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ORIGINAL ARTICLE

Underutilised crops in Europe: An interdisciplinary approach towards sustainable practices

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Abstract
In the context of a rapidly growing global population and significant climatic and environmental change, there is an urgent need to produce nutritious food in a sustainable manner. Some crops are underutilised in Europe, despite their suitability to local environments, viability for sustainable production and potential to improve diets. Rye (*Secale cereale*) has a long history of cultivation in Europe, yet is underutilised owing to complex historical, socio-cultural, socio-political, socio-economic and agronomic factors. This paper explores an innovative, cross-sectoral approach that harmonises existing datasets from archaeology, plant science, nutrition and policy, and establishes an inter-disciplinary dialogue to tackle this challenge.

INTRODUCTION

Agriculture in Europe relies on the cultivation of a relatively small number of crop species—mainly cereals—and local specialisation has depleted crop diversity further (Zander et al., 2016). Data from the UN Food and Agriculture Organisation, presented in Figure 1, indicate that members of the grass family (mainly wheat, barley and maize) accounted for over 60% of the European arable crop area harvested in 2022. The focus on these three cereals has remained relatively steady over the past decade (Figure 2), despite a growing awareness that specialisation in a limited number of crops is leading to environmental degradation and compromising food security (Willett et al., 2019). There is an urgent need to increase the variety of crops grown and agroecosystem diversity because these actions can enable significant improvements in biodiversity, the health of European citizens, and agricultural resilience in the face of climate change (BEUC, 2020; FAO, 2019; IPCC, 2022). Taking effective action is, however, not straightforward.

Several crops have become underutilised in Europe over recent decades and centuries, both in production and consumption, even though they have a deep history of cultivation for food in the region, great potential to improve human nutrition and provide useful traits for more

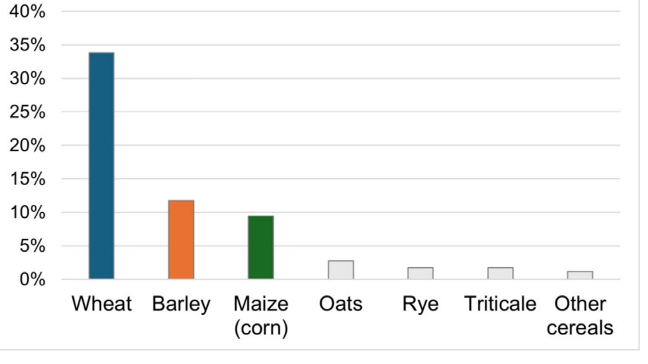

FIGURE 1 Cereal crops as a percentage of the total area of crops harvested (hectares) in Europe (EU27 and wider Europe), 2022. Data source: FAOSTAT, 2024. 2022 is the most recent year for available data.

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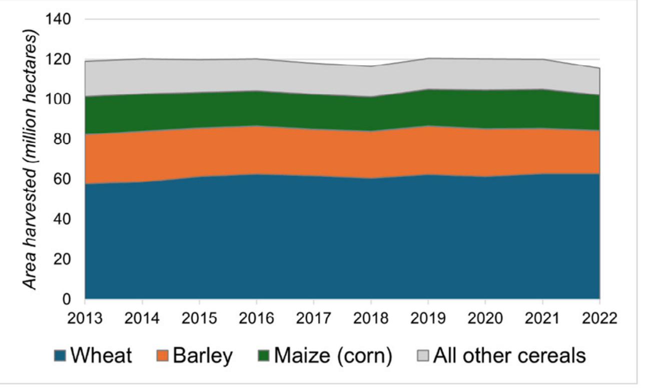

FIGURE 2 Changes in the area of crops harvested (hectares) for wheat, barley, maize and other cereals in Europe between 2013 and 2022. Data source: FAOSTAT, 2024.

sustainable food production. These are not 'lost' crops that require resurrection; rather they have persisted in farming systems across Europe but are not widely cultivated. This underutilisation of certain crops has developed because of complex historic, agronomic, socio-economic and socio-political factors, but it is increasingly recognised that change is required. Tackling this issue requires a radical new approach that takes into account distinct but entangled and often contradictory factors. This paper outlines some of the key challenges, emphasises the need for a multidisciplinary and multisectoral approach that incorporates an understanding of how past actions and traditions have shaped modern perceptions, practices and policies, and explores a pathway towards more sustainable farming and food systems.

CHALLENGES IN TACKLING THE UNDERUTILISATION OF CROPS IN EUROPE

Crop diversity can play an important role in the development of sustainable farming systems. Crop diversification is often defined as the addition of one or more crops to an existing cropping system (Feliciano, 2019, pp. 795–796), and it requires theoretical and technical knowledge to be implemented successfully (Baccar et al., 2022, p. 2). Europe has a deep history of using crop diversification as a food-security strategy, with archaeological evidence for such practices spanning thousands of years (Bogaard, 2004; De Vareilles et al., 2021; Sabanov et al., 2024; Zohary et al., 2012). In the past, diversification appears to have been employed primarily as a mechanism for reducing the risk of widespread crop failure in the short term (Halstead, 1989). The maintenance of a diverse crop spectrum is also argued to have enabled long-term resilience in farming practices at some locations, such as the large-scale prehistoric settlement at Çatalhöyük in Turkey (Bogaard et al., 2017). In more recent times, increasing crop diversity has been recognised as an important element of agricultural adaptation to climate change (FAO, 2019). In the quest for reliable harvests in their region, farmers are having to adapt their production systems and consider 'new' crops (Ceglar et al., 2019).

Intraspecies genetic diversity can also play a role in the development of sustainable farming systems. In recent decades, some crops have been bred for intensive production that maximises yield through high inputs, and negative consequences from this approach can include genetic uniformity (Massawe et al., 2016, p. 365). A more sustainable and resilient approach is sought in Target 2.5 of the United Nations Sustainable Development Goals (SDGs), which endeavours to 'maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species'.

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Changes in agricultural practices are also required because of the environmental impact of food systems, which are responsible for over one-third of all anthropogenic greenhouse gas emissions currently (Crippa et al., 2021). The European Commission has highlighted the need to develop more sustainable food systems to reduce Europe's carbon footprint and the potential role of agroecological practices in tackling this issue—such as crop rotation with legumes to support productive soils, as encouraged by Good Agricultural and Environmental Condition (GAEC) 7 under the current Common Agricultural Policy (CAP) (DAFM, 2023)—as well as reduced dependence on both nitrogen fertilisers and imported protein through the fostering of protein-crop production (European Commission, 2018; Murphy-Bokern et al., 2017). The European Union's (EU's) *Biodiversity Strategy for 2030* (European Commission, 2020a) has also highlighted how adapted practices in agriculture and land management can help protect and enhance biodiversity. The biodiversity of agricultural landscapes is the result of complex interactions between the variety of crops grown in the cultivated area, how these crops are managed, and the quantity, quality and spatial arrangement of uncropped areas. Increasing crop diversity can increase the diversity of structures and temporary in-crop habitats in the wider landscape, thereby supporting significant improvements in biodiversity.

The war in Ukraine has highlighted further vulnerabilities in European food systems. Estimates by the Food and Agricultural Organization (FAO) of the United Nations (UN) from mid-2022, only several months after the beginning of the war, suggested that damage to the agriculture sector caused by the conflict had already cost 4.3–6.4 billion USD, and that such an impact was eroding global food security (FAO, 2022, p. 8). Consequently, the UN FAO recommended regional diversification in crop production, processing, storage and export practices (FAO, 2022, pp. 17–18).

Adaptive practices must not be confined to farming only. Diets in Europe currently have a large carbon footprint and are not optimal for citizens' health (Poore & Nemecek, 2018; Springmann et al., 2018). Diets that are heavily reliant on air-freighted or processed foods, alongside commonly consumed animal-source foods in Europe, pose dual threats: first to human health (due to associated chronic diseases); and, second, to the environment (due to their high carbon footprints and resource-intensive production processes) (Crippa et al., 2021; Dixon et al., 2023). Transitioning from high-greenhouse-gas-emission diets to low-emission alternatives could potentially prevent approximately 2% of deaths annually, underscoring the potential dual benefits of environmentally sustainable diets (Pollock et al., 2022). A forward-looking approach to food consumption that promotes human health and environmental sustainability could emphasise whole, plant-based foods and a reduced reliance on meat and processed foods (Pollock et al., 2022).

Promotion of underutilised crops can address this issue by increasing and diversifying the supply of plant-based foods that foster healthier food choices among European citizens. Consumers in Europe are increasingly aware of relationships between changing climate, health and the food they consume, prioritising healthy diets and changing food habits (BEUC, 2020). Consumers also recognise the need for sustainable food-production solutions. The European Consumer Organisation (BEUC, 2020) reported that two-thirds of EU consumers are influenced by environmental concerns and are willing to change their food consumption, but clear information and a choice of sustainable options are important prerequisites for addressing consumers' attitudes.

It is also important to consider how national and regional economic policies can inhibit or incentivise crop diversification. It may not be financially viable for farmers and food producers to diversify if existing economic structures provide a significant barrier to diversification. For example, it has been argued that the CAP of the EU has encouraged farms to specialise in growing cereals over legumes and other crops to create comparative advantage (De Roest et al., 2018; Magrini et al., 2016). As a result, European farms cultivate low levels of legumes (Magrini et al., 2016) and, as of 2014, only 1.6% of arable European land is under legume

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cultivation (Watson et al., 2017). CAP policies have also failed to halt 'intensive crop specialisation'—a term that refers to the practice of focusing on a single crop or a few crops to the exclusion of others—and this practice continues in some regions, particularly those with the lowest cost of production (EUROSTAT, 2022; Pe'er et al., 2020). Ricardo's law of comparative advantage is also significant here, whereby European farmers often concentrate production on what they perceive they do best, which can lead to crop specialisation (Murphy-Bokern, 2022; Rumankova et al., 2022). If the upfront cost of adopting new crops and cropping systems is high, financial support may be needed, particularly where private benefits are not apparent or immediate from the change (Wreford et al., 2017). An example of regional policy that favours the transition towards new, sustainable and diversified forms of crops can be found in the Autonomous Community of Madrid (Spain), which encourages a change towards nutrient-rich crops such as legumes (IMIDRA, 2017). More widespread and comprehensive policy support is required across Europe, especially for farmers who are trying to change agri-food system lock-ins or path dependencies that support certain specific crops and instead create new spaces for other crops (Magrini et al., 2016; Voisin et al., 2014).

INTEGRATING KNOWLEDGE FROM ANCIENT AND MODERN AGRICULTURAL PRACTICES FOR THE SUSTAINABLE DEVELOPMENT OF FARMING SYSTEMS

There is an increasing awareness that a better understanding of traditional and past food systems can provide context to and inform approaches to current challenges. The European Commission Directorate-General for Agriculture and Rural Development and the European Innovation Partnership for Agricultural Productivity and Sustainability have recognised that crop diversification was a feature of European farming systems in past centuries, but modern farming practices have reduced diversity considerably, leading to overspecialisation and oversimplification of cropping systems (EIP-AGRI, 2019). These shifts in farming practice have been shaped by changing cultural practices through the centuries. The well-known maxim 'You are what you eat' has resulted in the construction of regional farming and food identities, but to what extent are these recent developments, and how might they be adapted?

Archaeology, as the study of past societies, provides important insights into ancient food choices and agricultural management practices. Archaeology enables us to take a deep-time perspective on the role played by crops in establishing local and national food heritages, and those that have persisted in shaping modern food identities. Researchers in archaeology are increasingly highlighting how learnings from the deep history of farming and food systems can contribute to the improvement of modern systems (Fisher, 2020; Fuks et al., 2024; Reed & Ryan, 2019; Valamoti et al., 2022), while acknowledging that ancient technology is not necessarily green technology (Boivin & Crowther, 2021, p. 276). Adaptive strategies can also tap into traditional knowledge systems built up by farmers over decades and centuries, thus avoiding a sense of disempowerment by farmers and devaluing of their traditions, and enabling impact at farm level.

There is increased interest in how traditional crops might play a key role in future sustainable food systems. Through the evolution of intraspecies genetic diversity (including landraces), some traditional food crops are well adapted to changing European climates and lower-input practices. The Intergovernmental Panel on Climate Change has indicated that traditional and locally adapted farming strategies can provide an important resource for climate resilience (IPCC, 2022, p. 745). The EU's Farm to Fork strategy has also identified the crucial role that could be played by a significantly increased uptake of resilient, traditional and locally adapted crops in sustainable food production systems as a route out of overly simplified cropping systems (European Commission, 2020b).

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Transforming archaeological knowledge into meaningful action in a modern context is challenging, however (Fisher, 2020, p. 398). An integrated approach that harmonises knowledge from multidisciplinary and multisectoral perspectives is better placed to unravel narratives from the past and develop modern and global solutions. The DIVERSICROP research network was established in 2023 to bring together researchers from archaeology, plant science, nutrition and policy to better understand the environmental, economic and socio-cultural circumstances that have led to the current underutilisation of certain crops in Europe (DIVERSICROP, 2024). Three target crops have been chosen for initial analysis: chickpea, *Cicer arietinum* L.; pea, *Pisum sativum* L.; and rye, *Secale cereale* L. This current paper by members of the DIVERSICROP team focuses on rye, exploring its deep history in Europe and potential pathways towards its revival for a sustainable future.

CHANGING FORTUNES OF RYE PRODUCTION

Europe produces more than 85% of the world's rye harvest (12.8 million tons in 2019), where rye is cultivated for food, animal feed and the malting industries (Brzozowski et al., 2023; Németh & Tömösközi, 2021). Current hotspots for rye production in Europe are located towards the north and east: Russian Federation, Poland, Germany and Belarus (Figure 3). Ukraine is also among the larger producers, and the war in this region has accelerated the need for innovation in production.

Despite Europe's status as a hotspot for rye production, it is not a staple food across the region. While rye is a major bread cereal in Poland, Hungary, Germany, Baltic and Scandinavian countries, it plays a minor role in human foods in many other areas (such as Greece, Spain, Ireland, UK and Belgium). Furthermore, rye consumption per capita has decreased over the last 20 years, both in European countries and globally (Korzun et al., 2021). This is despite the fact that rye is adapted to harsh climates (being winter-hardy and more drought-tolerant), requires lower fertilisation than crops such as wheat, is relatively easy to clean (because it is a 'naked' or 'free-threshing' cereal) and has health benefits when compared to cereals such as

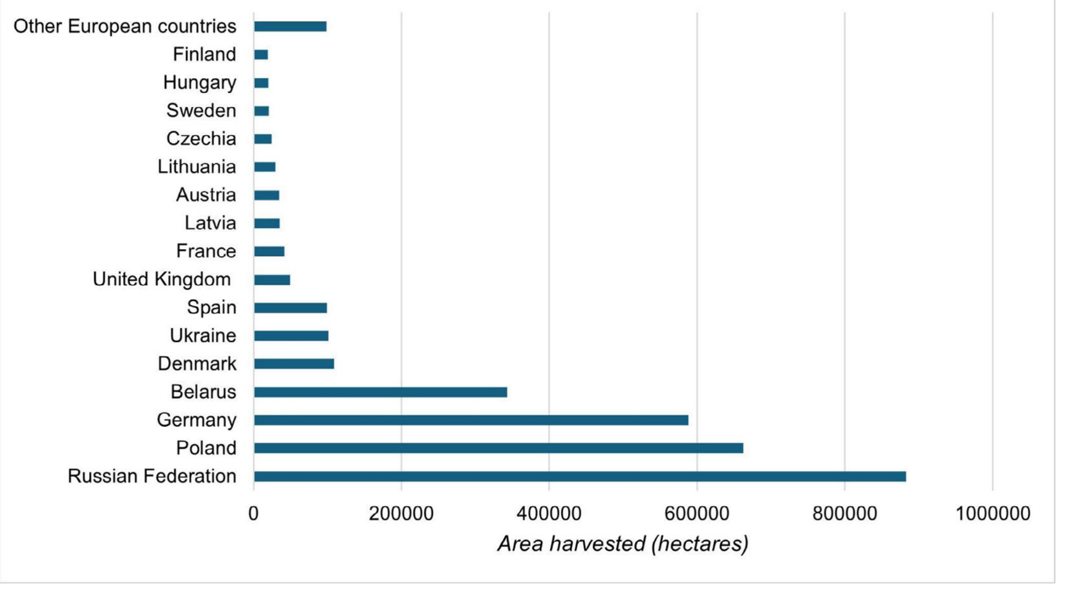

FIGURE 3 Area of rye harvested in European countries in 2022. Data source: FAOSTAT, 2024.

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bread wheat (Jonsson et al., 2018). Rye is not immune from the impacts of climate change, however. In 2022, the EU's cereal harvest fell sharply, impacted by a widespread drought in some regions (Figure 4). There was a significant decrease in the harvested area of rye, declining by 9.9%, which led to a corresponding reduction in harvested production by 7.7%. This decline was driven primarily by decreases in Poland (−9.5%), Germany (−5.8%) and Spain (−33.1%) (EUROSTAT, 2023). Figure 3 highlights a dependence on a relatively small number of European countries for rye production. By contrast, archaeological evidence suggests that rye was grown in a wider variety of geographic, social and economic circumstances in the past, sometimes at large scale (Behre, 1992). Archaeology can provide a tangible link to help farmers across Europe re-engage with rye, but this requires a better understanding of how rye was incorporated into farming and food systems in the past. This understanding can be achieved through a sub-discipline of archaeology, known as archaeobotany.

UNCOVERING THE LONG AND COMPLEX HISTORY OF RYE IN EUROPE

Archaeobotany is the study of past societies and environments through the analysis of preserved plant remains, which are usually derived from archaeological excavations (Pearsall, 2015). Archaeobotany provides a unique window into plant availability and dietary choices at different times and locations, and the role of food in shaping social identities and behaviours. Through geochemistry, genetics and functional interpretation of weed flora, archaeobotany can also provide insights into past management practices (including fertilisation inputs), crop combinations and cycles (e.g., which crops were grown together; which crops were selected for specialisation and diversification), changing environmental conditions, and what ingredients were combined in food preparation (Aguilera et al., 2018; Bogaard et al., 2016; Fuller & Lucas, 2014; Lepetz & Zech-Matterne, 2018; Toulemonde et al., 2021; Zech-Matterne, 2020; Zech-Matterne et al., 2021). The popularity of rye can thus be tracked across Europe over several millennia, as well as the reasons for changing practices.

Archaeobotanical studies reveal that rye is occasionally recovered from the excavation of prehistoric settlements, but it was not until the beginning of the first millennium CE that production became more widespread across Europe (Behre, 1992). During the early second millennium CE, it appears that rye was consumed by all classes of society in several regions, and it was grown on different types of soil, including some of the least productive soils (Seabra

FIGURE 4 Harvesting rye.

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et al., 2023; Zech-Matterne & Bouby, 2020; Zech-Matterne et al., 2017). There are some contradictions in the evidence, however. In medieval France, for example, several archaeobotanical studies suggest that rye was consumed by wealthier social classes, even though its use in this context was decried in written sources (De Hingh & Bakels, 1996; Van Zeist et al., 1994). Evidence from past societies requires careful and critical analysis, therefore, to determine changing attitudes to rye.

The Republic of Ireland provides a useful example of a region where rye was grown more widely in the past, with respect to both the volume harvested and the locations where it was grown. Data from Ireland's Department of Agriculture, Food and the Marine indicates that only 2713 ha of agricultural land was dedicated to rye in Ireland in 2022. This provides a stark contrast to the 67,230 ha of wheat and 190,250 ha of barley harvested in Ireland in 2022 (FAOSTAT, 2024). Rye has become a very minor crop in Ireland, but it was grown on a significantly larger scale in the past.

There are occasional finds of rye from later prehistoric deposits in Ireland, such as an Iron Age cereal-drying kiln at Kilmainham, Co. Meath, dated to the third to fourth centuries CE (Walsh, 2011). Rye began to be cultivated more widely during the early medieval period in Ireland (400–1150 CE), as reflected in other parts of Europe (Behre, 1992). Charred grains of rye (and occasional chaff elements) have been recorded from a wide variety of early medieval sites in Ireland, including large enclosed settlements, small isolated farmsteads, religious establishments and specialised agricultural facilities such as kilns (McClatchie et al., 2015), suggesting that many different communities were engaging with rye more than 1000 years ago. Contemporary documentary evidence indicates that rye was regarded as a high-status crop. A list of cereal types in the eighth-century law tract *Bretha Déin Chécht* (The Judgements of *Dían Cécht*) places cereals in the following order: bread wheat (*Triticum aestivum*); rye (*Secale cereale*); spelt wheat? (*Triticum spelta*); two-row barley? (*Hordeum vulgare* ssp. *distichum*); emmer wheat? (*Triticum dicoccum*); six-row barley (*H. vulgare* ssp. *vulgare*); oat (*Avena*) (Kelly, 1997, p. 219; Figure 5). Question marks are attached to some of the cereal types because their translation from Old Irish is uncertain. The order set out in this list represents the relative prestige of each cereal, which is correlated with a particular ranking in society. Bread wheat is equated with the rank of a superior king, bishop or chief poet. At the other end of the scale, oat is equated with the commoner. Cereals were not just regarded as a source of sustenance, it seems, but also as cultural symbols that could distinguish social classes (Fredengren et al., 2004), if indeed these legal texts are a true reflection of daily life, rather than an idealised society.

In medieval Ireland (1150–1500 CE), rye was produced at a scale that enabled both export and domestic consumption (Murphy & Potterton, 2010, p. 308). As well as documents that catalogued the locations of fields sown with rye, sources also noted rye fields and harvests bequeathed in wills (Murphy & Potterton, 2010, p. 309), underlining its social and economic importance. Although rye can thrive on poorer-quality soils, its cultivation in Ireland was not restricted to such environments. Archaeobotanical studies provide numerous examples of rye being recovered from areas where some of the best soils in Ireland are located. A good example of this is the large medieval settlement excavated at Landscape, near the border of Counties Kilkenny and Wexford in the south-east. This is a region well known for some of the best-quality soils on the island and its amenable climate. The excavation uncovered the charred remains of rye dating from the 13th to the mid-15th century CE (Hession, 2012), providing a useful example of rye production in a region that had the potential to support more demanding crops, such as bread wheat.

Mapping of the findspots where rye was recovered from archaeological excavations in the Republic of Ireland demonstrates that it was grown in many areas in Ireland's past (Figure 6, left). This provides a sharp contrast to modern Ireland, where rye is far less commonly cultivated, both in volume and geographically (Figure 6, right); its cultivation nowadays is largely

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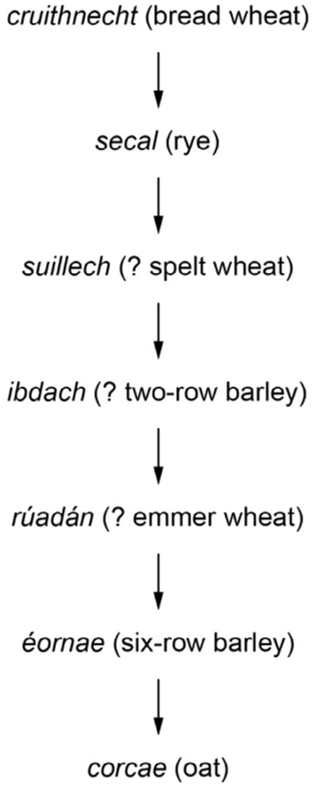

FIGURE 5 Order of cereals in the eighth-century law tract *Bretha Déin Chécht*, reflecting the relative prestige of each cereal type (Kelly, 1997, p. 219).

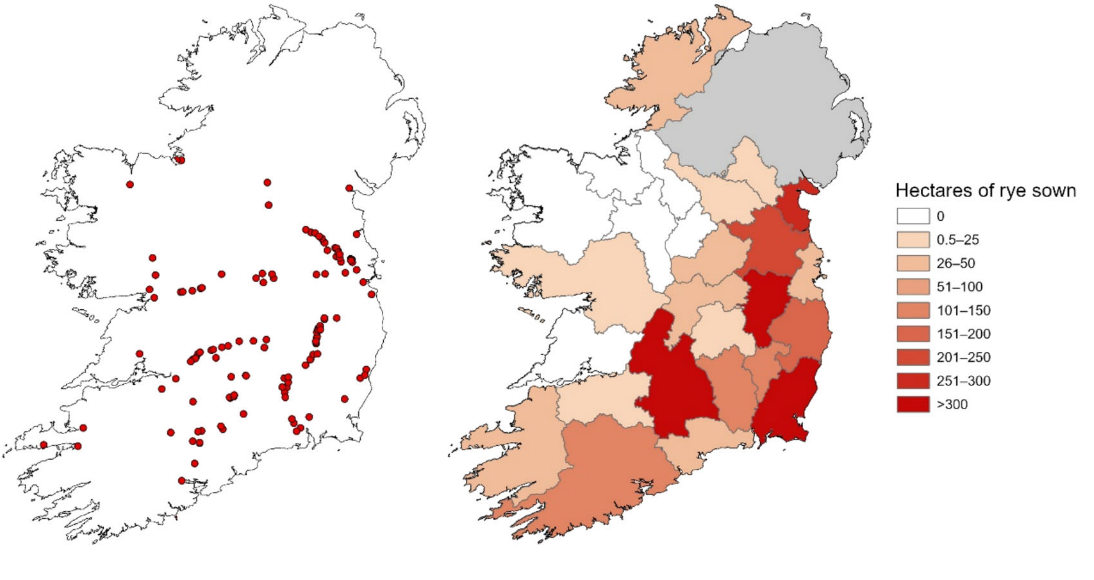

FIGURE 6 Map of Ireland showing (left) locations where rye was recovered from archaeological excavations, and (right) hotspots for rye production (hectares) in 2022. Data source (left): CROPREVIVE (2024); data source (right): DAFM (Department of Agriculture, Food and the Marine, Ireland).

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restricted to the east and south. This is likely to reflect diverse factors, including an increased focus on animal production in recent decades, as well as specialisation in cereal production, with a particular focus on barley (Central Statistics Office, 2024). But in other areas of Europe with evidence for large-scale production of rye in the past, such as Poland (Behre, 1992), rye has persisted and is still widely grown and consumed. An analysis of differing pathways is required to better understand why rye has become underutilised in some European regions but not others. In past centuries, the threat of ergot infestation would have discouraged some farmers from growing rye, due to the harmful effects of ergot consumption for humans and animals. Modern advances in rye breeding have reduced ergot alkaloid levels significantly, which means that ergot is far less of an issue nowadays (Brzozowski et al., 2023), but there are diverse reasons beyond ergot for Europe's disengagement with rye.

Archaeobotany has the potential to provide new insights into rye's pathway towards underutilisation, but archaeobotanical data are contained in disparate datasets across Europe. There are some large-scale archives, such as ADEMNES (2024) for Eastern Mediterranean and Near Eastern sites, CZAD (2024) for the Czech Republic, BRAIN (2024) for Italy and CARPODATA (2024) for France. But many datasets are stored in personal archives or shared only within research groups and not accessible online. This means that the data cannot be easily accessed or analysed by researchers or other interested parties. To address this issue, the DIVERSICROP research network has begun to merge and analyse available datasets in an effort to better understand the pathway of rye from staple crop to subsequent neglect, and the reasons why some regions have managed to preserve continuity of this crop.

This will not be enough to ensure substantial and sustainable change in farming practices, however. Research is also required to determine the traits and characteristics of certain crops that make them viable for sustainable production in a modern context. Plant science is well placed to tackle this issue. Information on current cultivation practices and crop varieties used by farmers is necessary to understand today's challenges to the uptake of underutilised crops, such as rye. There is a clear need to assess the nature of modern environmental constraints, the potential impact of growing modern cultivars, and modern scientific approaches to improving low or unreliable yields. Improvements could include reduced use of plant protection products (pesticides) as a result of reduced disease pressure, more diverse rooting systems, and reduced mineral fertiliser due to nitrogen fixation from legume crops (Zander et al., 2016).

Rye is remarkably resilient to biotic and abiotic stresses, making it an attractive option for farmers who wish to diversify (Brzozowski et al., 2023). Increased use of cover crops and the push to improve soil health has triggered a renewed interest in rye cultivation across Europe (Korzun et al., 2021), and breeding trials are being undertaken to improve yield and yield stability for rye (Hackauf et al., 2022). Disparate datasets are again an issue, however. Although rye has high potential for agricultural sustainability due to its stress resilience, regional data on its agronomic potential and stress resilience in the face of climate change are not easily accessible for farmers or policy makers. The DIVERSICROP network has begun the process of identifying regional environmental constraints that limit the production of rye, as well as the potential for environmental adaptation in underutilised germplasm. DIVERSICROP is also assessing crop quality and resilience by collating data from genebanks, historical collections and breeding lines, and assessing adaptability to European agro-climatic conditions, thereby creating an inventory of genetic resources. A variety of genetic resources is being investigated, including old cultivars, landraces, breeding lines and wild relatives. Such an approach enables identification of resilient lines that can be successfully produced in different agroclimatic regions or used for breeding programmes (Brzozowski et al., 2023). Consultation with stakeholders across Europe is also being undertaken to assess current agronomic practices and market supply chains.

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FROM FARM TO TABLE: THE IMPORTANCE OF CONSIDERING FOOD PRODUCTS AND POLICY MAKING

As outlined above, the sustainable development of European food systems requires adaptive practices for crop cultivation. Adaptive practices must also be extended to the end-products—the food products available to consumers—as well as the policy structures that influence farmer, processor and consumer decisions. Although the potential health benefits of rye as a food ingredient have been acknowledged (El-Mahis et al., 2023; Jonsson et al., 2018; Kaur et al., 2021), rye-based food products that can help foster healthier food choices are not widely available in some European countries, particularly in countries where rye is utilised more in livestock feed than human food. A clearer understanding of current practices across Europe is required, including regional trends in the production and consumption of rye-based food products. The establishment of baseline data would enable consideration of the potential for incorporating rye into new food products, as well as its overall market potential in the future. Consideration of cultural factors that shape food habits in the modern context is also required, including a recognition of the relationships between food, culture and regional intangible heritage, as has been highlighted by UNESCO and the Slow Food movement (Pietrykowski, 2004; Rosa et al., 2022).

The DIVERSICROP network is tackling these related issues by reviewing existing datasets to evaluate regional variation in the consumption of rye-based foods across Europe, the nutritional value of rye in various food products, and the environmental impacts of such foods. This includes analysis of how rye is incorporated into traditional cuisines, and its role in promoting sustainable agricultural practices and healthy diets. Data sources include food-consumption databases (such as FAOSTAT), market analyses, and consultation with food industry partners to gather data on sales trends and consumer preferences for rye-based foods in supermarkets and specialty stores.

The policy and governance structures that drive farmer, processor and consumer decisions also require attention. It has already been noted that many European farmers exploit Ricardo's law of comparative advantage by specialising in crops that grow especially well in the region. But Ricardo's law leads ultimately to over-specialisation, which has consequences for nature and system resilience when applied to agriculture. The strategic challenge is to raise the comparative advantage (economic competitiveness) of diverse systems. Governmental and European policies are key drivers in the specialisation of certain crops and the underutilisation of others, so it is critical to explore the steps that can be taken to address barriers to increased production for underutilised crops. In this context, the DIVERSICROP network is reviewing past and current policies and incentives, including the CAP, EU Biodiversity Strategy, Convention on Biological Diversity (CBD), Food and Feed Safety Regulations, European Agricultural Fund for Rural Development, Entrepreneurship and Innovation Programme, research and innovation strategies such as the Bioeconomy Strategy, and strategic approaches such as the Green Deal. Facilitation of multi-stakeholder dialogue is also required to support improved policy development. Stakeholders are extraordinarily diverse in this context; they include governmental ministries, local and regional policymakers, downstream actors such as processors and agroindustry, farmers' groups, higher education and research institutions, innovation support services and extension services, funding agencies, civil and consumer associations, NGOs, data providers and managers, professional associations and international organisations such as the UN FAO. While it may be challenging, consultation with stakeholders will enable a better understanding of how policy inhibits or enables agrobiodiversity integration into the value chain, with a view to establishing supply chains for the underutilised crops and, ultimately, more sustainable food systems (Magrini et al., 2016; Voisin et al., 2014; Watson et al., 2017).

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AN INTEGRATED WAY FORWARD

The need to increase the variety of crops grown in Europe and their incorporation into healthy foods is undeniable, but this is a complex challenge, and it requires an innovative approach that involves a wide variety of stakeholders. It has been outlined above how archaeobotany can play a key role in this challenge by unravelling the secrets of the past and tracking the changing fortunes of underutilised crops like rye over the past two millennia. This approach helps us understand how we have reached where we are today in European agricultural and food systems. But a multidisciplinary and multisectoral approach is required to enable a step-change in producer and consumer behaviour. This paper has set out the value of merging findings from the deep history of foodways in Europe with three other data sources: (i) data from modern plant sciences to understand genetic diversity and identify climate-resilient crop germplasm; (ii) data from nutrition to investigate current regional trends in the consumption of food products, and potential nutritional, health and environmental benefits of consuming certain foods; and (iii) data from national and European policy analysis to understand the barriers and opportunities for increased production of underutilised crops.

The DIVERISCROP network asks the question 'Why are these crops now underutilised?' before developing potential strategies for their revival. This approach brings together stakeholders and existing datasets from disparate perspectives to develop a new route to resilient and sustainable food systems in Europe. Mapping and harmonising data across borders and disciplines will unlock the potential of existing datasets and, more importantly, enable researchers, farmers, food businesses and policymakers to access and navigate valuable data and make evidence-informed decisions. This approach will help farmers connect with their regional heritage—both tangible and intangible—as well as develop an understanding of best practices in achieving the required yields, learn about the potential use of these crops in marketable food products, and thereby prioritise the cultivation of underutilised crops. The ultimate aim is to revive diverse crop production, rethink our food systems and maximise the impact of Europe's agricultural sustainability. This is certainly ambitious, but a joined-up approach based on high-quality scientific data, as outlined in this paper, provides an exciting new way to tackle this important social, cultural, economic and political challenge.

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DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article.

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