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Safeguarding, evaluating and valorizing fruit tree genetic resources in Belgium: Insights from nearly half a century of unsprayed orchard management

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Abstract: In response to the rapid genetic erosion threatening Belgium's fruit tree cultivar heritage, the Walloon Agricultural Research Centre (CRA-W, Gembloux, Belgium) initiated nationwide prospection campaigns in 1975 with support from citizens. These campaigns aimed to collect and conserve the country's highly diverse fruit tree genetic resources (FTGR), including historically significant amateur-bred and landrace cultivars, for future breeding efforts.

Since then, the CRA-W has maintained a diverse collection – primarily apples (1,629 accessions) and pears (1,198 accessions), but also cherries (355 accessions), plums (236 accessions), grapes (98 accessions), and peaches (29 accessions) – in *ex situ* unsprayed repository and experimental evaluation orchards.

This approach makes it possible to assess these cultivars for multiple traits related to their tolerance and adaptability to biotic and abiotic stresses. This long-term evaluation method enables the identification of numerous quantitative traits and their impact on robustness and stress tolerance. Moreover, CRA-W has actively sought ways to promote the sustainable use of FTGR through partnerships with public institutions, private stakeholders and citizens. One key initiative was the gradual establishment of a nursery network governed by a participatory fruit tree quality charter, coupled with a traceability system for high-quality propagation material.

This initiative led to the release of 33 well-performing heritage cultivars, notable for their sufficient robustness and disease tolerance, for use in both amateur and professional orchards. A decade later, a dedicated apple pre-breeding and breeding programme was launched to harness the extensive FTGR collection as a source of quantitative disease tolerance, robustness and quality traits.

Keywords: *Malus* x *domestica*, *Pyrus communis*, disease tolerance, robustness, untreated organic evaluation orchard, participatory breeding, collaborative breeding, low-input organic farming

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The origins of the fruit tree genetic resources collections at Gembloux

The establishment of the fruit tree genetic resources collection and its evaluation was initiated in 1975 (Populer, 1975) at the State Plant Pathology Station of the former Agricultural Research Centre of Gembloux (CRA, Gembloux, Belgium) under the leadership of plant pathologist Charles Populer.

Populer's initiative (Populer, 1979) stemmed from the observation that most cultivated apple (*Malus* × *domestica* Borkh.) and pear (*Pyrus communis* L.) trees offered by nurseries to both amateur and professional growers were highly susceptible to diseases such as scab (*Venturia inaequalis* on apples and *Venturia pirina* on pears). Additionally, the genetic diversity of these cultivars was quite limited, and most breeding programmes at the time focused on introducing monogenic resistance genes to improve apple tree resistance to apple scab.

It therefore seemed wise to begin collecting cultivars adapted to local climatic conditions that had been cultivated before the advent of modern fungicides (pre-World War II) and before the widespread use of Bordeaux mixture (late 19^{th} century).

During the same period (between 1975 and 1980), several independent initiatives emerged across Western Europe, aiming to collect the remaining old fruit tree varieties, particularly apple trees. In 1975, Corbaz and Stoll began surveys in Switzerland (Corbaz, 1983). In France, similar projects started in 1979, including Leterme's work at the Landes Regional Park (Leterme, 1983), and in 1982, Stievenard (1999) initiated a programme to conserve and develop local and heirloom fruit varieties in northern France at Villeneuve d'Ascq. In the Netherlands, Blommers (1983) and in Spain, Dapena (1996), also organized surveys in 1974 and 1987, respectively.

At the Walloon Agricultural Research Centre (CRA-W), the first intensive survey period occurred between 1975 and 1985. Initially, efforts focused on visiting historical horticultural formal collections (1975–1980), where materials were collected based on criteria outlined in Table 1. Ten Belgian collections – five in the Flemish Region, four in the Walloon Region and one in the Brussels-Capital Region – were surveyed, resulting in the collection of 620 pear and 580 apple accessions. Thirty-four accessions were recovered from foreign national collections (England, Brogdale Farm, Kent, and France, INRAE, Angers), and 160 were collected from private citizens. This effort unexpectedly led to many historical collection managers dismantling their collections, arguing they were safeguarded at Gembloux.

The programme's next phase was significantly boosted by widespread public interest, driven by media coverage in the press, radio and television highlighting efforts to preserve fruit tree heritage (Populer *et al*, 1998). Between 1980 and 1987, over 2,000 individuals contacted the institute, reporting hundreds of endangered old fruit trees in gardens and orchard meadows and requesting assistance in preserving them. In response, intensive prospection campaigns were organized across the Walloon Region. During this period, numerous landraces and previously unknown apple, pear, plum, cherry and peach varieties were collected. By 1987, the collection had grown to 2,181 accessions.

Each collecting mission involved engaging with tree owners to learn about the varieties' qualities, traits and uses, and to gather valuable ethnobotanical knowledge.

Post-1987, the collection continued to expand through collaborations with institutions such as the *Proefstation voor de Fruitteelt* (Wilhelminadorp, The Netherlands), the *Centre Régional de Ressources Génétiques de Villeneuve d'Ascq* (France), the *Station d'Amélioration des Espèces Fruitières et Ornementales* (INRAE, Angers, France), the Long Ashton Research Station (University of Bristol, Great Britain), the University of Illinois (USA), the Institute of Experimental Botany (Prague, Czech Republic), and the Research and Breeding Institute of Pomology (Holovousy, Czech Republic), reaching 2,526 accessions by 1997. About one-third of these accessions came from partner collections, while two-thirds were sourced from the countryside with citizens' assistance.

This extraordinary public engagement attracted the attention of the European Cooperative Programme for Plant Genetic Resources (ECPGR) and was presented at its Second Steering Committee Meeting in Oeiras (Portugal) in 1984 titled: 'Mobilization of Public Opinion (Including Practical Involvement of the Public) in the Preservation of Fruit Tree Genetic Resources' (ECPGR, 1984).

Regarding the selection of plant material (budwood) of cultivars to be introduced in a fruit tree collection (genebank), curators must prioritize based on objectives and available resources. Table 1 outlines the main criteria used for introducing varieties into the Walloon Agricultural Research Centre (CRA-W) collection.

Currently, collecting activities have slowed and are primarily driven by public requests for pomological consultations. Each year, dozens of fruit identification requests are received through a standardized template that includes contact information, sampling location and details on tree characteristics, fruit traits, uses and history. Annually, 300 to 900 fruit samples (mainly apple and pear) are submitted, though only a few are selected for inclusion in the collection. Depending on selection outcomes and consultation context (e.g. local survey for developing a regional repository orchard), budwood may be requested for propagation to be introduced into the collection or planted in local repository orchards. Upon receiving budwood, labels and passport data are

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Table 1. Criteria for selecting varieties introduced into the fruit genetic resources collection of CRA-W (Populer, 1980; Lateur and Populer, 1996)

Accessions collected from historical horticultural formal collections (1975-80)	Accessions collected with the help of the public from private gardens and orchards (ongoing process)
Varieties of Belgian origin	Named varieties, of local origin and with a local history and use
Varieties from neighbouring countries with similar climates to Belgium.	Varieties, even unnamed, that perform well against the main pests and diseases and/or abiotic stresses, which express good robustness.
Varieties dating back to before fungicide use (before 1850).	Varieties that significantly enhance existing diversity (hardiness, quality, storage ability, etc.).
Varieties noted in literature for good disease resistance/tolerance.	
Varieties at risk of extinction and absent from other ECPGR collections.	

recorded, initiating a traceability process from storage and propagation to nursery monitoring, inventory, and eventual tree lifting and planting.

A key principle of this programme has been to offer donors a young tree after successful propagation. This win-win approach acknowledges contributors by providing one or two young trees of the conserved variety and supports pragmatic on-site conservation by replanting original varieties in their native locations.

Definitions and categories of ‘Old Fruit Varieties’

The main hypothesis of the CRA-W Biodiversity and Plant & Forest Breeding Research Unit is that cultivars selected and propagated before the widespread use of fungicides underwent stronger selection pressures, leading to natural selection of more robust varieties that could thrive even without phytopharmaceutical treatments. This makes them more likely to exhibit greater tolerance to fungal diseases. Similarly, cultivars selected and released prior to the significant shifts in agricultural practices following World War I and World War II – and before the extensive use of mineral fertilizers – are presumed to be more resilient and better suited for low-input organic agriculture.

To support this hypothesis, we propose a classification system for pome fruit cultivars based on the period when they were first documented (Figure 1):

- Cultivars mentioned before 1760 are categorized as ‘ancient’
- Cultivars mentioned between 1761 and 1850 are classified as ‘very old’
- Cultivars first mentioned between 1851 and 1914 are designated as ‘old’
- Cultivars mentioned between 1915 and 1945 are labelled as ‘pre-modern’
- Cultivars mentioned after 1945 are categorized as ‘modern’.

This classification framework helps to contextualize the historical development and adaptive traits of apple and pear cultivars across different agricultural eras.

Defining the concept of landraces for fruit trees

The concept of landraces, introduced by von Rümker (von Rümker, 1908), originally referred to locally grown cultivars that were not consciously selected. Camacho-Villa *et al* (2005) further defined this concept highlighting the evolution of a genetically diverse and dynamic population. However, this definition primarily applies to seed-propagated crops. Negri *et al* (2009) expanded the definition of landraces for seed-propagated crops as follows: “A landrace of a seed-propagated crop can be defined as a variable population, which is identifiable and usually has a local name. It lacks “formal” crop improvement, is characterized by a specific adaptation to the environmental conditions of the area of cultivation (tolerant to the biotic and abiotic stresses of that area) and is closely associated with the traditional uses, knowledge, habits, dialects, and celebrations of the people who developed and continue to grow it”. However, perennial plants like fruit trees are predominantly propagated vegetatively, resulting in clonal populations (e.g. groups of trees that all have the same genome because they have been vegetatively propagated e.g. by grafting). Therefore, the concept of landraces must be adapted and redefined for these specific crops.

Historically, farmers propagated pome fruit from open-pollinated seedlings collected in their surroundings. Through mass selection, some of these seedlings (known as ‘chance seedlings’) occasionally gave rise to new landraces. The most promising ones were propagated vegetatively within limited areas. The less interesting ones were used as rootstocks and grafted with landraces to make high-stem trees for orchard meadows. The landrace cultivars propagated by rural communities were usually well-adapted to local needs, uses and environmental conditions, including biotic and abiotic stresses.

Charles Populer (Lateur, 2001) provided a more nuanced definition using pear trees as an example. According to those authors, pear landraces differ from amateur-bred cultivars in several key aspects (Table 2). These criteria are instrumental in distinguishing the

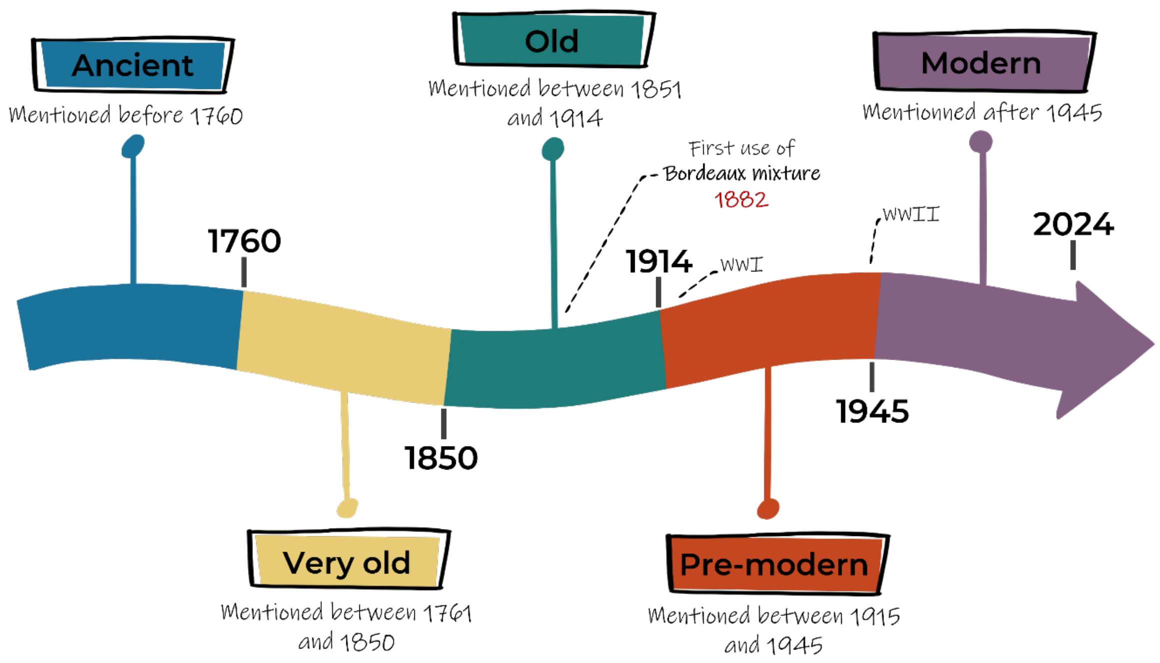

Figure 1. Classification of pome fruit (apple and pear) cultivars based on the period of their first documented mention. WWI, World War I; WWII, World War II

historical origin of pear cultivars within our collection (landraces or amateur-bred cultivars).

Nevertheless, since synonyms for cultivar names, mislabelling of material and errors are frequent in fruit tree genebanks (Oger and Lateur, 2004), it is essential to remain proactive in determining which material is true-to-type by cross-checking information, i.e. historical descriptions, accession evaluations and characterization data, expert knowledge and finally, genotypic data (e.g. molecular markers such as microsatellites and single-nucleotide polymorphisms).

Once materials have been carefully selected and ethnobotanical information has been gathered, a series of stages and activities follow over time, involving the active collaboration of multiple stakeholders. These steps and activities are illustrated in Figure 2 and are described in detail below.

Vegetative fruit accession propagation: an experimental organic nursery

After encountering challenges with local nurseries tasked with propagating our initial collected accessions, we established our own experimental nurseries in 1980. Currently, the area dedicated to fruit tree propagation covers approximately 1.5ha per year. Virus-free rootstocks are ordered from specialized professional nurseries. A decade ago, our nurseries transitioned to management under organic farming system regulations (EU, 2018), and for the past six years, they have been officially certified for organic production.

Each accession is grafted onto dwarfing or semi-dwarfing rootstocks. For apple trees, we primarily use 'M9' rootstocks, and more recently, the 'GENEVA® G11'. Due to frequent incompatibility or partial incompatibility between many pear accessions – particularly landraces – and quince (*Cydonia oblonga* Mill.) rootstocks, we traditionally used 'Quince A' grafted with a 'Beurré Hardy' used as 'interstock' before grafting the desired accession. To simplify propagation procedures, over the past ten years, we have progressively transitioned to using the 'Pyrodwarf' pear rootstock. This semi-dwarfing rootstock (about 20% more vigorous than 'Quince A') has a relatively short juvenile phase and, most importantly, is compatible with all pear varieties.

For European plum and cherry trees, we use the semi-vigorous rootstocks 'St. Julien A' and 'Gisela-5', respectively. Recently, the 'Rubira' rootstock has shown promising results in propagating our peach accessions. Nearly all grape accessions of our collection are propagated directly from cuttings.

To ensure proper conservation and evaluation of the accessions in our collections, we aim for a minimum of two trees per accession in the *ex situ* repository orchard and one in the evaluation orchard. Therefore, we routinely plan to graft at least five rootstocks per accession in order to get at least three trees per accession.

Organization of Belgian fruit tree genetic resources conservation

Repository orchards used as *ex situ* collections

Our first repository orchards were established during the 1978–1979 period, primarily focusing on apple

Table 2. Criteria that differentiate the historical origins of very old pear cultivars in two main classes: 'landrace' and 'amateur-bred', also known as 'Bourgeois' cultivars (Lateur, 2001).

	Landrace cultivars	**Amateur-bred or 'Bourgeois' cultivars**
1	No acquisition date	Date of the acquisition is very often known
2	Name of the breeder and location are usually unknown.	The name of the breeder is very often referenced. Breeders were often belonging to higher social classes (aristocracy, bourgeoisie, artisans, clergy – never female breeders).
3	'Chance seedlings'. Discovered by anonymous peasants, propagated by rural non-profit users.	Often from deliberate crosses, clonal seedlings or named (re-named) 'chance seedlings', propagated and released by historical well-known professional nurseries
4	Often distributed regionally or locally.	Distribution of the variety in larger areas, often international
5	Rural/dialectic cultivar name (cvs. 'Poire de Gros', 'Poire de Malades, 'Pwèr di Fièr', etc.)	The name of the cultivar usually refers to the breeder and their entourage, historical figures, or the fruit itself, often using a high lexical style ('Souvenir de la Reine des Belges', 'Hélène Grégoire', 'Napoléon Savinien', 'Nec Plus Meuris').
6	Almost never described in pomological historical literature nor in catalogues, Information sharing nearly always linked with oral transmission.	Well described in the literature. Can be found in old historical nursery catalogues. Often found abroad in many collections.
7	Fruits mostly selected for their long storage abilities or in order to enlarge the period of fruit consumption (from extremely early to extremely late).	Fruits usually selected for their taste or attractive visual appeal.
8	Mainly 'survival' uses, coarse texture and/or astringent used as cooked and or processed fruit for local products (e.g. 'Sirop de Liège' or oven-baked pear).	Mainly dessert fruit, buttery and smelting flesh.
9	Usually show better tolerance to pests and diseases and better robustness.	Not particularly selected for their robustness traits.
10	Grafted on seedling vigorous rootstocks and grown traditionally on high-standard trees in orchard meadows.	Grafted and grown on dwarfing rootstocks such as quince (very often as espaliers, counter-espalier).
11	Often graft incompatibility symptoms when grafted on quince.	Exceptionally rare graft incompatibilities on quince.

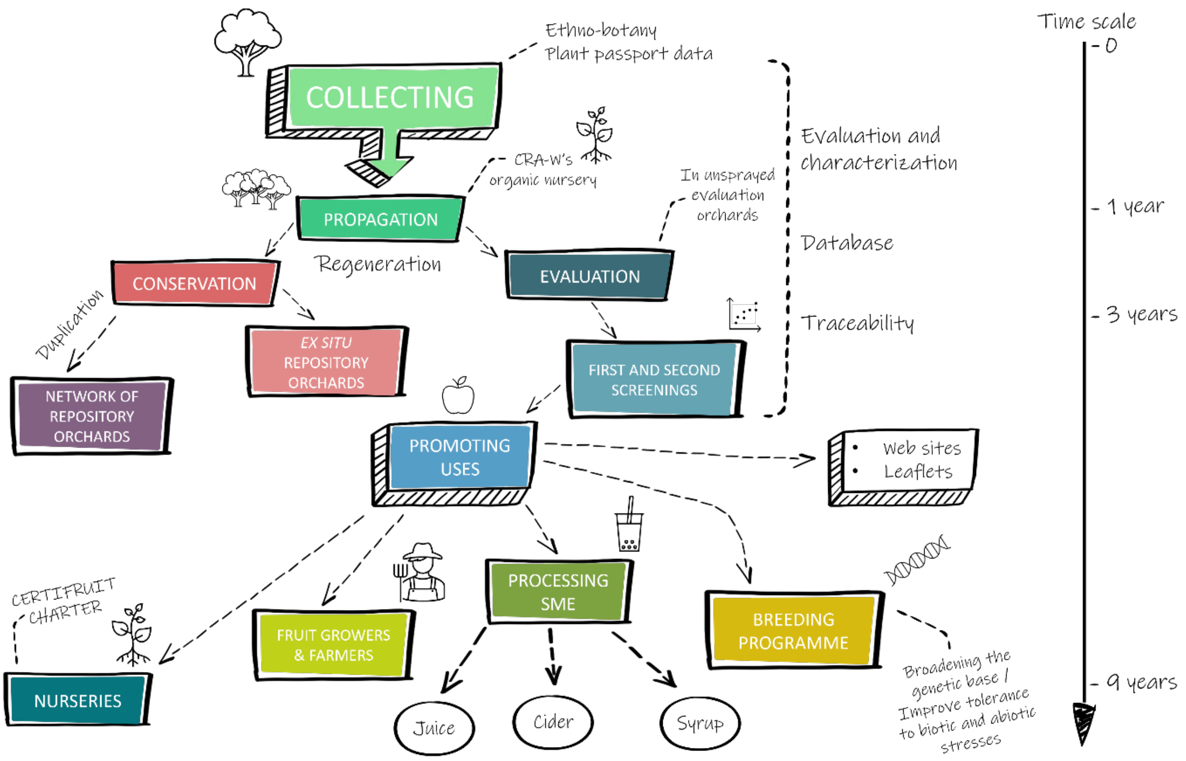

Figure 2. General overview of the steps and activities at the CRA-W research programme aimed at safeguarding and promoting the sustainable use of biodiversity in old fruit varieties.

and pear accessions. Due to limited land availability, a high-density planting system was employed, with 0.5m spacing between vertical cordons and 2.5m between rows, resulting in a density of 8,000 trees per hectare. Each accession was grafted on two trees planted side by side. Separate blocks were designated for apple and pear collections, planted adjacent to one another. These orchards were monitored but never sprayed against pests and diseases. To manage weeds, as dwarfing rootstocks were used, herbicides were periodically applied very locally in a narrow strip between grass and trunks at the base of the trees; however, we completely stopped using herbicides in 2000.

The repository orchard for plum accessions was established with a lower-density planting system of 6m × 5m, with one tree per accession.

Thirty-five years later, the need to regenerate trees planted at such high densities prompted the development of a second generation of *ex situ* repository orchards. This new design aimed to reduce the risk of losses in unsprayed conditions and to accommodate mechanical weed control.

Key improvements in the second-generation repository orchards included:

1. Separate locations for apple and pear collections: apple and pear repository orchards were planted in different locations to minimize the risk of disease epidemics, such as fire blight (*Erwinia amylovora*), which often spreads from pear to apple.
2. Dividing apple collections: the apple collection was split into two blocks located 1.5km apart, with a minimum of two copies but with one copy tree per accession planted in two different blocks, reducing the risk of total loss.
3. Increased spacing: spacing between trees and rows was increased to 1m × 3.5m for both apple and pear orchards. This adjustment reduced the risk of pest and disease spread, improved light penetration and ventilation, and allowed for better adaptation to mechanical weed control machinery.
4. Integrated hedgerows for pear orchards: in the new pear repository orchard, additional improvements included the introduction of multi-species hedgerows (excluding members of the Rosaceae family) planted every seven rows of pear trees. These hedgerows act as natural wind barriers, reduce disease dispersal, and serve as banker plants by attracting beneficial insects and fauna. They provide alternative nectar and pollen sources as well as reproductive habitats.

This innovative approach ensures the safe conservation and sustainable management of Belgian fruit tree genetic resources while promoting ecological balance and minimizing chemical inputs.

The *in horto* pear collection

During the early 1990s, outbreaks of fire blight (*Erwinia amylovora*) – one of the most devastating diseases affecting pear and apple trees – posed a significant threat in Belgium. Concerned about the potential loss of the pear collection, the most valuable cultivars were grafted onto ‘Quince A’ rootstock and preserved in containers within an insect-proof greenhouse. Remarkably, this pear collection has been maintained *in horto* as bonsai for over 30 years (Figure 3).

On-farm safe duplication orchard network

Since 1999, through collaboration with numerous partners, CRA-W established the ‘Walloon Repository Orchards Network’ (WRON) (Villette *et al*, 2003). This initiative aimed to enhance the safe conservation of heritage diversity by dispersing it throughout the region. The network partners include farmers, local authorities, nature parks, regional administrations, associations, schools, universities and private owners dedicated to conserving and promoting local fruit tree heritage.

The primary objectives of this network are to:

1. Actively involve local stakeholders in safeguarding, conserving and developing their fruit tree heritage
2. Coordinate the duplication of rare endangered local varieties identified in their areas of origin, as well as the true-to-type landraces from the *ex situ* CRA-W collection in Gembloux
3. Reintroduce true-to-type old local varieties into their sub-regions of origin by increasing the number of genetic conservation sites.

The spirit of this multi-partner conservatory orchard network is to reintroduce and duplicate the great diversity of true-to-type old varieties collected at CRA-W, particularly the rarest and most threatened varieties, back to their places of origin. This approach counters decades of fruit tree diversity erosion while fostering a participatory dynamic in conserving fruit tree heritage. The involvement of local partners in the conservation orchards is vital for success, relying on integrating new local surveys of existing old orchards and trees, and maintaining a network of local partners to manage the primary conservation actions.

We coordinate a collaborative and interactive network that enables enthusiasts of old fruit tree varieties to develop synergies and revive this fruit tree heritage. The network aims to coordinate actions, share expertise and develop strategies to enhance the value and uses of this diversity. Expanding the range of species and varieties is crucial for expressing the best adaptive traits to climate change and countering biodiversity loss. Bellon *et al* (2015) explored this concept and conducted an insightful study on the benefits and challenges of on-farm conservation.

Since 2019, a significant portion of on-farm repository orchards and their trees have been geo-referenced and monitored for health. Technical support is provided to orchard owners to ensure the long-term viability of the trees. In the latest update (2024), WRON includes 93 orchards covering 154ha for a total of 8,000 stan-

Figure 3. View of the *in horto* pear cultivars repository collection.

dard fruit trees representing approximately 3,000 accessions. According to our 2023 inventory, apple trees constitute 63% of the total, pears 21%, cherries 6%, plums 8%, and other species (peach, quince, walnuts, etc.) 2%. Our ongoing goals are to continue planting new on-farm repository orchards, provide stakeholders with appropriate support, and involve local organizations in the inventory, conservation, utilization and public awareness efforts to maintain this heritage.

Current status of our *ex situ* fruit tree genetic resources collections

CRA-W *ex situ* field collections currently comprise 1,629 cultivated apple tree accessions, alongside 172 indigenous *Malus sylvestris* (L.) Miller unique genotypes forming a Belgian 'core collection' (Keulemans *et al*, 2007; Jacques *et al*, 2009). The collections include also 1,198 cultivated pear tree accessions and 203 wild *Pyrus pyraster* Burgst. indigenous unique genotypes. Additionally, we maintain 317 sweet cherry (*Prunus avium* (L.)), 38 sour cherry (*Prunus cerasus* (L.)), and 107 botanical/ornamental cherry tree (*Prunus* spp.) accessions. Other species in the collections include 236 European plum tree (*Prunus domestica* (L.)) accessions, 98 table grape (*Vitis* spp.) accessions, 29 peach (*Prunus persica* (L.) Batsch) accessions, and six local walnut (*Juglans regia* (L.)) tree accessions (Table 3). Based on our latest data update, Table 3 gives also a preliminary estimation of unique accessions and landraces per fruit species.

Management of unsprayed evaluation and repository orchards

For each accession, one tree is planted in one of our evaluation orchards. The spacing is 2m × 4m for apple and pear, while plum trees are spaced 5m × 6m and trained as half-stem. Additionally, two trees of each accession are systematically planted at distinct sites within our conservatory orchards (1m × 3.5m). Similar conservation strategies are defined by other institutions, such as the German Fruit Genebank (GFG) (Höfer *et al*, 2019; Reed *et al*, 2004) and the USDA-ARS-NPGS apple field collection managed by the Plant Genetic Resources Unit in Geneva, NY (Bramel and Volk, 2019; Volk *et al*, 2015). However, we do not employ alternative preservation methods such as *in vitro* or cryopreservation but – at least for pome fruits – we plan to implement the concept of storing dried open-pollinated seeds from diploid pome fruit accessions at low temperatures as a complementary safety conservation tool.

Table 3. Summary of the number of accessions and cultivars per crop/species currently preserved in the CRA-W *ex situ* collections. [1], Total number of entries present in the collection; [2],Estimated number of different cultivars/genotypes among the accessions. As several accessions can be synonyms of the same cultivars or different origins of the same cultivars, we have fewer cultivars than accessions; [3], Estimated number of cultivars that are classified as landraces among all the accessions; [4], Total number of cultivars (all species combined) and percentage of accessions that represent different cultivars; [5], Total number of landraces (all species combined) and percentage of cultivars that are classified as landraces.

Crops	Species	No. of accessions[1]	Estimated no. of cultivars/genotypes[2]	Estimated no. of landraces[3]
Apple	*Malus* × *domestica* Borkh.	1,629	1,061	295
Wild apple	*Malus sylvestris* (L.) Miller	172	172	-
Pear	*Pyrus communis* L.	1,198	730	121
Wild pear	*Pyrus pyraster* Burgst.	203	203	-
Sweet cherry	*Prunus avium* L.	317	270	76
Sour cherry	*Prunus cerasus* L.	38	28	5
Botanical and ornamental cherry	Botanical & ornamental *Prunus* spp.	107	107	-
European plum	*Prunus domestica* L.	236	135	77
Peach	*Prunus persica* (L.) Batsch	29	29	8
Grapes	*Vitis* spp.	98	89	-
Walnuts	*Juglans regia* L.	6	6	6
TOTAL		**4,033**	**2,830 (70.2 %)**[4]	**588 (20.8%)**[5]

The total land area dedicated to fruit tree genetic resources (FTGR) research and management spans approximately 20ha across seven sites, all located within a 7km perimeter. Figure 4 depicts the principal apple, pear, grape and plum evaluation orchards situated near the main building. These orchards are managed in natural conditions without irrigation systems or crop protection measures such as hail netting.

Our philosophy emphasizes evaluating cultivars under the conditions they are expected to thrive in, particularly low-input, organic and regenerative agricultural systems. For this reason, our orchards, though certified for organic production, have never received plant protection treatments. In rare and exceptional cases, where pest damage threatens tree survival, we employ control methods that comply with organic production guidelines.

To create a favourable micro-climate, protect trees from strong winds and enhance biodiversity, the orchards are surrounded by highly diverse hedges. The inter-rows are grassed, featuring a central flower strip, and include additional ecological enhancements such as nest boxes, bat boxes and insect boxes.

Since 2013, the oldest apple and pear evaluation orchard (established in 1978–79 and grafted on 'M9' and 'Quince A' rootstocks, respectively) has been grazed by Shropshire sheep at a density of four to five females per hectare (Figure 5). This practice has proven effective in fostering synergies between livestock and fruit trees. Sheep trample and compact vole galleries, fertilize the orchard, graze on grasses which also helps birds of prey to hunt voles, and manage weeds that compete with trees. They also consume fallen diseased leaves and fruits, while benefiting from abundant food, natural shelter from sun and wind, and a secure environment. Consequently, the approach has been extended to a plum evaluation orchard (grafted onto 'St Julien A' rootstock) and a 30-year-old apple repository orchard (grafted onto 'M9' rootstock).

Evaluation and characterization process of genetic resources fruit tree accessions

The continuous adaptation of agriculture to ensure food security, through improvements in disease and pest resistance, tolerance to biotic and abiotic stresses induced by climate change, and other agronomic traits, relies directly on the genetic diversity of our genetic resources. These traits can only be effectively utilized if properly identified through evaluation activities. As Stalker and Chapman (1989) aptly noted: "A collection is of virtually no practical use until it has been properly evaluated and the data organised so that the content of the material collected can be known. Otherwise, it could be compared to a library whose books are neither sorted nor catalogued".

Evaluation data is therefore the most critical component, as it determines how and which parts of the collections can be utilized and improved. For this reason, our primary focus has always been on evaluation activities, with characterization being of secondary importance. Table 4 delineates the differences between evaluation and characterization activities.

Given the significant size of genetic resource collections and the low probability of finding desirable traits in a single genotype, the evaluation process is typically conducted in stages. These stages are outlined in Table 5. This structured approach is essential for broadening the selection base across numerous accessions.

An important aspect of this process involves performing a preliminary evaluation before collecting a new

Figure 4. View of part of the evaluation orchards (apple, pear, grapes and plum) near the main building at the CRA-W (Gembloux, Belgium). (Courtesy of Emilie Mulot, 2024).

Figure 5. View of the oldest plum evaluation orchard (established in 1983–87) grafted on 'St-Julien A' (left) and apple and pear evaluation orchard grafted on 'M9' and 'Quince A' respectively. Both orchards are grazed by Shropshire sheep. Photo: CRA-W (Gembloux, Belgium).

accession. This initial step allows for an informed selection based on priorities established by the collection manager. This general evaluation process also applies to assessing quantitative disease resistance traits, ensuring that the traits prioritized for future breeding programmes are thoroughly identified and understood.

Experimental growing conditions

Since the inception of the Plant Pathology Station, the evaluation of tolerance to pathogens and pests has been the primary research focus. From the outset, both our evaluation orchards and our nursery have been managed according to organic farming practices. However, our approach goes far beyond standard organic requirements i.e. we never use fungicides, and the application of organic insecticides is exceptionally rare. This unique approach serves two critical objectives:

1. Accurate evaluation of cultivar robustness: for an important part of the accessions we have more than 25 years of collected evaluation data which allows for a reliable and/or non-parametric assessment of each cultivar's resilience in the absence of phytosanitary plant protection.
2. Preservation of pathogenic and beneficial diversity: Maintaining a diverse population of both pathogens and beneficial organisms in our long-term non-sprayed evaluation orchards ensures that new breeding cultivars are tested under high and varied selection pressures, providing a robust evaluation of their adaptability to biotic stresses prior to release (Lateur *et al*, 2000).

Table 4. Description of evaluation and characterization activities applied to plant genetic resources collections (Lateur, 2001).

	Characterization	Evaluation
Definition	Description of the most stable traits with respect to interaction with the environment	Study of traits for which the degree of expression is influenced by environmental factors.
Main objective	Distinguish and identify genotypes	Improve knowledge of the potential of the accessions
Traits	Mostly qualitative	Mostly quantitative
Time required	Relatively short for trait stability validation	Relatively long to be able to define the extent of variability of traits depending on the interaction with the environment
Experimental protocols	Relatively simple, based on standardized descriptors	Experimental conditions need to be well defined and, for a given collection, should initially be relatively stable
Descriptors	Yes - Qualitative Nominal variable scales or binary categories	Yes - Quantitative Often ordinal variable scales – need of reference cultivars.
Examples	Specific descriptive fruit traits (fruit shape, presence of ribs, fruit crowning at apex, aperture of eye, length of stalk etc.)	Agronomic features, disease, pest or abiotic stress tolerance/resistance, flowering period etc.

Descriptors used

Aligned with ECPGR goals, considerable effort has been dedicated to developing harmonized and standardized protocols for evaluating and characterizing plant genetic resources. These efforts have been especially collaborative within the ECPGR *Prunus* and *Malus/Pyrus* Working Groups, leading to the creation of comprehensive descriptor lists (Lateur and Populer, 1996; Lateur *et al*, 1999; Lateur, 1999a; Lateur *et al*, 2002; Lateur, 2010; Kellerhals *et al*, 2012). Most recently, this work culminated in the updated ECPGR Characterization and Evaluation Descriptors for *Malus* and *Pyrus* Genetic Resources (Lateur *et al*, 2022a,b)

Apple and pear accessions are systematically evaluated for a wide range of traits, including fruit and tree characteristics, agronomic performance, fruit quality attributes and tolerance to biotic and abiotic stresses. A notable recent development is the introduction of a global foliage quality descriptor. This integrated trait provides an overall assessment of tree health and tolerance to various stresses by combining multiple individual indicators.

In the context of the European InnOBreed project, new descriptors are being developed to enhance the characterization and evaluation of fruit tree genetic resources' tolerance to abiotic stresses associated with climate change (drought tolerance, sunburn and flower frost tolerance).

Direct valorization of best-performing cultivars through public–private partnerships

A vital strategy for increasing public awareness of FTGR is to allow the public to visit the evaluation orchards. The orchards serve as open spaces where the public, professionals and policymakers can periodically visit to taste fruits, discover heirloom varieties and learn about their historical significance.

Although the programme initially focused on safeguarding FTGR and utilizing them as breeding material, several cultivars naturally exhibited desirable traits suit-

Table 5. General stages in the evaluation process of genetic resource collections (Dotlacil *et al*, 1994; Horvath and Szabo, 1997)

	Stages	Description, objectives (O) and responsibilities (R)
A	Preliminary evaluation	(O) Simple evaluation carried out before collecting the material in order to avoid accessions that are (1) virus-infected and/or (2) not adapted to the soil and climate conditions, (3) duplicates and (4) accessions that are too susceptible to pests and diseases or to abiotic stresses under *in situ* conditions. (R) Fruit tree genetic resources managers.
B	Basic primary evaluation	(O) The first evaluation is carried out during a strict minimum of a 5-year period under experimental harmonized conditions and using standardized protocols, but the experimental setup is simple because it must be applied to a large number of accessions. (O) Initial screening of accessions to highlight the most interesting material (best performing for the traits of interest). (R) Fruit tree genetic resources managers and/or interested potential users.
C	Secondary and specific evaluation	(O) More accurate experimental design involving a sufficient number of replicates; multi-location trials; in the case of disease resistance, possible use of well-characterized pathogenic strains and artificial inoculation techniques. (O) A more detailed evaluation of the material that was pre-selected during the basic evaluation. (R) Potential users such as breeders and multidisciplinary teams.

able for direct propagation. These cultivars were propagated by a network of small family-run nurseries and offered to amateur gardeners and farmers for cultivation in unsprayed high-stem orchard meadows.

Since 1985, CRA-W has actively promoted these outstanding old varieties, recognizing their excellent balance of disease tolerance, agronomic performance and unique qualities suitable for cultivation without plant protection products. This initiative led to the creation of a new range of varieties and a production chain through partnerships with Belgian nurseries. These 33 exceptional heirloom varieties have been reintroduced to the market under the collective name 'RGF-Gblx Varieties', an abbreviation for *Ressources Génétiques Fruitières de Gembloux*. These are typically endangered, original varieties that align with the growing public interest in heritage and sustainable fruit cultivation.

The varieties progressively released under the 'RGF-Gblx' label are primarily old, forgotten or neglected local varieties, often landraces or selections from former amateur breeders that had disappeared from the market. These varieties, once common in the Belgian countryside, were rediscovered through survey campaigns and subsequently evaluated for a minimum of ten years in untreated orchards. This evaluation focused on their tolerance to diseases, pests and climatic stresses, their agronomic characteristics, quality and uses, and their adaptability to different rootstocks and regions.

These varieties also stand out for their originality compared to the classic commercial range, offering a rich diversity of taste profiles, forgotten aromas and various uses – both for fresh consumption and processing. They feature staggered ripening periods, easy tree management, and a strong level of robustness, meaning a better overall ability to adapt to various stresses and efficient nitrogen use.

More recently, new varieties resulting from the CRA-W breeding programme have been introduced. At least one parent of these new cultivars is an old local variety known for its polygenic resistance to scab and robustness traits. These selections must demonstrate long-lasting and sufficient tolerance to major diseases, mainly scab-robust agronomic traits suited for amateur cultivation and untreated high-stem orchards, original qualities and diverse uses, and solid adaptation to different rootstocks and regions, all evaluated over a minimum 10-year period in untreated orchards.

Currently, the range of old fruit varieties released to nurseries under the 'RGF-Gblx' label includes 18 apple varieties, 7 pear varieties, 4 European plum varieties, 3 cherry varieties, and 1 peach variety (Figure 6). Some of these are described in Figure 7.

The successful valorization of our FTGR is mainly due to the establishment of organized distribution channels through public-private partnerships. To support this, we outsourced the distribution of budwood and the associated phytosanitary monitoring activities to the

Figure 6. Promotional poster for the CERTIFRUIT 'RGF-Gblx' cultivars available on CERTIFRUIT nurseries and resellers.

Ormeignies nuclear stock managed by the regional *Centre d'Essais Horticole de Wallonie* (CEHW).

The CERTIFRUIT quality charter and the associated nursery network

To ensure better traceability and guarantee the true-to-type identity of varieties for customers, the CERTIFRUIT quality charter and label (Figure 8) were developed for the 'RGF-Gblx' old varieties of merit. This initiative was created through a participatory approach in collaboration with a group of volunteer nurserymen.

The CERTIFRUIT charter (available at www.certifruit.be) certifies:

1. A carefully selected assortment of more robust and disease-tolerant varieties
2. The guaranteed origin and identity of the propagation material, including cultivar, rootstock and any inter-stem
3. The superior quality of the nursery trees
4. Local and artisanal production methods.

Additionally, the CERTIFRUIT nursery network ensures high-quality advice and expertise from certified nurserymen. In 1991, a CEHW nuclear stock (3.3ha) was established – initiated by nurserymen and the CEHW,

‘Cwastresse Double’ (‘Calville des Vergers’, ‘Triomphe du Luxembourg’) [RGF-Gblx]: Medium to large, ribbed apple with reddish-orange stripes. Ripe in late September, stores until December. Very crisp, juicy, sweet for one month, then turns mealy. Moderately susceptible to scab, low susceptibility to powdery mildew, and moderately susceptible to European Canker on ‘M9’, but more resistant on vigorous rootstocks. *Flowering period:* Mid-season flowering; poor pollinator. *Origin*: Traditional Walloon high-stem variety.

‘Coxybelle’ [RGF-Gblx-COV/PBR]**:** Recent CRA-W release. Medium to large, elongated, truncated cone-shaped fruit with smooth, pinkish-red streaked skin. Excellent dessert apple – sweet, crisp, juicy and highly aromatic. Ripens late September to early October; stores until December. Very low susceptibility to scab and powdery mildew; moderate susceptibility to European Canker. Vigorous, hardy and very healthy tree, suitable for all forms but ideal for bush forms (‘M9’, ‘MM106’, ‘MM111’). *Flowering period:* Mid-season; good pollinator. *Origin*: CRA-W cross between ‘Président Van Dievoet’[RGF-Gblx] and ‘Rubinola.’ Released in 2023, exclusively via CERTIFRUIT nurseries

‘Gris Braibant’ [RGF-Gblx]: Medium-sized apple with dark green skin and a small dark red blush on the sunny side; heavily russeted. Harvested in late October, stores well until May. ‘Reinette’-type flesh, best when wrinkled. Dessert apple but with a slightly bitter flavour. Fertile tree, adaptable to all forms, especially on axis. Low susceptibility to scab, moderate susceptibility to powdery mildew and European Canker. *Flowering period:* Mid-season; poor pollinator. *Origin*: Very old traditional Belgian variety.

‘Président H. Van Dievoet’ (‘Cabarette’) [RGF-Gblx - CRRG]**:** Medium-sized green fruit turning yellow with a slight pink-orange blush. Very white, firm flesh with a sweet-acidic flavour. Winter variety with excellent shelf life, storing until May–June. Very productive with biennial bearing. Low susceptibility to powdery mildew; moderate susceptibility to scab and European Canker. *Flowering period:* Mid-season; good pollinator. *Origin*: Bred in Poperinge in 1878; widely grown in Belgium and Northern France. Distributed by CRRG as ‘Cabarette’.

‘Radoux’ [RGF-Gblx]: Medium-sized, bright red apple, usable from October to December. Very fertile with a tendency for biennial bearing. Sweet-tart white flesh, very crunchy and juicy, though not highly aromatic; stays crunchy until late November, then turns mealy. Tree has an upright, then weeping habit, well-suited for single-axis training, especially in high-standard forms. Slight to moderate susceptibility to scab; moderate susceptibility to powdery mildew and European Canker, varying by location. *Flowering period:* Mid-season; good pollinator. *Origin*: Historic variety from the Liège region (Belgium).

‘Reinette Charles Populer’ [RGF-Gblx-COV/PBR]**:** The latest CRA-W release (2025–26). Medium-sized, globe to flattened bicoloured ‘Reinette’-type dessert apple. Very firm, yellowish flesh; juicy, tangy-sweet, becoming sweeter in storage without turning mealy; light aroma. Ripens mid-October, keeps well until May–June. Very low susceptibility to scab and powdery mildew; low to moderate susceptibility to European Canker. Vigorous, healthy, and robust tree, suitable for all forms. *Flowering period:* Medium to late; good pollinator. *Origin*: CRA-W cross between ‘Président Van Dievoet’[RGF-Gblx] and ‘Rubinola’. Exclusive to CERTIFRUIT nurseries. Named in honour of Charles Populer (CRA-W Honorary Director).

‘Reinette de Waleffe’ [RGF-Gblx]: High-quality dessert apple, good size, semi-smooth, intense orange-red bicolour. Very white, fine, firm flesh; not mealy, excellent sugar-acid balance, aromatic, and stores well through winter. Very fertile, early fruiting; ripe fruit drops easily. Low susceptibility to scab; medium to high susceptibility to secondary powdery mildew and European Canker. Unsuitable for cold, damp areas. *Flowering period:* Medium to late – Poor pollinator. *Origin*: Old variety from Vieux-Waleffe, Hesbaye Liégeoise.

‘Reinette Dubois’ [RGF-Gblx]**:** Late autumn dessert apple with smooth skin, bright red over green turning yellow. Very white, fine, firm flesh – never mealy – with a sweet-tart, excellent flavour. Stores well until April. Slow to fruit but becomes productive and regular, ideal for small gardens with good fruit set. Very low susceptibility to scab, low to moderate for powdery mildew, but quite susceptible to European Canker. *Flowering period*: Late to very late – good pollinator. *Origin*: Traditional Belgian peasant variety from the Herve region.

‘Reinette Hernaut’ [RGF-Gblx]: Large wine-red apple with a green-yellow background, smooth skin with occasional russeting. Stores from October to February with excellent shelf life. Very crisp, juicy, tart-sweet flesh – never mealy – and very refreshing; also ideal for pies. Easy to grow, adaptable to all shapes, quick to bear fruit with regular and abundant yields. Low susceptibility to scab and powdery mildew, moderate susceptibility to European Canker. *Flowering period:* Mid-season – Poor pollinator. *Origin*: Traditional variety from Pajotteland (Ruisbroeck).

‘Reinette Professeur Lecrenier’ [RGF-Gblx]**:** High-quality dessert apple, good-sized, flattened-globose shape with fine russeting and dark red skin. Ripens in late September and keeps until Christmas. Flesh is firm, fine, with a well-balanced sweet-tart flavour and pleasant aroma. Healthy, robust, moderately vigorous tree, best grown on rootstocks more vigorous than ‘M9’, though adaptable to all forms. Very low susceptibility to scab, quite susceptible to powdery mildew; European Canker susceptibility under evaluation. *Flowering period*: Very late (Group 7) – Poor pollinator, partially self-fertile. *Origin*: Red, russeted mutant of ‘Reinette de France,’ discovered in Wallonia around 1970.

‘Transparente de Lesdain’ [RGF-Gblx]**:** A new cultivar bred by CRA-W. Elongated, smooth fruit, yellow with orange-pink blush. Should be picked ripe around mid-September, stores for over a month. Crunchy, firm, sweet-tart flesh. Very fertile, easy to grow, with very low disease susceptibility (pending confirmation in colder, wetter regions such as the Ardennes). *Flowering period:* Mid-season – Good pollinator. *Origin*: Developed by CRA-W in 2011; likely an open-pollinated seedling of ‘Florina’ (‘Querina’), initially thought to be from ‘Obus Vivier’.

Figure 7. Short description of a selection of ‘RGF-Gblx’ apple varieties. CRRG, *Centre Régional de Ressources Génétiques des Hauts de France*

with funding from the Ministry of the Walloon Region – to distribute certified budwood to nurseries. Currently, about half of the 'RGF-Gblx' released cultivars are certified as 'virus tested', while the remaining cultivars are distributed under EU CAC regulations (EU, 2008, 2014).

Figure 8. The CERTIFRUIT logo

Promoting fruit tree heritage through the Diversifruits Association

One of the key objectives of CRA-W is to encourage the use of its extensive fruit tree collection gathered over the years. Among several initiatives, the Diversifruits Association (www.diversifruits.be) was established in 2018, driven by CRA-W and the *Fédération des Parcs Naturels de Wallonie*.

The association, managed by volunteers and supported by two publicly funded project managers, brings together around 150 members. Its mission is to unite the public and stakeholders in safeguarding and promoting this valuable fruit tree heritage. This is achieved through the planting of high-stem unsprayed orchard meadows and various agroforestry projects.

Diversifruits offers guidance in selecting the most suitable cultivars and support in orchard management. It is also involved in developing the economic sector related to both the direct sale of fruits and the production of processed goods (such as juice and cider) through its 'Wal4Fruits' project. Over the past decade, more than 500ha of orchard meadows have been planted by farmers with the association's support. Each year, Diversifruits organizes approximately 70 activities, including conferences, training sessions and awareness events for both the general public and professionals.

To further promote and distinguish locally grown fruits – such as apples, pears, plums, cherries, walnuts and chestnuts – produced through this extensive and organic farming model (Figure 9A), the association created the '*Vergers Vivants*' label. This certification guarantees that fruits are cultivated in non-sprayed orchard meadows. Officially recognized by the Walloon Region, the label also advocates for the fair remuneration of farmers.

These extensive orchards (Figure 9B, C, D) improve the ecosystemic services and provide fruits of superior quality.

Pre-breeding and breeding programme using fruit tree genetic resources

The breeding programme at CRA-W was initiated in 1988 with the primary objective of developing cultivars exhibiting polygenic resistance to apple scab (*Venturia inaequalis*) and other biotic stresses, aiming for commercial production. This programme leverages both ancient and modern cultivars, using extensive phenotypic data collected over the years on our FTGR to select parent plants for crossing. The chosen parents possess complementary traits that help mitigate each other's weaknesses (Lateur, 1999b).

The initial phase of seedling evaluation (Figure 10) focuses on assessing tolerance to apple scab. At the 3-4 leaf stage, seedlings are sprayed with a mix of *V. inaequalis* strains with a defined concentration of spores using a pulverization bench. After a controlled incubation period, the seedlings are rated for apple scab tolerance using a simplified scale based on the percentage of leaf surface affected by lesions. Our selection is not limited to fully resistant seedlings; those with up to 25% – and occasionally up to 50% – leaf damage are also retained for further evaluation.

Once transplanted to our nursery and evaluation orchard, these young trees undergo comprehensive assessments for various traits. This includes tolerance to apple scab, powdery mildew, European canker, anthracnose (*Elsinoë piri*), and apple rosy aphid. Elite cultivars that perform well are subsequently grafted and further evaluated for fruit production and quality traits.

This comprehensive, multi-stage selection process ensures the development of robust cultivars that combine resilience to biotic stresses with desirable agronomic and fruit quality traits, supporting sustainable and low-input fruit production systems.

Novafruits: a transborder participatory breeding programme

Since 2014, our breeding activities have primarily focused on participatory breeding within the framework of a public–private partnership. This programme involves two distinct growers' associations, with the Novafruits association serving as a transborder collaboration between partners from northern France and southern Belgium (Wallonia). Novafruits brings together 31 organic fruit tree growers, two regional public institutes – the *Espaces Naturels Régionaux* (ENRx) and CRRG – and CRA-W, along with both the GAWI and the *Chambre d'agriculture de Normandie* organic fruit extension services.

Through this partnership, elite cultivars selected by CRA-W and CRRG are planted by organic growers under professional cultivation conditions. Each year, Novafruits members convene to evaluate the traits of the fruits and corresponding cultivars. Since many growers sell their products directly to consumers, they gather and share public feedback on fruit quality and performance.

Figure 9. A, Fruit harvest of one conservatory orchard; B, High-stem orchard meadow at the harvesting period; C, Visit to a young high-stem orchard meadow; D, An old high-stem orchard meadow.

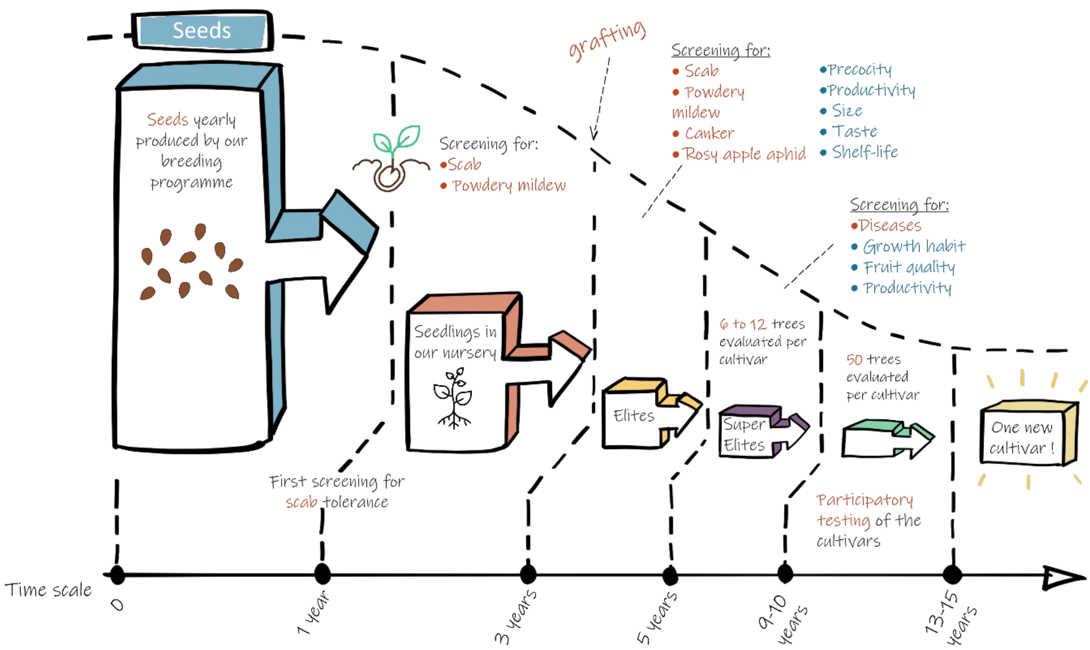

Figure 10. Illustration of the different steps of our breeding programme selection process.

Additionally, since 2012, CRA-W and CRRG have been officially linked by a collaboration agreement through which both institutes are: (1) developing shared database facilities, (2) pooling expertise in the identification of local fruit cultivars, (3) rationalizing and sharing responsibilities for cross-border fruit tree genetic resources, (4) mutualizing high-quality plant propagation material, (5) co-steering participatory apple and pear breeding activities (e.g. through the cross-border Novafruits association, including planning common breeding objectives and sharing breeding material and offspring), and finally (6) jointly managing two organic variety and elite testing experimental apple and pear orchards.

This collaborative approach has led to the release to cross-border organic fruit growers of several cultivars, the most recent being 'Ducasse' (OCVV/CPVO), a cross between 'Reinette Libotte' and 'Rubinola.'

Perspectives

The emergence of new pathogens, such as apple blotch disease (*Diplocarpon coronariae*) and anthracnose (*Elsinoë piri*), along with the increasing frequency of abiotic stresses like sunburn, prolonged drought, and to a lesser extent, partial lack of chilling requirement, have become evident through the monitoring of our collections. This situation compels us to develop new descriptors to better assess the individual tolerance of our cultivars to these emerging threats and to enhance parent selection in our organic breeding programme.

Another ambition of the CRA-W collection is to broaden the diversity of cultivars for certain species, including peaches and table grapes, and to introduce new fruit species such as persimmons and fig trees. These species may prove suitable for cultivation in Belgium, offering organic farmers both increased resilience to climatic variability and opportunities for income diversification.

We firmly believe that the success of robust organic fruit farming relies on a systems-based approach. This approach integrates the use and selection of more robust, more resilient and well-adapted cultivars such as recently described by Serrie *et al* (2024) with agricultural practices that promote biodiversity, soil health, and the regeneration of agroecosystems. Consequently, we are also exploring the impact of several practices – such as fruit hedges, grazed orchard meadows, agroforestry and successional agroforestry – alongside measures designed to enhance functional biodiversity on fruit production and crop health.

Managing and monitoring our collection is both time-consuming and complex. To address this, we are investing in digital tools that streamline data acquisition and analysis, making data collection more efficient. Additionally, we are adopting sequencing technologies to deepen our understanding of the genetics within our collections, thereby guiding our breeding strategies.

As emphasized in the ECPGR report dedicated to strengthening the 'AEGIS' European strategy (Engels *et al*, 2019), we believe that it is essential for collection managers to use a standardized and common tool for genotyping their germplasm, such as the set of apple 16 SSR markers (linked to the *Malus* UNiQue genotype codes, MUNQ) developed for apple (Muranty *et al*, 2020) and similarly on pear (Durel *et al*, 2023), or the recently proposed SNP-based MUNQ system based on a set of 96 SNPs (Muranty *et al*, 2024). These valuable tools help eliminate duplicates from collections, verify that accessions are true-to-type, and facilitate comparisons between collections at national and international levels. This enables the identification of common and unique accessions across collections, thereby supporting the development of a robust conservation strategy for the most valuable genotypes.

The challenges ahead for low-input organic farming and integrated fruit production are significant. Addressing these challenges will require strong collaboration and synergy between genetic resource collection curators and research institutes. To this end, we are actively working toward and advocating for the establishment of participatory organic breeding programmes, supported by European research initiatives such as InnOBreed (https://innobreed.eu/, grant agreement no. 101061028) and FRuitDiv (https://fruitdiv.eu/, grant agreement no. 101133964).

Conclusions

Low-input organic fruit production and integrated fruit production face numerous challenges: (1) the emergence or the increased impact of new pathogens on crops, (2) the rise of abiotic stresses linked to climate change, (3) evolving restrictions and standards requiring the development of innovative, environmentally friendly control techniques, and (4) the accelerating erosion of genetic diversity in cultivated plants.

In this context, the conservation and valorization of FTGR have become increasingly important. The collection and conservation efforts initiated nearly 50 years ago at CRA-W underscore the enduring importance of the preservation and valorization of plant genetic resources. It is essential to continue expanding their collection, not only by increasing the number of accessions but also by integrating new species that may demonstrate promising adaptation to changing environmental conditions. Additionally, there is a critical need to improve the characterization and evaluation of existing genetic resources, focusing on their tolerance to emerging biotic and abiotic stresses and deepening our genetic understanding of these resources.

This article presented our diverse approaches and experiences in managing and promoting the use of FTGR collections. A pivotal aspect of this work is the systematic, long-term evaluation of varieties under unsprayed conditions. This process identifies superior-performing cultivars with valuable traits such as enhanced disease tolerance and greater overall robustness – qualities that are increasingly vital in the face of climate change. Evaluation data are crucial for releasing robust old varieties directly for use through public–private partnerships, enabling their marketing to individuals and farmers via the Certifruit and Diversifruits associations. Moreover, these evaluations support the development of participatory breeding programmes, exemplified by the Novafruits association, which aim to introduce new fruit varieties with broader genetic diversity, improved robustness and better adaptation to low-input organic and integrated fruit production systems.

Our overarching goal is to sustain more durable production systems with fruit tree cultivars that exhibit greater resistance and adaptability. The conservation, deeper understanding and promotion of agrobiodiversity and fruit genetic resources depend on collaborative efforts among research institutes, farmers, small family-run nurseries, NGOs and the general public (Lateur, 2003). This work would not have been possible without the support and interest of the public. Therefore, it is crucial to return to citizens the best cultivars we have safeguarded, along with the new varieties developed from crosses using these valuable genetic resources.

Authors' contributions

Marc Lateur and Baptiste Dumont wrote this manuscript. The other authors contributed to the review of this manuscript.

Conflict of interest

The authors declare no conflict of interest.

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