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RESEARCH ARTICLE

The social valuation as a limiting factor in plant breeding research: The case of Iberian rye

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Abstract
Focusing on Iberian rye, we explain how social opinion about crops can influence botanical scholars' studies and breeding engineers' research. Rye was an essential plant in some agricultural systems of the Iberian Peninsula for centuries because of its resistance. However, despite rye's superiority over other cereals in adverse environments, its inferior position compared to wheat regarding food preferences helps to explain a lower consumption and an overall adverse social reputation. The early botanical investigation that formed the basis of later scientific research reflected this appreciation. Thus, with such weak foundations, given the lack of interest, when Iberian rye engineering began to develop in the 20th century, it looked abroad to find varieties of agronomic interest, barely studying native landraces. Analysing this phenomenon is a significant step towards drawing attention to a multifunctional plant adapted to the territory, which can offer solutions to present food and environmental challenges.

Introduction

Rye (Secale cereale L.) is a cereal that grows better in adverse conditions than other grasses such as wheat, barley, or oats. Especially since the Middle Ages, some characteristics have made this grain an indispensable resource in some European areas (Schlegel, 2013), including the Iberian Peninsula. Rye tolerates low temperatures and winter frosts better and has lower nutrient requirements than other grasses. An extensive root system allows the plant to grow in poorly fertilised or recently ploughed plots and in low-quality, acidic, or high-salt and aluminium-concentration soils where other cereals cannot be cultivated. Rye root branching also explains a lower water demand and a higher resistance to drought (Aguado Marín, 1957; Aguado Marín and Martínez Vázquez, 1959; Geiger and Miedaner, 2009; Schlegel, 2013; Miedaner and Laidig, 2019). Despite these advantages and the great potential for addressing the current food challenges in the context of climatic change, botanical and scientific research on rye in the Iberian Peninsula has been scarce, especially in comparison with other cereals. In this article, we show that the adverse social valuation of rye has played a significant role in configuring this situation in the Iberian context.

Rye has been underappreciated in the agricultural Iberian literature since the 16th century, as evidenced by the lack of interest among Portuguese and Spanish authors. Over centuries, this issue manifested through poor descriptions and often non-existent analyses of varieties, while calls for studying rye morphology and types peppered the botanical and agronomic literature. However, even in the 20th century, those calls persisted among agronomists. Consequently, when modern Iberian breeding programmes started, the required knowledge and materials could only come from places with a longer tradition in rye breeding.[1] Thus, some German varieties acquired a prevailing role in the Iberian Peninsula, becoming an object of concern for scientists due to their genetic predominance. This issue remains unchanged in recent years (Monteiro et al., 2016).

Historically, in the Iberian context, there has been a negative social esteem of rye that favoured this situation. This lack of appreciation resulted either from consumption patterns and food identities based on a preference for wheat according to organoleptic factors or, more recently, from the industrial interest in other crops due to their new possibilities – e.g., maize. As people of their time from the upper classes, this lack of appreciation for rye negatively affected the attention paid by scholars in the botanical, agronomic, and academic literature in previous centuries. By the 20th century, this factor also limited the basis for modern Iberian research, as there had never been an interest in identifying essential characteristics of rye for breeding purposes, in contrast with other grains.

This article is organised as follows, aiming to fulfil a double objective. Firstly, we expose some of the essential components of rye social interpretation. Some researchers studied the social status of rye in the northwest Iberian Peninsula, especially in relation to maize (Dubert García and Saavedra, 2018; Saavedra, 2018), a crop that experienced a shocking expansion in that area from the 17th century onwards. However, our paper also addresses how the agrarian, botanical, and academic literature depicts this pejorative valuation, a novel analysis approach. Secondly, we aim to present the core aspects that characterised the origins of Iberian breeding on rye and triticale – the hybrid between rye and wheat – in the 20th century. We pay attention to centres that conducted innovative work and draw connections with the research developed in other territories.[2] By analysing these subjects together – valuation and breeding – we better understand some of the keys to the historical development of rye, the historical study and the experimentation carried out about this grain.

The use of various written sources makes these analyses possible. These include, on the one hand, botanical and agricultural manuals published in Spanish and Portuguese from the 16th century onwards.[3] On the other hand, in the 20th century, activity reports, informational publications, and correspondence from Iberian scientific centres provide an insight into their lines of work.

The social valuation of rye in the Iberian Peninsula

Rye is present in agricultural systems in cold and mountainous areas where it grows better than other cereals. Thus, although common in all European latitudes, it is more frequent in the centre and north, even above the Polar Circle, but also at high altitudes. In the Iberian Peninsula, rye's maximum cultivation elevation is around 1600 metres above sea level, while the limit for other grasses such as oats, maize, or common wheat is 900–1000 metres (Azevedo et al., 2016, 24). This distribution is a consequence of a progressive expansion across Europe since the Bronze Age, although rye arrived in the Iberian Peninsula in the Late Iron Age (Seabra et al. 2018, 374). From its centre of origin and domestication in Anatolia and southwest Asia, rye migrated as a companion species to other grasses – already with the characteristics of a cultivated plant – but the adverse climatic conditions and soil acidity favoured its prevalence over other species in the areas noted above. Its cultivation spread widely in the medieval centuries (Hillman, 1978; Behre, 1992; Schlegel, 2013).

In the Iberian northwest, the most diversified agricultural systems included rye followed by turnips that fed animals and people. In the second year, the rotation ended with a third harvest that included maize and beans intercropped. In some northern Iberian agroecosystems, the cultivation of rye was essential in scrublands through the *estivada*, a type of slash-and-burn agriculture that required ploughing the land after burning the brushwood and scattering the ashes. According to some estimates, farmers could produce around 20–25% of the total winter cereal harvest by this method, widely regulated in many rural communities (Sobrado Correa, 2023). In sandy or clay-rich soils, rye cultivation is traditionally associated with wheat and some leguminous plants and is complemented with the fallow system. In this case, the main options are rye-fallow-wheat and rye-legume (e.g., vetch)-fallow (Aguado Marín, 1957, 7–8).

Despite rye's attractive characteristics for Iberian soils, general appreciation led this grain to a very different social reality, both from the popular point of view and from the perspective of botanical and agronomical research. Overall, this esteem given to rye, which is lower than that of other cereals, can be defined as adverse and burdened with pejorative connotations. This valuation manifests through various aspects, most notably in popular food predilections related to palatability issues. The preference for wheat is indisputable even in places where rye was the main cereal for mass consumption, as was the case in the inland Iberian northwest or mountainous, cold, and humid areas, where it grows better than wheat and may be the only option for cereal cultivation. Also, in places where the two coexisted, tax documentation shows the relegation of rye to the plots with the worst productive capacity (González Remuiñán, 2019, 346). This preference stems from the flour and bread-making properties of both grains: agrarian instruction books indicate that wheat bread is fluffier, lighter, and easier to digest. Rye flour is stickier and moister, resulting in a heavy bread that can cause heartburn if consumed immediately after baking (Valcárcel, 1765, 184; Arias y Costa et al., 1818, 118).

This valuation scale changed with the arrival of maize, which took on a lower social status than wheat and rye, although the relationship between these two previous grains remained unaltered. In areas where the three coexisted, it is well known that, together with the appreciation for wheat by social elites, rye producers showed disdain for maize growers as part of a series of cultural food identities derived from the type of bread consumed in each household (Saavedra, 2018). Also, in ecclesiastical institutions, there was a marked class system of consumption, with wheat reserved for ecclesiastics and rye for servants and dependents who, unlike the poorer strata of the population, only consumed maize in contexts of food shortages (Dubert García and Saavedra, 2018). Similarly, in ecclesiastical organisations of northern Portugal, there are references to 'second-class bread', whether made of rye or maize.[4] The various qualities of flour – influenced by the way and the tools used – resulted in several types of bread with different social consumption patterns (Lopes, 2015, 5).

With these considerations in mind, it is necessary to note an essential distinction between the dietary esteem that popular classes had for rye and the intrinsic valuation of the rye crop in the farming economy as a resource provider. In this last case, rye emerges as a helpful product with various uses beyond its primary role as a foodstuff. Regarding this last aspect, rye consumption even left its mark on the vocabulary through the colloquial name of bread. Thus, in some areas of the northwest Iberian Peninsula where rye was the main consumed cereal, the word 'bread' referred to rye bread – as reflected, for example, in ecclesiastical accounts or rents in land transfer contracts. Meanwhile, bread baked with wheat flour, which was more unusual in some of these areas, was called 'wedding bread' or simply 'wheatbread (*pantrigo*)' (Saavedra, 2018), a word that is still present in the dictionary of the Galician Royal Academy. Undoubtedly, these names also denote the preference for wheat, preserved for special occasions.

However, far from ending here, the list of uses of rye extended to other fields. Rye straw after the grain harvest or the whole plant mowed unripened – sometimes mixed with other grains, especially wheat – was used for livestock feed. This meslin received several names in different regions of the Iberian territory – e.g., *tranquillón*, *morcajo*, *mixtura*, *revoltizo*, *mitadenco,* or simply mixed wheat – showing its widespread use. Some 18th- and 19th-century scholars questioned the agricultural value of this practice if farmers intended to make double use of rye and wheat grains, alleging differences in the ripening times of each species (Valcárcel, 1765, 186; Quinto, 1818, 198).

Besides human and animal consumption, rye straw fulfilled handicraft and architectural purposes. Among the former, its length and flexibility made it preferable for manufacturing mats, chairs, hats, plaits, or strings (Aguado Marín, 1957, 6). Among the latter, rye straw formed the

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cover of thatched houses, abundant in mountainous areas in rye-growing areas (Sobrado Correa, 2016, 140). Also, as a tool, rye straw was part of the pig slaughtering procedure to clean the meat – burned as a torch to remove the animal's hair – and to bind wheat and barley sheaves, vines, and other species that grow on trellises (Quinto, 1818, vol. I, 196; Lopes, 2015, 7). For these uses, rye straw was preferred to other options, such as wheat straw, because of its lower tendency to rot. However, despite being a common resource among the population, some authors recognised that the use of this rye straw for manufacturing purposes was far from being industrial (Quinto, 1818, vol. I, 196).

Eventually, we must mention ergot as a resource, as it constitutes the main exception to the general pejorative appreciation of rye.[5] In the first decades of the 20th century, this rye fungus provided a valuable income for farmers, especially in humid and cold areas (Brasa Arias et al., 2010, 114). This 'black gold', as it was also popularly known, was coveted by the chemical-pharmaceutical industry and became more valuable than the grain itself. For this reason, women and children carefully collected it before the harvest to sell it at local fairs (Aguirre Fanaique, 1944; Vázquez Bonome, 1951). Thus, rye has been a multifunctional cereal that provides essential services to farming communities: nourishment for people and animals, craft materials, construction inputs, and extra money. Its social importance was evident, even if there were more appreciated cereals for food consumption.

Although these aspects are essential to clarify the general social valuation of rye, the image of the crop that survived in the academic literature followed the classification of food identities and, therefore, was much lower than wheat. Many scholars, members of the elites, reproduced this class perspective of cereal consumption in their texts. Thus, rye appeared in these works as a product socially despised by the literate culture. Another example of denying farmers any capacity for independent thinking or the search for alternatives (Fernández Prieto, 1992, 81).

A few examples will illustrate this point, providing a general idea of rye studies in the previous centuries in the Iberian Peninsula. Critically analysing these early studies is fundamental, as they support later ones. At the beginning of the 16th century, Gabriel Alonso de Herrera suggested that planting wheat in unsuitable soil 'would produce an awful grain on the first sowing, but the second would be pure rye'. This impoverishing process – described as the transmutation of one species into another of lesser value – occurred in mountainous areas where 'the people have no better land to sow wheat, and they exploit it in the best way they can' (Alonso de Herrera, 1513, 9–10). The first edition of the text also disdained the cereal as livestock feed and discouraged its consumption. Reflecting the author's lack of knowledge about the grass and with an argument that was more superstitious than rational, some animals were said to die from consuming rye (Alonso de Herrera, 1513, 14). In the 17th century, Friar Miquel Agustí (1626, 236) indicated that this cereal could grow in any soil, so its cultivation was profitable even for mediocre farmers.

The food obtained from rye was also rated negatively. In a later edition of Herrera's *magnum opus*, the author noted that rye produced a 'terrible bread (. . .) suitable for people who do a lot of movement and exercise' (Alonso de Herrera, 1528, 16). Another scholar, Valverde de Arrieta (1578, 84), characterised rye bread as harmful to the stomach, while for Agustí, it was 'heavy and viscous', helpful in times of famine 'for rude and poor people' but 'not for the alimentation of rich men'. Among the animals, rye could feed dogs, pigs, and poultry, but not other valuable species such as horses (Agustí, 1626, 236). It is necessary to draw attention to the dissemination of this valuation of rye in written format, as these works by Herrera, Valverde, and Agustí had abundant reprints in the centuries following their original publication (Pablo Núñez, 2007; Quirós García, 2015; Baranda Leturio, 2018). Although their main occupation were different – Herrera and Agustí were clergymen, while Valverde was a treatise writer – all three authors had agricultural training.

The opinion on rye evolved with the development of botanical and agricultural disciplines. The derogatory rhetoric that reflected the preferences of the social elites changed to a more neutral discourse with scientific language. If authors from the 16th and 17th centuries offered a pejorative vision of this grass, the texts from the 18th century onwards also qualified rye in terms of its physical characteristics and main uses according to practical experience. However, the previous social valuation of rye remained, so the taint of its association with poverty or its vileness as a human and animal foodstuff continued to a large extent.

José Antonio Valcárcel, a Valencian agricultural scholar, acknowledged that rye was the most appropriate grain after wheat for making bread but added that 'it is only used in times of famine because it has an unpleasant taste for those who are not familiar with it' (Valcárcel, 1765, vol. III, 184). Another agricultural expert, Agustín de Quinto, stated categorically that 'pure rye bread is only made in those poverty-stricken countries where no other type of grain is available' (Quinto, 1818, 196). The scholars of the Royal Botanical Garden of Madrid who revised and expanded Herrera's work on the third centenary of its publication recognised his opinion as far-fetched. However, they recommended rye consumption to individuals 'with a robust stomach', referring to the working classes (Arias y Costa et al., 1818, vol. I, 129). The same argument is observed in Portuguese works of the same period, alleging that rye bread was also indigestible and less nutritious (Franco, 1823, 113). Also, in Tras-os-Montes, the main Portuguese rye-growing area, rye straw was used to feed cattle, even though it was supposedly less nutritious than other species. The reason, again emphasising the misery, was the existence of livestock 'mostly afflicted by hunger' (Lima, 1859, 9). This association of rye with the poor social strata remains even in scientific texts in the 20th century. Thus, the Portuguese agricultural engineer João de Carvalho e Vasconcellos recognised the importance of rye bread because it was 'the bread of the poor people in many areas of our country' (Vasconcellos, 1940, 23).

To deepen the aspects related to the valuation of rye in the botanical and agricultural literature of the 18th and 19th centuries, it is also helpful to approach the existing knowledge about the cereal and its morphology. Variety studies are a good option here. Of course, the typologies developed before genetic science presented some problems – such as the application of incorrect or subjective morphological and organisational criteria that have changed today (Revilla Temiño et al., 1998, 176). However, analysing these studies is useful because they reflect an interest in the species and the will to know it better. But even on this point, the poor social esteem of rye hindered any progress, and the cereal received limited attention compared to other plants. In other words, the literature showed a negative attitude towards rye and less interest in studying it. In his work, Valcárcel (1765, vol. III, 185) recognised a winter rye and a spring rye, which he described briefly. The botanist Arias y Costa (1816, vol. II, 48) barely mentioned autumn and spring rye. The agronomists Ortiz Cañavate (1895, 47) quickly dismissed the question by stating that 'many varieties are known', citing only Saint John, autumn, spring rye 'and others', without describing any of them.

The essential point here is to notice the low quality of these analyses. Other cereals have better catalogues of varieties in these or similar books. However, in the case of rye varieties, authors only noted a single name and no description. Something closer to a curiosity than to a rigorous study. Finally, some of the cited types are foreign, as an exoticism. The lack of information turns them into a mere erudition exercise, as foreign and local varieties often appear together, cited at the same classification level. Considering the unsubstantial treatment of these classifications, if not their dubious quality, it is clear that the traditionally secondary position of rye regarding other cereals hurt the attention paid to it by scholars.

The same was true for the quality and depth of the analytical knowledge that these authors transmitted about this plant in their texts. Exceptions are scarce, as trials with Iberian rye before the 20th century are very unusual. For the Spanish case, a literature review showed only two experiments carried out under the auspices of the Royal Botanical Garden, published in 1806–07. A local variety from Tahal (Almería, SE of Spain), called Filabrese rye, played a central role in these experiments (Clemente Rubio, 1806; Boutelou, 1807). In these same texts, the authors criticised as 'inconceivable negligence', 'shame' or 'scandal' the existing backwardness in the knowledge of the varieties of agricultural species 'which form the basis of our subsistence', citing rye among them.

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All the studies included in this section laid the foundations and formed part of the subsequent development of the empirical Iberian botanical and agricultural knowledge that contributed to the progress of sciences and study fields such as biology, agronomy, plant breeding, and engineering. Although international knowledge networks have emerged in more recent times – as we will see in the next section – it is clear that Iberian authors paid attention to previous studies of the territory in which they worked. Furthermore, early 20th-century scientists also shared the cultural preferences of the social groups to which they belonged. Thus, we can draw a line of interpretation from these botanical and agronomic writings and authors to the work of agronomists in the early 20th century, among whom an evident lack of interest in studying Iberian rye persisted. In Portugal, it was clear that this interest should focus on wheat, which was more highly valued and consumed, as evidenced by the arguments of the Wheat campaign (*Campanha do trigo*) promoted by the State, especially during the 1930s (Saraiva, 2010; Faísca and Freire, 2025).

In summary, there were two ways of valuing rye. One, a proper rural culture, has left almost no documentary trace. Farmers cultivated rye not only because it provided food for themselves and their animals. In areas of the Iberian Peninsula with adverse climate conditions, this cereal also provided materials for construction, handicrafts, tools, and even a supplementary income. From this viewpoint, the value of the cereal was positive. However, peasants also preferred wheat in terms of food, reflecting another social trend that belonged to elite preferences and established the primacy of wheat over rye, as well as the association of the latter with poverty. From elitist views, the trend was disseminated through written sources, persisted for several centuries, and laid the foundation for future studies that appeared well into the 20th century. Those elite's visions probably had little influence on farming practices among peasants, who sowed rye in areas where wheat would not grow due to the lack of better alternatives. However, analysing the views of literate elites on rye in the long term makes it possible to understand how these conditioned the scientific study of the plant and why knowledge about the rye crop developed scarcely. The scholars, botanists, and engineers who studied rye in each era adopted the convictions of the social elite to which they belonged. When agronomic and genetic research on Iberian rye took off, it did so from these weak foundations, which gave rise to some initial peculiarities, as shown in the following section.

The development of Iberian rye breeding in the 20th century

At the beginning of the 20th century, considering what has been mentioned in the previous section, with such a scarce Iberian tradition in the study of rye, the problem regarding its knowledge was as evident as it was alarming. In the middle of the century, the issue still persisted. In Portugal, the aforementioned engineer Vasconcellos criticised the lack of any descriptive catalogue for rye in 1940. He pointed out that only a handful of varieties were recognised – common, winter, little, and spring rye – 'and not much else'. These varieties are once again cited without description. Also, he drew attention to the necessity of studying and improving landraces to assess their cultural and industrial value (Vasconcellos, 1940, 22; 1933, 1). However, although the task seemed obvious, the issue described by Vasconcellos for rye does not seem to differ widely from the classifications drawn up in the previous century. In fact, wheat was the focus of the first decades of genetic experiments carried out in Portugal, especially at the Plant Improvement Station (*Estação de Melhoramento de Plantas*) created in Elvas – in the South – in 1942, but also at the National Agronomic Station (*Estação Agronómica Nacional*), established in the Lisbon area in 1936 (Borges et al., 1986, VII-4–5).

In Spain, the study of rye did not improve even several years later. The reference book on Spanish rye provides only a morphological exploration of the plant, i.e., a study of its anatomy – roots, leaves, and other tissues – at a microscopic level. However, the classification of Iberian rye in this work is nonexistent, despite the authors' emphasis on the need for suitable varieties and

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in-depth knowledge about national rye characteristics to improve cultivation (Aguado Marín and Martínez Vázquez, 1959, 7). This absence contrasts with other works on wheat and maize from the same period (Sánchez-Monge, 1957; 1962), which studied national landraces in depth.

Thus, when Iberian scientific research took its first steps, agronomists had to look towards other countries. The development of international scientific networks promoted this exchange (Fernández Prieto et al., 2024). In those territories, rye played a central role in nutrition, had a better valuation, and consequently concentrated higher plant breeding efforts. In other words, agronomic research for improving Iberian rye must have had an exogenous basis, with genetic material coming especially from northern European countries and the United States. In particular, Germany emerged as a supplier of varieties of great agronomic interest from the second half of the 19th century onwards. A series of pioneering producers gained prominence. They were private entrepreneurs operating their farms according to principles of rationalisation from their agricultural training, who displayed political commitment and had strong influence in their social context. Their farms, at first mere experimental scenarios, became authentic seed production centres. Drawing on their scientific training, they even contributed to establishing a technical corpus that helped them solve some problems at a time when genetic studies still offered little guidance (Wieland, 2006, 313–15, 325–26; Harwood, 2012, 36). In rye experimentation, two names stand out. On the one hand, Wilhelm Rimpau pioneered the method of mass selection of landraces. He began his work in 1867, and his efforts to obtain the Schlanstedter variety helped him to establish some basic knowledge about cross-pollination (Wieland, 2006, 31–19). On the other hand, Ferdinand von Lochow obtained the highly successful and internationally renowned Petkus rye,[6] a variety commercially available since the last decade of the 19th century. By the middle of the 20th century, it was already the origin of other valuable breeds (Aguado Marín, 1957, 11).

Understanding these processes in northern Europe makes it easier to appreciate what happened immediately afterwards on the Iberian Peninsula. Here, the first scientific approaches to rye in the 20th century were scarce, timid, and not necessarily successful. Experiments developed in prominent northern Iberian institutions, such as the Agricultural-Experimental Farm of Coruña (*Granja Agrícola Experimental de A Coruña*) or the Galician Biological Mission (*Misión Biológica de Galicia*), allow for an approximation. In the first of these centres, despite the importance of rye in the region, the work carried out cannot even fit into the field of plant breeding. These experiments focused only on analysing a disease that affected cereals in the region in the early 1920s, locally known as 'foot rot'. However, the misunderstanding of the agrarian reality reflected by some of the Agricultural-Experimental Farm directors at the time – even recommending the elimination of rye and its replacement with oats – has been highlighted as a factor that may explain the decisions taken and the absence of more realistic approaches (Fernández Prieto, 1988, 64–7).

The case of the Galician Biological Mission in the 1930s was a more successful example. A study of unpublished documentation has revealed that in 1929, the centre performed a trial with five German winter and spring varieties, which presented severe difficulties.[7] In the case of the winter rye, the complications stemmed from the lack of adaptation to the significant climatic difference compared to their Central European origin. The spring varieties suffered the attack of cereal rust, a parasitic fungus. A few years later, other reports documented further trials with six German winter varieties in 1933–34 (Junta para Ampliación de Estudios, 1935, 381; Cabo Villaverde, 1997, 121). The experiment outcome was mediocre because of similar causes as in the previous trial: insignificant yields, lower than those of local rye, caused by a higher incidence of pests in the German varieties. During the work developed in these years (Figure 1 shows a picture of the plots), all German rye varieties were discarded, with only one exception. The German rye that prevailed was the famous Petkus, probably known first-hand by the director of the Mission, Cruz Gallástegui, during a visit to its town of origin as part of his attendance at the 5th Berlin Genetics Congress in 1927.

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Figure 1. Rye cultivation trials at the Galician Biological Mission (March 1935). Galician Biological Mission Archives, CSIC.

The aim was to perform a mass cross between Petkus and a local rye variety, naturally resistant to indigenous fungi and suited to the regional climate. Starting with the 1929 experiments, and while other varieties were being tested, the way towards this goal progressed considerably in just a couple of years. The date Gallástegui noted for the hybrid obtention was 1933. He described the resulting variety as far superior to the country's rye. Its properties included higher yield and earlier maturity compared to both parent varieties. This second characteristic made it particularly valuable, as it allowed earlier sowing of late maize – in lowland and coastal areas – and turnips – in mountain areas. Furthermore, the higher productivity remained for the following three harvests, although it was advisable to revitalise the seed annually by a crossing process.

However, despite the documentation underlining the need to continue the work, rye disappeared from the mission's activity reports in the following years. Among the possible reasons for the lack of development of this work, the consulted documents point directly to the complex situation in Germany in the subsequent years, which eliminated the possibility of importing the rye needed for the crosses. It is difficult to say when the production of this hybrid seed stopped. A 1941 complaint by the Provincial Tax Office of Pontevedra against the Mission provides significant data.[8] The Tax Office complained about overpriced sales of rye seed during the previous year. A report written by Gallástegui stated that this high price was a deterrent mechanism to prevent non-farmers from using rye seeds for consumption rather than for sowing. Once the measure had the desired effect, farmers received a refund of the extra cost. In addition, the report indicates that the amount of seed distributed in 1940, the only production data available for this hybrid, amounted to 1204 kg. Although the report indicated that this rye was in great demand throughout the Galician region, the truth is that half a tonne was reserved only for farmers in the parish of Salcedo, where the Biological Mission remains today. Moreover, the figure is small compared to the up to 70,000 kg of double hybrid maize seed distributed from this centre in the years prior to the 1936 coup d'état in Spain (Esperante et al., 2020, 58). Even if the figure for rye seed production dates from after the Spanish Civil War (1936–39) and this comparison may be problematic, the scarce references to rye in the mission's activities would confirm that its importance at the centre was significantly lower than that of maize.

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During the next two decades, the status of rye experimentation at the mission remained unknown, as there were no further references to it in the activity reports. When reports on rye reappear sporadically in the sixties, seventies, and eighties, it is in the context of several trials to check the incidence of various pests and to measure yields under different fertiliser conditions. The first trials of this period involved a new variety produced at the Aula Dei Experimental Station (*Estación Experimental Aula Dei*–EEAD–), analysed below.

It was precisely the EEAD, from its creation in the mid-1940s, where research on rye reached its peak development in Spain.[9] This centre launched an improvement programme for rye in a sustained way over time, although this work was not as important as the research developed with other species – such as wheat, maize, oats, vetch, some fruit trees, and, especially, barley and sugar beet. In 1952, an institutional reorganisation led to the creation of a plant breeding department – which was in charge of research with rye – directed by Enrique Sánchez-Monge. This scientist, present at the EEAD between 1948 and 1957 (Fonfría and Calvo, 2016, 539), eventually became one of the most brilliant Spanish professionals in this field. His achievements surpassed rye itself and addressed the field of triticale, the hybrid species between rye and wheat.

The EEAD is the place of origin of the first Spanish rye tetraploid variety,[10] known as *Gigantón* – Gigantic. From the point of view of its productive use, it is necessary to stress that this type of rye surpassed the natural diploid varieties in grain size and flour quality for bread production, although not necessarily in terms of yield (Aguado Marín, 1957, 12). As indicated in the station's activity reports, *Gigantón* was obtained in 1956 from samples of Spanish rye sourced from places as diverse as Teruel, Huesca, Granada, Santander, and Albacete. Its characteristics consisted of a considerable ear size, which gave it its name, high resistance to lodging and frost, vigorous germination, good floral fertility, and a higher protein content than other common varieties (Aula Dei Experimental Station, 1978, 42). In addition to the natural strengths of rye, the agronomic advantages of the *Gigantón* variety included its considerable height – upwards of two and a half metres – which prevented the growth of weeds, and its ability to develop in chalky soils. The variety was essentially for fodder (Moro Serrano, 1988), which means that these qualities were not enough for it to prevail in bread production.

From then on, an agricultural organisation – Agrar S.A. – multiplied and commercialised the new rye. To this end, EEAD first reproduced elite seeds in small quantities to preserve the main variety. Then, through a second multiplication process, the centre obtained the so-called 'original seed' and delivered it to Agrar. An analysis of the quantities reveals a significant fluctuation in the production of rye seed, with a temporary drop in the second half of the 1960s – from almost 2500 kg of original seed sent to Agrar in 1965 to around 1000 kg in 1967–68 and only 400 kg in 1969 – and a recovery in the following decade – from around 40–70 kg of elite seed in the second half of the 1960s to quantities of 100–300 kg a decade later. On the whole, data on certified seed produced for marketing are much scarcer in the station's reports, as the agricultural organisation was responsible for the process. However, the 1967 document records the seed examination work conducted by the station's technicians. The sowing totals at the time amounted to 16 Tm of rye, 25 Tm of oats and 350 Tm of barley, showing the significance of each cereal in the centre's activity (Aula Dei Experimental Station, 1965, 16–17; 1967, 10–11; 1968, 41–42; 1969, 13–14; 1974, 16; 1975, 14; 1977, 22).

At the end of the 1970s, a new internal restructuring changed the centre's working interests (Aula Dei Experimental Station, 1978, 3). The reorientation to other priority species marked a progressive decline of *Gigantón* at the Aula Dei, gradually disappearing from the following activity reports. Technicians noted that the centre does not conserve the variety (Lacadena, 2010, 16), although the moment of its abandonment is difficult to pinpoint. Some researchers suggest that the use of this rye ceased at the station in the mid-1990s (Fonfría and Calvo, 2016, 543).

Regarding triticale, the hybrid of rye and wheat, the Aula Dei is also a pioneering centre in Spain. This plant was the first large-scale attempt to create a new plant species with agronomic value for humankind (Gustafson, 1976, 108), and its history is very recent. Although the first

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experiments and records date back to the 1870s–80s in Scotland and the USA, these attempts were unsuccessful, as the outcome was the usual after crossing different species: a sterile offspring. In 1888–91, the already mentioned Wilhelm Rimpau obtained the first described fertile specimen (Müntzing, 1974; Sánchez-Monge, 1974; Gustafson, 1976). However, it was in 1937 when the scientist Arne Müntzing finally solved the infertility barrier, making it possible to produce unlimited new triticales thanks to the application of colchicine. In Müntzing's own words, this breakthrough ended the archaic period of growing triticale. With a significant boost during the Second World War, worldwide interest in its production exploded in the 1950s following various symposia on both sides of the Atlantic. Extensive progress led to the commercialisation of new varieties in the following decade (Müntzing, 1974, 13, 19–22; Wrigley y Bushuk, 2010, 116; Sánchez-Monge, 1974, 32; 1995, 160).

The starting point of this triticale research in the EEAD was Sánchez-Monge's stay at the Svalöv seed station in 1946 and his subsequent contacts with the Institute of Genetics at the University of Lund, where Müntzing worked. Back in Spain, the aim was to create a new cereal to replace meslin and rye on plots with poor soils while combining the latter's hardiness with wheat's baking quality[11] (Aula Dei Experimental Station, 1953, 8; Sánchez-Monge, 1974, 32). The experiments were conducted in the period 1950–55 and concluded with the breeding of a single attractive triticale for agricultural use, the result of crossing Andújar dwarf, a Spanish durum wheat, with the renowned Petkus rye. It was a plant resistant to cold and lodging, with a thick, rigid cane and a long ear. However, it had a very coarse grain, a problem addressed in the following years when Sánchez-Monge had already left the Aula Dei for the National Institute of Agronomic Research (Sánchez-Monge, 1956; 1969). Following continuous progress, twenty years after the initial theoretical approaches, the first *Cachirulo*, the name given to the variety, was commercialised in 1968 (Lacadena, 2010, 16). Overall, the objective of finding a cereal with wheat bread-making qualities and the resistance of rye remained unfulfilled. *Cachirulo* had a high protein content but a low flour production, so the aim was to convert it into a feed grain, with new experiments conducted at the National Institute with good results. However, years later, Sánchez-Monge criticised the interruption of these research lines due to a lack of funding for long-term trial programmes (Sánchez-Monge, 1969, 798–99; 1995, 160–62).

The advances in the field of rye in the EEAD are evident, whether in its natural form or its hybrid with wheat, triticale. However, it is also necessary to consider the origins of the experimentation materials in this centre and others across the Iberian Peninsula. Although these organisations studied and included national varieties in breeding programmes, there is no doubt that the basis of the *Cachirulo* triticale was Petkus rye, also present in the hybrid studied in the Biological Mission of Galicia. Across the border, the National Plant Breeding Station in Elvas also carried out experiments with this rye from Germany. Here, a Portuguese plant breeding programme included experimentation with triticale for the first time in the late 1930s, resulting in the breeding of a hybrid between the wheat variety Ardito and Petkus rye (Maças, 2004, 135).

Beyond the influence of the German variety, the EEAD's annual activity reports show a significant tendency to use a few American rye families. The regular collaborations with the US Department of Agriculture in the 1960s led to the prevalent use of certain rye varieties – such as Gator – which appeared in trials with triticale in all the crosses carried out at this institution for several crop years (Aula Dei Experimental Station, 1964, 16; 1965, 17; 1967, 82). Finally, since the 1970s, cultivars from the International Maize and Wheat Improvement Centre (CIMMYT) have played a significant role in developing new varieties in both Iberian states (Bagulho et al., 1996, 635; Royo et al., 2004, 141).

The availability of genetic material from a limited number of varieties is a global phenomenon that has caused a serious problem of narrowing the genetic diversity of crops and has been a growing concern in the scientific community for over a century (Chapman and Heald, 2019). Certain varieties take priority for their high yields, earliness, or resistance. The systematic exploitation of hybrid rye production, which did not start until 1970 – the first commercial

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cultivars appeared only in the mid-1980s (Hackauf et al., 2022, 3) – worsened the problem. Two German genetic pools – Carsten and then again Petkus – showed the best performance, putting them at the basis of experimentation, where they remain firmly anchored. The current practice of growing rye based on modern, high-yield varieties containing only a few families of genetic material poses a threat to local diversity – e.g., through the loss of space or cross-contamination between varieties. Also, the progressive abandonment of agriculture and rural exodus is cornering the increasingly scarce producers who cultivate local varieties and remain as the last strongholds of conservation outside laboratories. These issues require quick and decisive action when it comes to characterising and evaluating landraces for scientific use (Monteiro et al., 2016, 2).

Conclusions

Although the scientific worry over biodiversity loss barely altered the basic status regarding rye experimentation, it led to a conservation effort and the gathering of a wide range of genetic material. As the problem affected many commercial crops, the concern about this erosion of genetic variability led to initiatives to ensure the conservation of plant genetic resources – such as establishing germplasm banks – developed in Spain and Portugal since the 1970s (Rosa and Martín, 2016, 53; Rocha, 2018). In the specific case of rye, in the northwest, there were also more recent significant initiatives, already in the 1990s, focusing on winter cereals (Urquijo Zamora, 2018, 35–7). However, in the transition to the 21st century, the lack of characterisation and evaluation of the accessions collected became a limiting factor for recognising their value for breeding purposes (Bettencourt and Carnide, 1998). Some of these collections of local material revealed that the scarce rye maintained by farmers still has a considerable genetic variety, damaged by the notable abandonment of agricultural activity (Lopes, 2015, 8–11).

Plant breeding science recognised the usefulness of conserving landraces because these dynamic populations – whose historical origins had given them a distinctive identity – were genetically diverse, locally adapted, and well-integrated into traditional farming systems, although lacking formal breeding (Camacho Villa et al., 2005). In this adaptation, defined by artificial selection by farmers and by natural selection according to the characteristics of the environment, lies an unexplored potential and its primary value. However, this scientific concern and conservative effort do not cause a transformation of the social appreciation of a crop. Instead, the change appears in the valuation of the resources this plant provides to biological research when confronting a scientific problem. In the case of rye, its position as a relegated cereal and the pre-eminence of other species over it had developed for centuries due to multiple causes at different historical moments. Compared to wheat, rye was part of the dietary preferences of the lower social classes. As for maize, the success of this American grain rested on higher yields than other cereals, relative ease of cultivation, considerable oil and starch content with many industrial uses, and palatability for consumption by many animal species (Salvador Chico, 1964, 5; Eckhoff and Paulsen, 1996, 77).

However, there is no doubt that social valuation is also essential in favouring these institutional efforts. Nowadays, although the sustainable recovery of any crop or its local varieties is only possible when there is an economic outcome, attempts to valorise them – such as protected designations of origin, among other formulas for seeking market spaces – are equally necessary as a vital part of the conservation process (Mallor Giménez et al., 2014, 39). In other words, in the fate of a crop, it is also decisive to redirect the existing social perception towards a more favourable one. In the case of rye, this powerful force determined the configuration of social food identities but also contributed to the development of studies of lower quality than those involving other, more highly esteemed cereals. When rye research took off in the 20th century, it did so quite timidly due to the lack of an analytical basis derived from the lack of interest in previous centuries. Paradoxically, this appreciation is the factor that can contribute to changing – through community, scientific and academic initiatives – the situation of a cereal that has very suitable environmental characteristics for the Iberian Peninsula.

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Notes

1 We can frame this process within the broader context of the creation of agricultural innovation structures in European states in the final decades of the 19th century and the early decades of the 20th century (Fernández Prieto et al., 2024, 157–58).

2 Two organisations receive further in-depth analysis. First, the Galician Biological Mission operates in the main Iberian rye-growing area from a historical point of view, in the northwest. In the mid-20th century, the largest Spanish area dedicated to this cereal still coincided with the provinces of Lugo, Ourense, León, Zamora, and Salamanca (Aguado Marín, 1957). The northern and northeastern territories of Portugal bordering them – the districts of Bragança, Vila Real, Guarda, Castelo Branco, Porto, Braga, Viana do Castelo, and Viseu – complete this area (Girão, 1941). The second centre studied is the Aula Dei Experimental Station, located on the eastern edge of the Spanish rye-growing area formed in recent decades. According to data from the Spanish Ministry of Agriculture (2022) for 2021, although provinces such as Zamora and León are still important, they have been overtaken by Palencia or Soria. For decades, rye and triticale have been important lines of research at the centre.

3 The books analysed here include mainly botanical and agrarian manuals, but also economic essays. Although they belong to different genres, all these books offer useful agricultural knowledge. Thus, we can refer to these books as agrarian instruction books.

4 Braga District Archive. Monastery of Santa Ana de Viana do Castelo [1549/1896], Book of income and expenditure [1753/1755] 56, p. 71.

5 The fungus Claviceps purpurea mainly affects rye, among other grains, and has multiple popular names. Its medical applications stand out in obstetrics, with a centuries-old use in folk medicine. The harmful consumption of contaminated rye flour has been well known since ancient times as a cause of ergotism epidemics (Illana Esteban, 2008). However, the discovery of several alkaloids in ergot composition from the mid-19th century onwards made it a coveted product, given its scarce production areas. Thus, contemporary pharmaceutical use mirrored what traditional rural wisdom had been exploiting for centuries, starting with obstetric service. These factors turned ergot into a strategic commodity during the autarkic period of Francoism, as shown by the usual regulations published in the provincial legislative bulletins and the press. Moreover, one of the main focuses of the chemical-pharmaceutical industry developed from natural substances of plant origin since the 1940s in Spain was the production of active ingredients from ergot (Rodríguez Nozal, 2017).

6 Petkus rye won first prize in the variety tests of the German Agricultural Society from 1891 to 1914, and estimations indicate that it occupied 75% of the area planted with rye in Germany by 1930 (Harwood, 2012, 37). To obtain it, the breeder planted each selected seed separately and recorded the characteristics of each individual used or produced in the breeding process. Since the breeder only selected individuals with the desired characteristics, the method efficiently led to a relatively homogeneous variety. The success led to the process becoming known as the German selection method, although von Lochow was not the first to implement it. However, two aspects of the procedure received some criticism. On the one hand, the descriptions emphasised successes over failures, which blurred the actual work. On the other hand, the method lacked a theoretical basis because it consisted of pure trial and error. Thus, it was not legitimised so much by a scientific concept as by the commercial success of the new cereal varieties obtained. This way, the method and the variety gained wide acceptance in the inter-war period (Wieland, 2006, 322–25).

7 Galician Biological Mission Archive, Report 'For data requested by the High General Staff', ref. B-11.

8 Galician Biological Mission Archive, Invest folder, correspondence 116.

9 Established by the CSIC (Spanish National Research Council – *Consejo Superior de Investigaciones Científicas*) on 20 January 1944 in Zaragoza as the Cogullada Experimental Biology Station, the change to the current name occurred in 1948. Like the Galician Biological Mission, it depended on the Alonso de Herrera Board, responsible for developing agricultural, forestry, and livestock research.

10 Tetraploid rye is larger than natural varieties and is obtained by manipulating chromosomes with a substance called colchicine (Moro Serrano, 1988).

11 This theoretical concept of combining the flour production capacity of wheat with the resistance of rye confirms that, as in the cases of Iberian farmers in previous centuries and Gigantón, scientists once again valued the agronomic benefits of rye over its culinary ones.

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