in response to market expectations and weather events and his observation of the field's soil quality.

To guarantee that the intermediate crops do not displace existing crops, we recommend that they may only be developed on fallow land in the period between two adjacent crops, in break years (long period of fallow during which in other years usually a crop would have been cultivated), or when replacing catch or cover crops. Intermediate crops may be introduced on land that was otherwise left barren, or they may replace catch or cover crops that otherwise would have been terminated.

In Figure 8, this implies that everywhere outside the "existing crop" periods intermediate crops may be grown. In Appendix B.4, we propose how it can be certified that intermediate crops are only grown in such periods.

Requirement #3 […] provided the soil organic matter content is maintained […]

Soil organic matter content must be maintained as it plays a significant role in crop production and soil health by improving physical, chemical and biological functions of the soil. It aids the soil structure, water-holding capacity, nutrient mineralization, biological activity, and water and air infiltration rates.

The soil organic matter on the land is by definition higher than on idle or fallow land during the cultivation of the intermediate crop. After harvesting the functional root system remains in the soil,[32] and further contributes to maintaining soil organic matter. Leaving part of the residues of intermediate crops on the field further contributes to meeting this requirement. The requirement to maintain soil organic matter content is therefore deemed fulfilled when an intermediate crop is grown.

Compliance with the requirement could be further substantiated by demonstrating that part of the crop remains on the field, for instance by time/geo tagged photos of the situation before and after harvest. In the larger development of precision agriculture, we imagine that in due time other evidence could be collected to demonstrate the crop share that remains on the field. To limit the marginal administrative burden this should then not only be done for intermediate crops, but for all crops.

[32] For instance, camelina and canola have a root system reaching to 150 cm deep and brassica carinata reaching to 50 to 100 cm. Depth of roots is not the most meaningful insight, as lateral (horizontal) roots contribute more to soil structure. Most importantly, the entire root system remains in the soil after harvest.

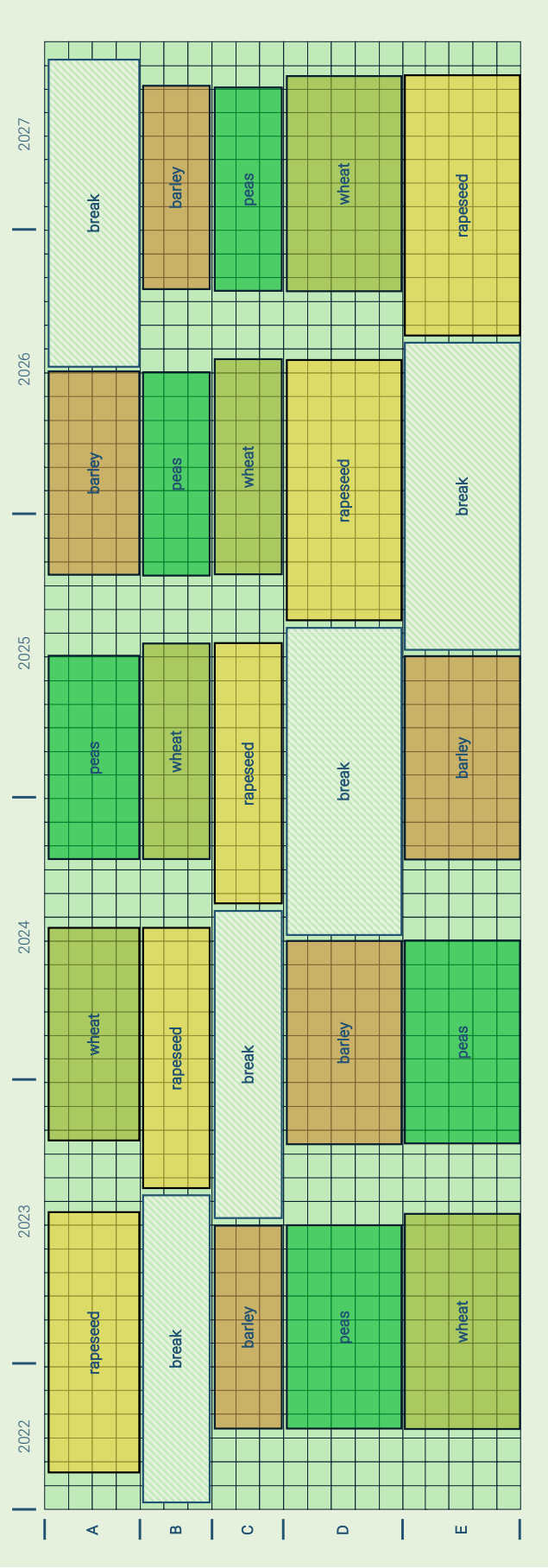

Figure 8. Schematic example of crops that rotate over fields of a farm. Combination of Figure 6 and Figure 7.

B.3 Practical guidance for certification of the additionality of intermediate crops

Land utilisation rate concept

To certify that intermediate crops are only grown in periods outside (historic) periods of productive crops, we recommend using the land utilisation rate.

This rate gives insight in the number of hectare × days that are technically used for the existing crops on the farm and, subsequently the hectare × days that could be available for the cultivation of intermediate crops.

Documenting historic land use, and calculation of the land utilisation rate

First, the farmers enrolling in an intermediate crop programme identify the fields where they would like to develop intermediate crops. In the example of Figure 8 above, the rotation can be translated into a table that, covering a historical period, evaluates the crops that were cultivated on the field, for their planting and harvesting dates and how much of the field they covered. In this example:

- Rapeseed was grown for 11 months, from half August to half July, on field A (4 hectares)
- It was followed by 3 months of fallow
- Subsequently, wheat was grown for 9 months, from half October to half July
- It was followed by 3 months of fallow
- Subsequently, peas were grown for 8.5 months, from half October to end of June
- These were followed by 3.5 months of fallow
- Subsequently, barley was grown for 8.5 months, from half October to end of June
- Et cetera

We propose to calculate the annual land utilisation rate per calendar year (in the northern hemisphere) or at the end of June (in the southern hemisphere).

We advise to calculate this utilization rate for the full farm, so that the average break year area is also included. Note that since field sizes may differ, this may impact the outcome (see below).

The land utilisation rate should be calculated for a historic period of at least three years. This will usually provide sufficient insight in the complete rotation pattern of all fields. The farmer may apply a longer historic reference period, if that would give a better representation of the rotation pattern.

In the EU, the farmer's CAP registration may provide sufficiently detailed information to establish the land utilisation rate.

In Figure 8, the land utilisation rate per year would equal the total surface of the dark green blocks (per calendar year). The average land utilisation rate over the past years, and how it changes per year, provide a reference for the purpose of independent auditing.

This method will also inform farmers to know how much land they are allowed to use for intermediate crops based on their historical land utilization practices.

Intermediate crops should not (significantly) decrease the land utilization rate

Farmers will be allowed to grow intermediate crops any time of the year, as long as they maintain the land utilization rate threshold. When intermediate crops are grown on the farm, the hectare × days of the existing crops should not significantly decrease. Two considerations are furthermore important:

- Since field sizes differ and since some crops have longer cultivation periods than others, the calculated *average* historic land utilisation rate may overestimate the available space in some years and underestimate it for other years. It is better to project the continuation of the historic rotation, and within this establish the × space that would be available for the intermediate crops.

- To provide operational flexibility in the face of weather conditions or other situations that advance or delay planting and harvest moments, or to allow optimal integration of the intermediate crop within the rotation, the land utilisation rate can maximally be decreased with 10%, on the condition that this is not caused by the reduction of field sizes (hectares) but only by the reduction of the cultivation time (days).

In the continuous calculation of the land utilisation rate, the hectare × days of intermediate crops are counted in the same way as idle or fallow land. Per calendar year, the farmer indicates which of the crops are "intermediate" (and should be certified as such), and which are "existing" (and are used to evaluate that the land utilisation rate does not decrease).

Notion on break years

In the past, the EU Common Agricultural Policy required that EU farms left 4% of their agriculture land fallow at any time of the year. Depending on the conditions (which changed throughout time), such land may not be available for the production of intermediate crops. In countries where fallow (or another use of the land not for productive crops) is obligated, that land and time period should be included as productive in calculation of the Land utilisation rate.

Following the Russian attacks on Ukraine, the set-aside land obligation was relaxed and eventually abandoned to increase the European land use.

Since 2024, Ecoscheme measures in the CAP, including the application of a break year or the use of catch and cover crops, are considered in direct payments to EU farmers. The exact rules may differ per Member State, but in any case, it is now a free choice for farmers whether or not to include a break year or apply catch and cover crops, while considering the cost and benefits and the health of this farm soil. Potentially, the cultivation of intermediate crops instead of break years or catch and cover crops limits the subsidy that the farmer receives. If that is the case, this would likely limit the deployment of intermediate crops, as discussed in Chapter 4. But under the Ecoscheme, the use of intermediate crops would not trigger demand for additional land elsewhere.

Appendix C Timeline of intermediate crops in EU legislation

Background on the regulatory development of Annex IX of the Renewable Energy Directive

Ideas on creating specific policy incentives for intermediate crops as a feedstock for biofuel production began to take shape during the Fit-for-55 debates in 2018-2019. At the time, RefuelEU Aviation was also being proposed, which was planning to disallow food and feed crops for sustainable aviation fuel (SAF) from compliance. Industry actors quickly realised that a diversification of feedstocks was needed, and that there would be a need to include additional feedstocks in Annex IX to make them eligible for compliance. This created an early policy push from industry for the consideration of certain crops under Annex IX, with discussions including intermediate crops as well as crops produced on non-agricultural land (degraded, abandoned).

The process of amending Annex IX lists was foreseen in the RED II, which required the Commission to review Annex IX by 2019 and every two years thereafter, with a view of adding feedstocks to the lists. However, this process was delayed and only in 2021, a consultant consortium was tasked to assess the potential for new feedstocks for the production of advanced biofuels.[41] Their study was the first official document to flag intermediate/cover crops as promising but fraud-sensitive candidates for inclusion.

In December 2022, the European Commission published a draft Delegated Act for consultation, proposing amendments of the Annex IX feedstock lists. In this proposal, intermediate crops, restricted to certain conditions, were added as a feedstock category under Annex IX Part B, which would mean their application would be limited to the cap of 1.7%, applicable to Part B. The public consultation generated many responses, with many industry stakeholders asking for a placement of an 'intermediate crop' category in Part A instead, for which a sub-target rather than a cap applies.

Proponents argued that intermediate crops offer a truly additional source of biomass, as they occupy the land during an otherwise idle window between two main harvests.

- Producing meal/proteins for livestock fodder
- No additional land claim (when additionally applied – i.e. not when intermediate crops were already planted commercially for food applications or 1st gen crop-based biofuel feedstock) – hence no ILUC
- Improving soil health for future main crops – yield increases of main crops
- More than 6 Mtonne per year of oil feedstock (when in Annex IX A)
- Soil carbon accumulation

In November 2023, an informal coalition of industry stakeholders, in a joint industry letter to the Commission, voiced support for intermediate crops and other crop-based options.[42]

Finally, in May 2024, the Commission published the long-awaited Annex IX update. This amended Annex IX includes intermediate crops as eligible feedstocks in Part A when used for the production of aviation fuels and in Part B when used for the production of other biofuels. The way the intermediate crops were included on the Annex IX feedstock lists is untypical, when considering the criteria previously applied for the Annex IX feedstock lists. for Annex IX inclusion. Feedstocks listed in Part A of the Annex IX were considered to be 'advanced' in the sense that these require a processing technology that is not fully cost-effective and commercially scaled yet. Annex IX Part B, in contrast, was reserved for feedstocks that could be processed with mature technology.

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[41] E4tech, ICCT, Cerulogy, Wageningen University Research, Navigant and SCS global 2021, Assessment of the potential for new feedstocks for the production of advanced biofuels.

[42] Various companies 2023, Industry Joint Letter on Scalability and development of biofuels supply, particularly for the maritime and aviation sector.

The Commission agrees that intermediate crops are a feedstock that from a technology-readiness perspective are rather mature – as these can be processed with hydrotreatment processes that are already applied to other feedstocks at scale.

However, they argue (in recital 3 of Delegated Directive (EU) 2024/1405) that

> *"the technologies needed to process those feedstock into biofuels used in aviation are not yet commercially deployed at scale, while mature technologies are already available and deployed at scale to process the same feedstock into other types of biofuels that are used in other transport sectors such as biodiesel […]"*

However, the production of renewable diesel (HVO) and SAF (HEFA) from intermediate crops largely uses the same technology pathway. HEFA technology is already commercially deployed. It is unclear what "at scale" the Commission implies it should have before it would be considered mature. And it is unclear what would happen to the categorization of intermediate crop based SAF when the technology is commercially applied "at scale".

The specific conditions under which intermediate crops are considered as Annex IX Part A are:

- They are grown in areas where due to a short vegetation period the production of food and feed crops is limited to one harvest;
- Their use does not trigger demand for additional land; and
- The soil organic matter content on the land they are grown is maintained.

Timeline RED Annex IX process

Year	Milestone
2018-2019	The RefuelEU-Aviation draft banned food crops from SAF; intermediate crops were seen as alternative feedstock, but to avoid that would be freely interpreted, the requirement was included that they would only be accepted if Annex IX-listed
2021 (June)	Commission commissions E4tech/WUR study reviewing new Annex IX feedstocks; intermediate crops highlighted as "low-risk-if-properly-certified"
2022	Informal stakeholder coalition was formed to campaign for specific crop feedstocks (intermediate crops, crops on degraded land) to be included in Annex IX
2023	Coalition publishes joint industry letter and draft certification text; proposes amendments to Regulation 2022/996 to cover intermediate crops
23 May 2024	Commission adopts Delegated Regulation updating Annex IX. intermediate crops enter Part A (SAF) & Part B (other biofuels)
2025 (Q3–Q4, planned)	Commission to table detailed certification guidance via a revision of Implementing Regulation 2022/996

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