LiveSeeding

Characterization of genetic resources publicly available

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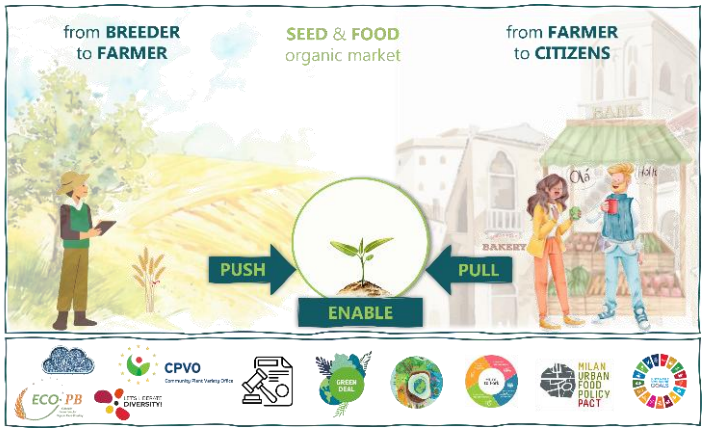
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LiveSeeding - Organic seed and plant breeding to accelerate sustainable and diverse food systems in Europe *is a 4-year Innovation Action funded by the European Union, the Swiss State Secretariat for Education, Research and Innovation (SERI) and UK Research and Innovation (UKRI). The project started in October 2022 and brings together 37 organisations operating in 16 European countries. LiveSeeding provides science-based evidence and best practice solutions to help achieve 100 % organic seed.*
LiveSeeding contributes to the transition towards environmentally-friendly, climate-neutral, healthy and fair food systems through a ***PUSH-PULL-ENABLE strategy*** *to*

- enhance the availability and adequacy of organic seeds of cultivars appropriate to organic farming (PUSH),
- increase and stabilise the market demand for organic seeds of cultivars appropriate to organic farming (PULL),
- foster an enabling policy and regulatory environment where both demand and supply can harmoniously and productively negotiate without irrelevant constraints due to legal restrictions and/or regulatory fragmentation (ENABLE).



LiveSeeding addresses the topics in a ***holistic multi-actor***, ***multi-stakeholder***, ***participatory approach*** *involving stakeholders along the value chain in 17 local* ***Living Labs*** *(LLs) and 3 established networks of organic breeders (****ECO-PB****), seed savers (****ECLLD****) and Milan Urban Food Policy Pact (****MUFPP****). 15 European countries cover the different pedoclimatic zones and socio-economic contexts, including countries with a low level of development in organic seed and breeding in East and South Europe.*

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List of abbreviations

PGR	Plant Genetic Resources
OHM	Organic Heterogenous Material
OV	Organic Variety
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
CBD	Convention on Biological Diversity
DOI	Digital Object Identifier
UPOV	International Union for the Protection of New Varieties of Plants
LL	Living Lab
AEGILOPS	DIKTYO GIA TIN VIOPOIKILOTITA KAI TIN OIKOLOGIA STI GEORGIA
RSR	Rete Semi Rurali
INRAE	INSTITUT NATIONAL DE RECHERCHE POUR L'AGRICULTURE, L'ALIMENTATION ET L'ENVIRONNEMENT
FiBL DE & CH	Research Institute of Organic Agriculture FiBL Germany and Switzerland
PSR	Pro Specie Rara
LSSV	Living Seeds Sementes Vivas SA
KIS	Kmetijski institut Slovenije / Agricultural Institute of Slovenia
NARDI	INSTITUTUL NATIONAL DE CERCETARE-DEZVOLTARE AGRICOLA FUNDULEA
IPC	Instituto Politécnico de Coimbra
UPV	UNIVERSITAT POLITECNICA DE VALENCIA

SUMMARY

*A key strategy for combining the conservation and use of genetic resources is **dynamic management**, which involves growing them in different environments and real cultivation settings beyond ex situ conservation, allowing for adaptation. The characterisation of plant genetic resources (PGR) in LiveSeeding was designed to generate publicly available phenotyping data relevant to organic, agroecology-oriented and low-input farming systems. To accomplish this, the project employed the dynamic management approach, combining on-station and on-farm trials, including participatory evaluation with farmers as well as value chain building around the tested materials within the Living Lab networks active in the project.*

The project generated relevant data to increase the use of landraces in sustainable agriculture, provided start material for organic breeding programmes and identified traits relevant to organic and low-input farming systems. The results contribute to the conservation and sustainable use of plant genetic resources, while also supporting innovation in breeding and farming practices. This report is structured into five chapters, with main target audiences of farmers, scientists and, community and public seed bank operators.

Chapter 1 includes the background, objectives of the work and scope of the deliverable.

Chapter 2 describes the Materials and Methods of Plant Genetic Resources dynamic management in LiveSeeding.

Chapter 3 presents the results of the activity providing access info for the data made available in SeedLinked and Zenodo, as well as for the dissemination-oriented PGR cards. In addition, for each of these three typologies of results delivery, examples are presented in depth.

Chapter 4 is dedicated to the discussion of PGR characterisation and data sharing impact, with focus on the role of these activities in defining diversified seed systems with a positive interaction between formal and informal seed systems.

In **Chapter 5** the main conclusions are summarized together with key take-home messages about the role of dynamic management of genetic resources in diversified seed systems.

The **main outcomes**[2] of this work are:

- >700 PGR accessions newly characterised
- 33 datasets published in Zenodo
- 34 trial records published on SeedLinked

[2] Some datasets are embargoed until they are published in scientific journals. Additional datasets will be published alongside related scientific publications. As some trials will only conclude at the end of the summer season in 2027, the full dataset will not be ready for publication by the time this report is published. More records in SeedLinked and PGR cards may be published.

- 21 dissemination flyers (PGR Description Cards) of highly relevant materials that proved of high interest for cultivation by organic and agro-ecology oriented farms in Europe.

1. OBJECTIVES OF THE WORK AND SCOPE OF THE REPORT

Plant genetic resources (PGR) are the foundation of sustainable food production, agricultural biodiversity, and adaptation to changing environmental conditions. Europe hosts a rich diversity of landraces, traditional varieties and ecotypes, which are highly valuable for organic and agroecology-oriented farming systems. These genetic resources harbour traits that enable resilience to abiotic stresses, pest resistance, and adaptation to marginal environments, while also contributing to nutritional and sensory quality.

Despite their importance, they remain poorly characterised. Existing data are often scattered and not publicly accessible, limiting their use. Furthermore, most characterisation efforts rely on centralized on-station trials, which do not fully capture the performance under real farming conditions or the preferences of end-users.

At the same time, European and international frameworks, including the **International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), "Seed Treaty", the Convention on Biological Diversity (CBD), "Biodiversity Convention", and the EU Biodiversity and Farm to Fork Strategies**, emphasize the need for sustainable management, conservation, and equitable use of PGR. **Open science** initiatives and FAIR data principles provide a framework to ensure that high-quality characterisation data are accessible and reusable, supporting both research and practical applications in agriculture.

Therefore, the **general objective** of the PGR characterisation task in LiveSeeding (T1.1) was to generate open access phenotyping data relevant to organic, low-input and agroecology-oriented farming systems. To accomplish this, the project employed an integrated on-station and on-farm trials approach, including participatory evaluation with farmers and other actors of the value chain. This characterisation effort aimed to accelerate the use of PGR (with focus on landraces) by farmers for cultivation and breeders (including farmer-breeders) for new cultivar development (Figure 1). This task, focusing on several nice crops, also aimed to revive traditional and regional crops and to promote the use of new and underutilized crops.



Figure 1: Greek pepper diversity from AEGILOPS' trials (Photo: Eleni Phaniadou)

The **specific objectives** were to: (i) evaluate morphological, agronomic, and quality traits; (ii) identify traits relevant to organic and low-input farming systems; (iii) support participatory and decentralized breeding approaches with suitable start material; and (iv) generate harmonized datasets in line with FAIR data principles for long-term use and reuse.

This activity was at the interface with other actions of the project (cross-WP synergies) namely:

- Data from PGR characterisation feed into breeding (T1.2), and is connected to cultivar testing (T2.3 and T2,4), and seed multiplication activities (WP3).
- Participatory trials with farmers and engagement of other actors of the value chain including citizens enhance the Living Lab approach and the integration of cultivated diversity in the market and in the society (WP6).
- The practical experimental cases were very useful as examples in several interactions with policy makers, especially in the context of including cultivated biodiversity topics in local food policies (WP4 and WP6).

This report aims to summarise the outcomes of the PGR characterisation activity, presenting the datasets and communication material produced. Given the high number of datasets produced the results are presented in depth for example cases only, while all data are available in the SeedLinked or Zenodo repositories.

2. MATERIALS AND METHODS

2.1 Target crops and PGR accessions

LiveSeeding PGR characterisation (T1.1, plus synergies with T1.2 and T2.3) focused on arable and vegetables crops) including cereal, oilseed, legume, different vegetable groups, forage, and even herb crops (Figure 2, Figure 3). The PGR comprised landraces, traditional varieties, breeding materials and selected commercial cultivars used as references (Table 1).

The PGR were sourced from gene banks, research institutions, community seed banks and farmers' own materials. Particular emphasis was placed on locally adapted landraces due to their potential contribution to resilience, quality, and adaptation to organic and low-input conditions.

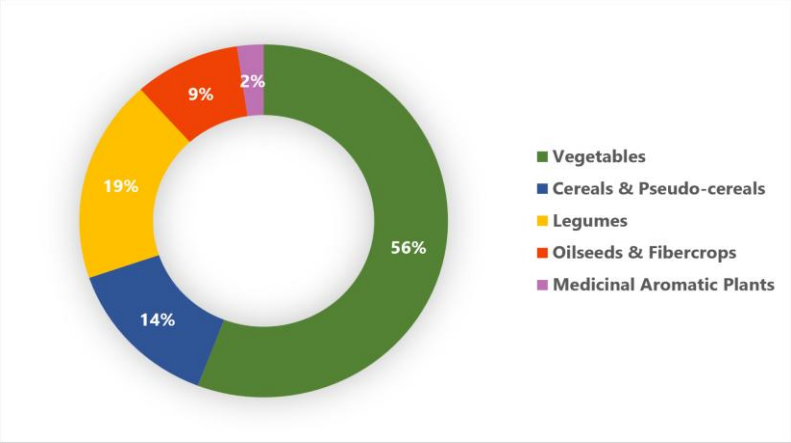


Figure 2: Distribution of trials across major crop categories based on the evaluated crop species included in Task 1.1

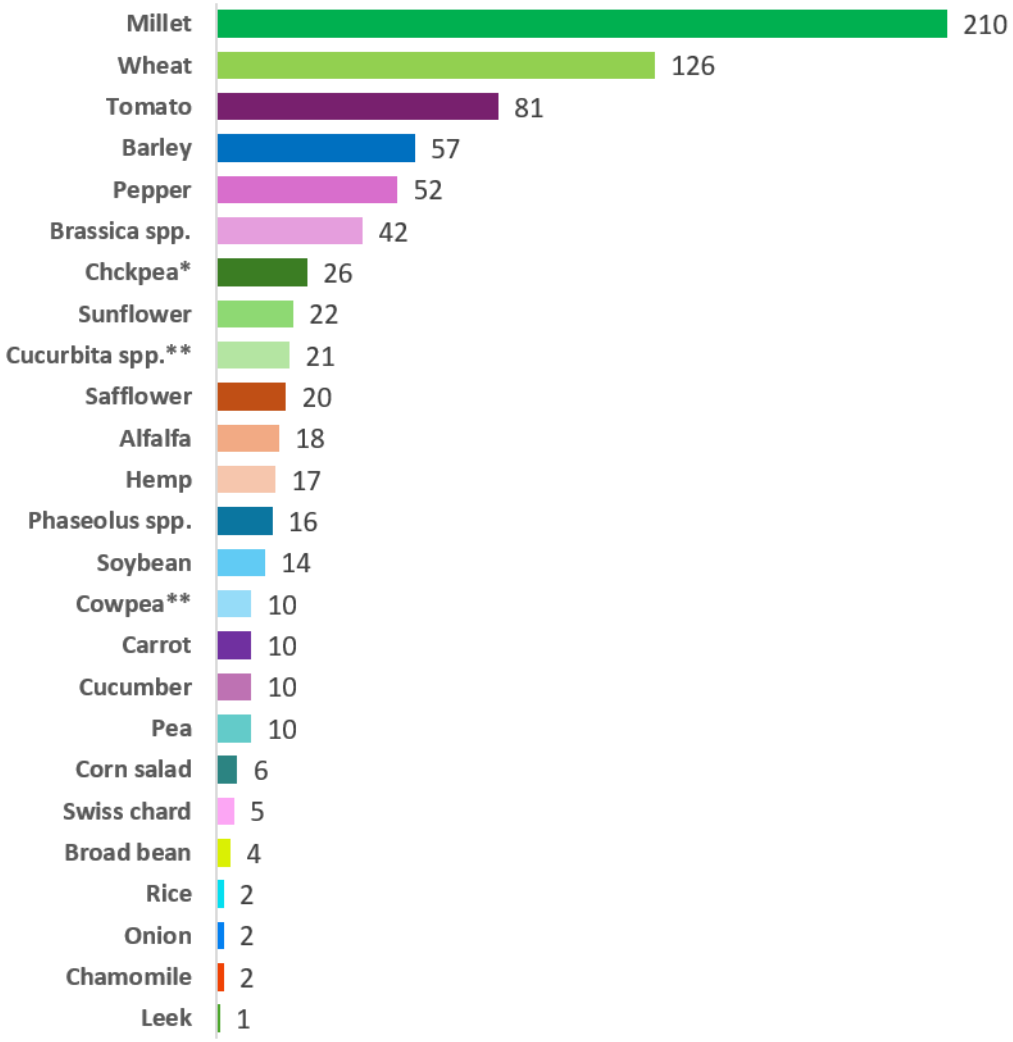


Figure 3: Number of PGR accessions per crop species within Task 1.1.
Millet includes Panicum miliaceum and Echinochloa frumentacea; Wheat includes Triticum aestivum and Triticum durum; Brassica spp. includes Brassica oleracea L. var. costata, Brassica oleracea var. Sabauda and Brassica oleracea var. botrytis; Cucurbita spp. includes Cucurbita pepo L., Cucurbita moschata L., Cucurbita maxima L.; Phaseolus spp. includes Phaseolus vulgaris and Phaseolus coccineus. For the crops with asterisk (/ **) no dataset was generated. Chickpea trials failed (*) due to poor germination and crop failure, preventing the collection of phenotypic data. Some Cucurbita and Cowpea trials included adaptation and seed multiplication only (**), therefore no dataset was generated.*

Table 1: Types of PGR material included in Task 1.1 by crop

Crop species	Landraces	Populations/OHM	Breeding lines	Varieties
Alfalfa			✓	✓
Barley	✓			✓
Brassica spp.[†]	✓			
Broad bean	✓			
Carrot	✓			
Chamomile		✓		✓
Chickpea[*]	✓			
Corn salad	✓			
Cowpea[**]		✓		
Cucumber				✓
Cucurbita spp.[†,**]		✓		✓
Hemp	✓	✓		✓
Leek	✓			
Millet[†]	✓			
Onion	✓			
Pea	✓			
Pepper	✓	✓	✓	✓
Phaseolus spp.[†]	✓			✓
Rice		✓		
Safflower	✓			
Soybean	✓			✓
Sunflower		✓		✓
Swiss chard	✓			
Tomato	✓	✓	✓	
Wheat[†]	✓		✓	✓

[†]*Millet includes Panicum miliaceum and Echinochloa frumentacea; Wheat includes Triticum aestivum and Triticum durum; Brassica spp. includes Brassica oleracea L. var. costata, Brassica oleracea var. Sabauda and Brassica oleracea var. botrytis; Cucurbita spp. includes Cucurbita pepo L., Cucurbita moschata L., Cucurbita maxima L.; Phaseolus spp. includes Phaseolus vulgaris and Phaseolus coccineus. For the crops with asterisk (* / **) no dataset was generated. Chickpea trials failed (*) due to poor germination and crop failure, preventing the collection of phenotypic data. Some Cucurbita and Cowpea trials included adaptation and seed multiplication only (**) therefore, no dataset was generated.*

2.2 Characterisation approaches

The field activity included **on-station and/or on-farm trials** (Figure 4 - A). **Participatory approaches** played a central role in the characterisation process. Farmers, and in some cases also other actors such as food processors and citizens, were actively involved in the evaluation activities (Figure 4 - B).

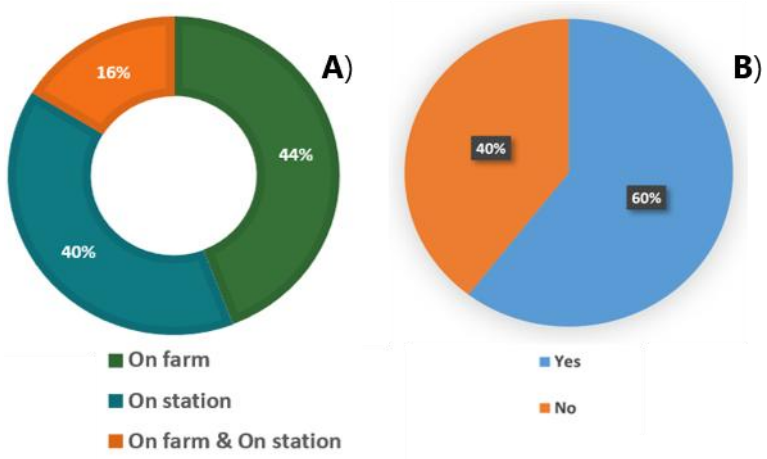


Figure 4: Distribution of trial approaches (A) and implementation of participatory approaches (B) applied for PGR characterisation, within Task 1.1, across the LiveSeeding network.

2.2.1 On-Farm Characterisation of Plant Genetic Resources

On-farm characterisation of plant genetic resources (PGR) refers to the systematic evaluation of crop diversity directly within farmers' fields, under the real agronomic, environmental, and socio-economic conditions in which crops are cultivated and utilized. It involves the observation and measurement of agronomic performance, adaptation, resilience, and quality traits. On-farm characterisation captures the complexity of genotype × environment × management (G×E×M) interactions, providing a more realistic and context-specific understanding of crop performance.

On-farm trials (replicated or non-replicated) were implemented in collaboration with farmers across different regions, representing diverse agroecological conditions. These trials were conducted under organic or low-input management systems, reflecting real farming practices. On-farm characterisation supports the selection of promising germplasm for use as **parental material** in breeding programs. In the LiveSeeding case the specific focus was on materials interesting to use as start material for the development of Organic Heterogeneous Material (OHM) and Organic Varieties (OV), the new cultivar types introduced by the EU organic

regulation 2018/848[3]. On-farm characterisation provided the appropriate setting for ensuring that identified genotypes are adapted to organic farming systems. Additionally, organic breeding emphasizes **decentralization.** On-farm characterisation aligns closely with these principles by enabling region-specific selection. This decentralized approach supports the development of locally adapted varieties that respond to specific environmental conditions and local markets demands.

2.2.2 On station characterisation

On-station characterisation enables the precise measurement of morphological, agronomic, physiological, and quality traits by minimizing environmental variability through replication, uniform management, and controlled inputs. Trials followed usually a replicated experimental design (e.g. randomized complete block design), with uniform agronomic management practices applied across all plots. A key strength of on-station characterisation lies in its ability to allow for the **detailed assessment of traits that require precise and/or time-consuming measurement**, including phenological stages, yield components, and certain physiological or biochemical characteristics that cannot be easily captured by farmers' observations.

2.2.3 Participatory approach

The participatory evaluation approach acknowledges farmers and other actors of the value chain as key knowledge holders and innovators, whose experiential knowledge complements formal scientific assessment. Through **participatory evaluation** farmers and other actors of the value chain score and rank accessions, contributing directly to the identification of locally adapted and preferred genotypes. This co-creation of knowledge enhances the relevance, usability, and eventual adoption of selected materials.

Another important contribution of participatory characterisation to organic breeding is the integration of **qualitative and socio-economic traits** into the evaluation process. Organic and local markets often prioritize characteristics such as taste, nutritional quality, and traditional uses, which are difficult to capture through standard laboratory assessments alone. By involving farmers and, in some cases, consumers in the evaluation process, on-farm characterisation allows these dimensions to be incorporated into selection decisions, making breeding outcomes more aligned with societal needs.

Participatory evaluation can be conducted in the on-farm but also in the on-station trials. When done on-farm, the participatory characterisation also **enables the inclusion of diverse agroecological contexts**.

[3] More info on OHM: D2.2 Guidelines for OHM Notification: https://orgprints.org/id/eprint/56459/ and on OV: LiveSeeding Policy brief #2 – Definition of organic plant breeding for registration of Organic varieties suitable for organic production https://orgprints.org/id/eprint/56308/

2.2.4 Involvement of Living Labs and European Seed Networks

This PGR characterisation activity was implemented in 8 (from overall 17) Living Labs within the project (Table 2)**.** A number of PGR characterisation activities in T1.1 have also taken place outside the LL framework, but within a multi-actor involvement framework in local networks that are not formally designated as LL in LiveSeeding. Additionally, strong interaction with ECO-PB and ECLLD networks allowed technological advancements to be aligned with socioeconomic needs.

Table 2: Overview of LiveSeeding Living Labs participating in characterisation of PGR (T1.1)

Partner	Living Lab	Country	Crops	Description
INRAE & UBIOS	Cereals_FR2	France	Arable crops	Arable crops (cereals, legumes, oil crops) all in organic. Main breeding focus on wheat OHM.
INRAE & FRAB	Arables_FR1	France	Arable crops	Arable crops including traditional minor crops and neglected crops. Breeding focus on dynamic population development.
AEGILOPS	Cereals_EL	Greece	Arable crops	Soft wheat organic breeding selections as candidates for OVs.
AEGILOPS & OIKOS	Pepper_EL	Greece	Vegetables	Pepper local and old domestic registered varieties. Organic farming in rotation with legumes, corn.
RSR	Rice_IT	Italy	Arable crops	Rice OHM breeding, seed system and value chain within an agro-ecology Living Lab
RSR	Cereali Resilienti	Italy	Arable crops	LL established for many years in Tuscany. Value chain of evolutionary populations of cereals. LL not part of LiveSeeding, but dedicated PGR activities in the frame of the project.
LSSV	Vegetables_ PT	Portugal	Vegetables	Tomato, peas, faba bean, broccoli, pumpkin, cucumber

Partner	Living Lab	Country	Crops	Description
				Farming practices: organic, biodynamic, organic regenerative certified, organic not certified.
UPV, RASA, Villena Cooperative farmers	Vegetables_ ES2	Spain	Vegetables	Vegetables and organic farming.
PSR	Vegetables_ CH	Switzerland	Vegetables	Vegetables, local landraces. Mostly organic in small structures, but not only

2.3 Characterisation purposes and target traits

The characterisation activities specific for T1.1 included trials in six European countries with trial sites representing a range of agroecological zones, including coastal, continental, and semi-arid environments (Figure 5).



Figure 5: Participatory evaluation of pepper PGR in Greece (Photo: AEGILOPS)

The data collection focused on a vast set of traits grouped into four main categories:

i. Morphological Traits

These included plant architecture, leaf characteristics, and fruit or seed morphology, providing descriptors for variety identification and diversity assessment.

ii. Agronomic Traits

Key agronomic traits included yield, earliness, plant vigor, and tolerance to abiotic and biotic stresses. These traits are critical for evaluating performance under organic and low-input.

iii. Quality Traits

Quality-related traits included sensory attributes (e.g. taste, texture), nutritional characteristics, and market-related features such as size, shape, and colour.

iv. Farmer-Preferred Traits

Traits identified by farmers as important for cultivation and commercialization were also recorded, including adaptability, ease of management, and market acceptance.

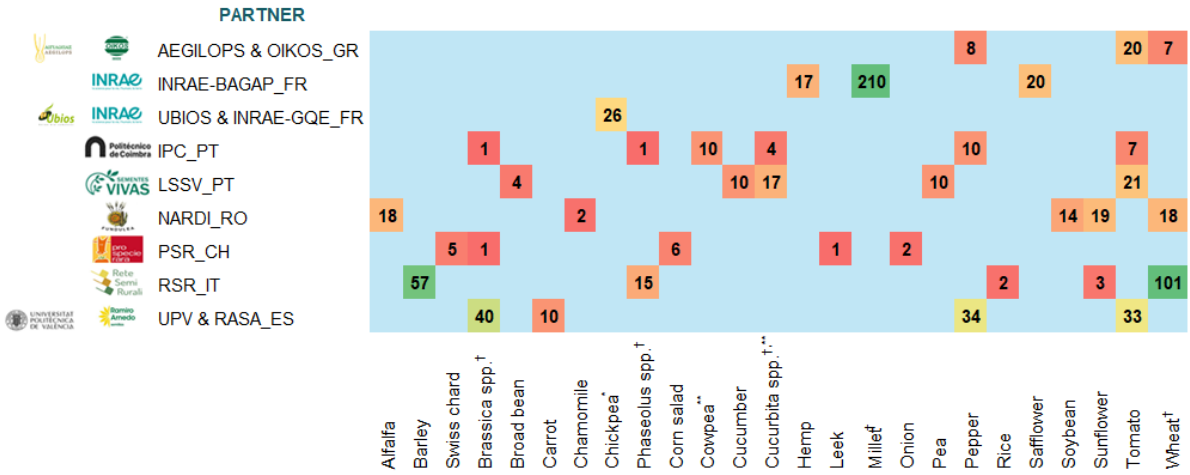


Figure 6: Number of PGR accessions per crop species and contributing partner organizations within Task 1.1, across the LiveSeeding network.

†Millet includes Panicum miliaceum and Echinochloa frumentacea; Wheat includes Triticum aestivum and Triticum durum; Brassica spp. includes Brassica oleracea L. var. costata, Brassica oleracea var. Sabauda and Brassica oleracea var. botrytis; Cucurbita spp. includes Cucurbita pepo L., Cucurbita moschata L., Cucurbita maxima L.; Phaseolus spp. includes Phaseolus vulgaris and Phaseolus coccineus. For the crops with asterisk (/ **) no dataset was generated. Chickpea trials failed (*) due to poor germination and crop failure, preventing the collection of phenotypic data. Some Cucurbita and Cowpea trials included adaptation and seed multiplication only (**) therefore, no dataset was generated.*

The purpose of the characterisation within T1.1 in LiveSeeding (Figure 6) spanned from organic agriculture adaptation to climate resilience improvement and in several cases was directly connected with the genetic base selection for new cultivar development (Table 3).

Table 3: Objectives of PGR Task 1.1 characterisation trials by crop. Some of the activities were conducted in synergy with T1.2 (breeding)

Crop	PGR Conser-vation	OHM Development (synergy T1.2)	OV Development (synergy T1.2)	Adaptation to Organic manage-ment	Climate resilience & local adaptation	Yield and/or quality and/or disease resistance	Other	Notes
Alfalfa		✓	✓	✓	✓			*Local condition adaptation*
Barley		✓		✓	✓			
Brassica spp.†	✓			✓	✓	✓	✓	*Seed commercialisation*
Broad bean		✓			✓			
Carrot	✓			✓	✓	✓		*Local condition adaptation*
Chamomile		✓		✓	✓	✓		
Chickpea*					✓			
Corn salad	✓			✓	✓	✓	✓	*Seed commercialisation*
Cowpea **							✓	*Seed multiplication in organic*
Cucumber						✓		*Yield and quality improvement*
Cucurbita spp.†,*						✓	✓	*Seed multiplication in organic*
Hemp				✓	✓		✓	*Dynamic and evolutive population*

Crop	PGR Conser-vation	OHM Development (synergy T1.2)	OV Development (synergy T1.2)	Adaptation to Organic manage-ment	Climate resilience & local adaptation	Yield and/or quality and/or disease resistance	Other	Notes
Leek	✓			✓	✓	✓	✓	*Seed commercialisation*
Millet[†]				✓	✓		✓	*Dynamic and evolutive population*
Onion	✓			✓	✓	✓	✓	*Seed commercialisation*
Pea					✓			
Pepper		✓		✓	✓	✓	✓	*Shuttle breeding (T1.2)*
Phaseolus spp.[†]				✓	✓			*Local condition adaptation*
Rice		✓		✓	✓			*Local condition adaptation*
Safflower				✓	✓		✓	*Dynamic and evolutive population*
Soybean		✓	✓	✓	✓			*Local condition adaptation*
Sunflower		✓		✓	✓		✓	*Local condition adaptation*
Swiss chard	✓			✓	✓	✓	✓	*Seed commercialisation*
Tomato		✓	✓	✓	✓	✓	✓	*Shuttle breeding (T1.2)*
Wheat[†]		✓	✓	✓	✓			*Local condition adaptation*

[†]*Millet includes Panicum miliaceum and Echinochloa frumentacea; Wheat includes Triticum aestivum and Triticum durum; Brassica spp. includes Brassica oleracea L. var. costata, Brassica oleracea var. Sabauda and Brassica oleracea var. botrytis; Cucurbita spp. includes Cucurbita pepo L., Cucurbita moschata L., Cucurbita maxima L.; Phaseolus spp. includes*

Phaseolus vulgaris and Phaseolus coccineus. For the crops with asterisk (/ **) no dataset was generated. Chickpea trials failed (*) due to poor germination and crop failure, preventing the collection of phenotypic data. Some Cucurbita and Cowpea trials included adaptation and seed multiplication only (**), therefore no dataset was generated.*

2.4 Trait descriptors and protocols

To support coordination and synergy among all evaluation activities within LiveSeeding, data collection followed standard descriptors. For the sake of continuity in the long-term process of breeding and management of crop diversity for organic farming, an effort has been made to promote the use of known benchmarks such as crop ontology and standard procedures from international organisations when relevant and, in other cases, to adopt the internal descriptors developed or used in past projects.

The list of traits planned to be measured by crop for characterisation (T1.1) and breeding (other activity tasks in WP1) was agreed at the beginning of the project and consolidated in Milestone 04 (April 2023). The list is published, together with the metadata template in the Zenodo entry: https://doi.org/10.5281/zenodo.22091667 .

This file includes the LiveSeeding project metadata template that was developed to accompany the publication of data in Zenodo from the WP1 (Increase and Manage Crop Diversity) field trials. For each crop, the file contains a tab with the complete list of traits potentially target of phenotyping with description and refence guidelines. The traits included in the actual Zenodo datasets published by the project are often a reduced set from this list, according to the final phenotyping plan of each field trial implemented.

2.5 Data standards & sharing

Data were collected using standardized templates and, where possible, digital tools (e.g. Field Book app) to facilitate data entry and reduce errors. Quality control procedures included data validation checks and consistency reviews. All datasets were curated and formatted according to agreed standards.

The partners were provided with three options for data publication:

- Using the **SeedLinked** platform (adapted in WP2 for on-farm cultivar testing) and publishing the records directly on the platform (Chapter 3.2);
- Publishing raw data and related metadata as datasets in the **LiveSeeding Zenodo Community** (Chapter 3.3).
- If the data are to be used for a scientific paper, the dataset will be published on Zenodo after the paper is online.

In addition, **PGR description cards** (Chapter 3.4) have been developed for the most interesting materials to boost their cultivation by farmers.

3. RESULTS

3.1 Results overview

In total the LiveSeeding dynamic management of PGR (T1.1) output[4] accounts for (at the date of publication of this report):

- >700 PGR accessions newly characterised
- 33 datasets published in Zenodo
- 34 trial records published on SeedLinked
- 21 PGR description cards published on Organic Eprints and Organic Farm Knowledge Platform to accelerate the use of the most interesting materials.

A few additional datasets are expected to be published once the scientific publications related to those datasets will be accepted. Some trials are still ongoing in the 2026 summer season and the full data will be available only after the end of the project.

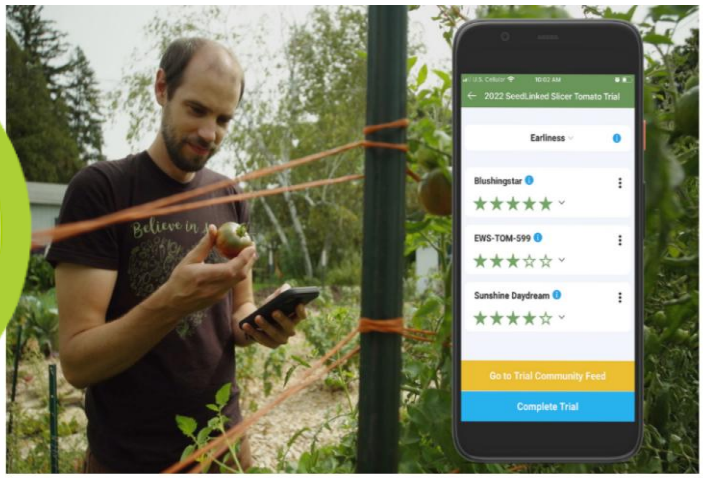
The results of the characterisation activities directly support cultivation of landraces and plant breeding and selection efforts. Promising accessions with desirable traits have been identified for further evaluation and potential use in organic and participatory breeding programs. The integration of farmer preferences ensures that selected materials meet practical needs, increasing the likelihood of adoption.

3.2 PGR characterisation results on Seedlinked

3.2.1 The Seedlinked tool

SeedLinked (Figure 7) is a platform for decentralized cultivar evaluation and inclusion of real-time multi-actor feedback (from farmer to consumer). It is an all-encompassing platform from trial creation, participant registration, logistics, data collection, grower communication and real-time sharing of results. It also offers content-sharing capabilities, making generated insights accessible to everyone. This approach generates localized, farmer-driven data that helps identify which varieties perform best in specific environments, while also supporting breeders in selection decisions. Its tools for data collection, analysis, and sharing are accessible via both web and mobile apps, supporting multiple languages to ensure wide accessibility and GDPR compliance.

[4] Some datasets are embargoed until they are published in scientific journals. Additional datasets will be published alongside related scientific publications. As some trials will only conclude at the end of the summer season in 2027, the full dataset will not be ready for publication by the time this report is published. More records in SeedLinked and PGR cards may be published.



Grower participating in a collaborative variety trial on SeedLinked

Figure 7: SeedLinked logo and view of the platform webpage

More info on SEEDLINKED:

Practice Abstract PA 4 – Enhancing Organic Variety Development with SeedLinked: A Collaborative Digital Approach

SeedLinked website seedlinked.com

3.2.2 LiveSeeding PGR characterisation Results on SeedLinked

Over 30 trial records related to PGR characterisation (T1.1) are available on SeedLinked (Figure 8, Table 4). These add up to the ones related to on-farm cultivar testing pilots (T2.3).

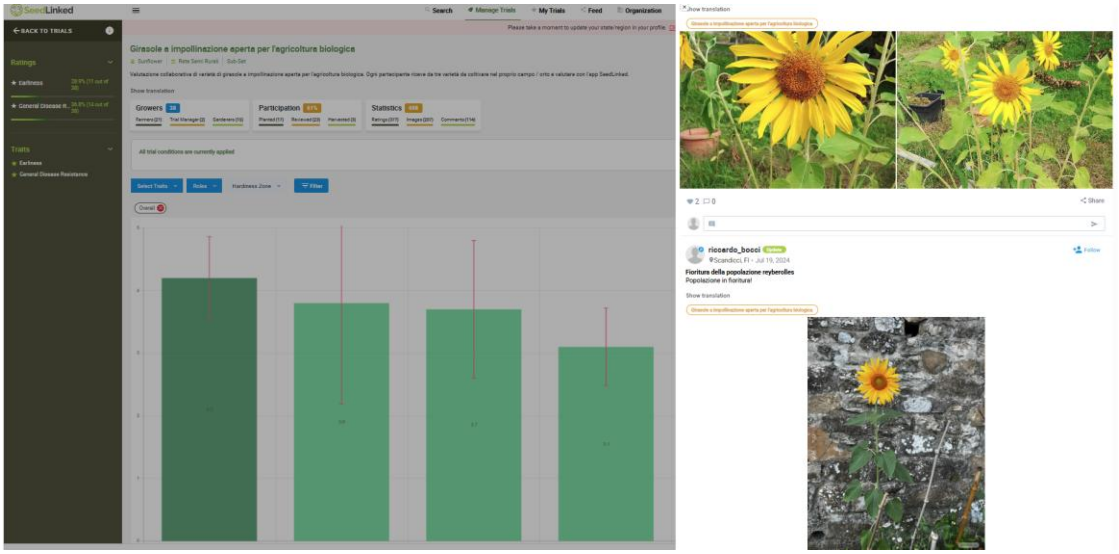


Figure 8: Screenshot of the public results of trial "Open-pollinated sunflowers for organic farming" in Italy with an impression of the pictures shared by the participants

Table 4: LiveSeeding PGR characterisation (Task 1.1) records publicly available in SeedLinked

Partner	Country	Crop	Trial type	Trial title	SeedLinked access link
LSSV	Portugal	Tomato	On farm; On station	Dryland Cherry Tomatoes	https://app.seedlinked.com/en-US/trial/analytics/MjgwMw
IPC	Portugal	Pepper	On station	Evaluation of Peppers LIVESEEDING 2023_Iberian landraces_LORETO	https://app.seedlinked.com/en-US/trial/analytics/guest/MTk2MQ
IPC	Portugal	Pepper	On station	Evaluation of Peppers LIVESEEDING 2023 - Iberian Varieties_ESAC_Agroforestry	https://app.seedlinked.com/en-US/trial/analytics/guest/MjA1Mg
IPC	Portugal	Tomato	On station	Tomato Tasting - LIVESEEDING - ESAC 2024	https://app.seedlinked.com/en-US/trial/analytics/guest/MjYxMg
RSR	Italy	Sunflower	On farm	Open-pollinated sunflowers for organic farming	https://app.seedlinked.com/de-DE/trial/analytics/MjM2OQ
RSR	Italy	Wheat	On farm	Bread - Resilient Cereals - Local Tasting SUN Agriculture 2024	https://app.seedlinked.com/en-US/trial/analytics/guest/MjQ0Ng
RSR	Italy	Wheat	On farm	Biscuits - Resilient Cereals - Floriddia 2023 Local Tasting	https://app.seedlinked.com/trial/analytics/guest/MjE1Mg==
RSR	Italy	Wheat	On farm	Schiacciata - Resilient Cereals - Floriddia 2023 Local Tasting	https://app.seedlinked.com/trial/analytics/guest/MjE1MQ==
RSR	Italy	Wheat	On farm	Bread - Resilient Cereals - Floriddia 2023 Local Tasting	https://app.seedlinked.com/trial/analytics/guest/MjE1MA==
RSR	Italy	Wheat	On farm	Egg Pasta - Resilient Grains - Local Tasting at Le Pietre 2023	https://app.seedlinked.com/trial/analytics/guest/MjE0Nw==
RSR	Italy	Wheat	On farm	Schiacciata - Resilient Cereals - Local Tasting at Le Pietre 2023	https://app.seedlinked.com/trial/analytics/guest/MjE0Ng==

Partner	Country	Crop	Trial type	Trial title	SeedLinked access link
RSR	Italy	Wheat	On farm	Bread - Resilient Cereals - Local Tasting at Le Pietre 2023	https://app.seedlinked.com/trial/analytics/guest/MjE0NQ==
RSR	Italy	Wheat	On farm	Pasta - Resilient Grains - Local Tasting at Podere Montisi 2023	https://app.seedlinked.com/trial/analytics/guest/MjEyNQ==
RSR	Italy	Wheat	On farm	Biscuits - Resilient Cereals - Local Tasting at Podere Montisi 2023	https://app.seedlinked.com/trial/analytics/guest/MjEyNA==
RSR	Italy	Wheat	On farm	Bread - Resilient Cereals - Local Tasting Podere Montisi 2023 - Bread	https://app.seedlinked.com/trial/analytics/guest/MjEyMw==
RSR	Italy	Wheat	On farm	Pasta - Resilient Cereals - Local Tasting Sara Passerini 2023	https://app.seedlinked.com/trial/analytics/guest/MjA1OQ==
RSR	Italy	Wheat	On farm	Biscuits - Resilient Cereals - Local Tasting Sara Passerini 2023	https://app.seedlinked.com/trial/analytics/guest/MjA1OA==
RSR	Italy	Wheat	On farm	Bread - Resilient Cereals - Local Tasting Sara Passerini 2023 - Bread	https://app.seedlinked.com/trial/analytics/guest/MjA1Nw==
RSR	Italy	Wheat	On farm	Farri Grains - Resilient Cereals - Local Tasting SUN Agriculture 2023 - Farri Grains	https://app.seedlinked.com/trial/analytics/guest/MjA0NQ==
RSR	Italy	Wheat	On farm	Pasta - Resilient Cereals - Local Tasting SUN Agriculture 2023 - Pasta	https://app.seedlinked.com/trial/analytics/guest/MjA0NA==
RSR	Italy	Wheat	On-farm	Bread - Resilient Cereals - Local Tasting SUN Agriculture 2023 - Bread	https://app.seedlinked.com/trial/analytics/guest/MjAyMQ==
RSR	Italy	Wheat	On farm	BREAD Resilient Cereals 3.0	https://app.seedlinked.com/trial/analytics/guest/MTg1Mg==

Partner	Country	Crop	Trial type	Trial title	SeedLinked access link
RSR	Italy	Wheat	On farm	BISCUITS Resilient Cereals 3.0	https://app.seedlinked.com/trial/analytics/guest/MTg1MQ==
RSR	Italy	Wheat	On farm	Evolutionary Tasting of Soft Wheat Bread	https://app.seedlinked.com/trial/analytics/guest/MTgxMg==
RSR	Italy	Wheat	On farm	Evolutionary Tasting of Soft Pasta	https://app.seedlinked.com/trial/analytics/guest/MTgxMQ==
RSR	Italy	Wheat	On farm	Evolutionary Tasting of Monococco Pasta	https://app.seedlinked.com/trial/analytics/guest/MTgxMA==
UPV	Spain	Pepper	On farm	Peppers UPV Meliana 2023	https://app.seedlinked.com/trial/analytics/guest/MzI3Nw==
UPV	Spain	Pepper	On farm	Peppers UPV Picassent 2023	https://app.seedlinked.com/trial/analytics/guest/MzI3Mw==
UPV	Spain	Pepper	On farm	UPV Picassent Peppers 2024 100% Irrigated	https://app.seedlinked.com/trial/analytics/guest/MzI3NQ==
UPV	Spain	Pepper	On farm	UPV Picassent Peppers 2024 IRRIGATION 60%	https://app.seedlinked.com/trial/analytics/guest/MzI3Ng==
UPV	Spain	Pepper	On farm	Villena White Pepper 2023	https://app.seedlinked.com/trial/analytics/guest/MzQwNA==
UPV	Spain	Pepper	On farm	Villena White Pepper 2024	https://app.seedlinked.com/trial/analytics/guest/MzQwNQ==
UPV	Spain	Tomato	On farm	Meliana Tomato 2024	https://app.seedlinked.com/trial/analytics/guest/MzQwMg==
UPV	Spain	Tomato	On farm	Tomato Picassent 2024	https://app.seedlinked.com/trial/analytics/guest/MzQwMw==

3.2.3 Example of PGR characterisation with SeedLinked in Portugal

Patricia Pires and Els Wijnstra (LSSV)

Living Seeds – Sementes Vivas (LSSV) is an organic and biodynamic seed company based in Idanha-a-Nova, Portugal. The company specializes in the production, selection, and marketing of high-quality organic seeds for a diverse range of clients. LSSV has worked on the recuperation and promotion of traditional varieties, as well as breeding for the mediterranean area. The farm in Idanha-a-Nova acts as a central hub for seed production, plant breeding, variety trials, quality control, and research activities. To strengthen its breeding programs, LSSV considers the SeedLinked platform a valuable tool for engaging more closely with farmers and consumers, facilitating the collection of practical feedback on the performance and viability of new vegetable varieties.

Trial: Case Study - Tomato Breeding Lines

Seedlinked was initially used with preliminary trials in order to understand the use of the platform and the adherence of the participants, whether they were farmers, gardeners, or consumers. The platform was tested with various types of trials such as sensory evaluations with QR codes, subset and single site trials, and then used for a full-set trial for LiveSeeding´s case study: Tomato Breeding Lines (Figure 9).

Over a seven-year period, LSSV developed determinate cherry tomato breeding lines with tolerance to extreme heat and drought, focusing on the challenging climatic conditions of Beira Baixa, Portugal. In the final stage of this breeding program, six promising lines were selected based on traits of potential interest to farmers. In 2025, these lines were evaluated with the objective of gathering farmer-led performance data across multiple regions of Portugal under open-field conditions.

LSSV sent the seeds in spring 2025 and participants recorded key agronomic and quality traits through the SeedLinked app. These traits included plant vigour, productivity, fruit cracking, blossom end rot, ease of harvest, marketability, and flavour, complemented by dates, observations and pictures.

Trial Development

At the outset, 19 farmers from different regions of Portugal enrolled in the trial, including SeedLinked users and first-time participants. To address initial difficulties with the use of the app, a Portuguese instruction manual was developed, and close communication was maintained with the SeedLinked development team to improve features and translations. Despite these efforts, only eight participants completed all trial evaluations. Follow-up phone

calls helped to understand the lack of trial completion. This was either due to personal circumstances or certain obstacles, highlighting the need for clear guidance, technical simplicity, and ongoing support in participatory digital trials

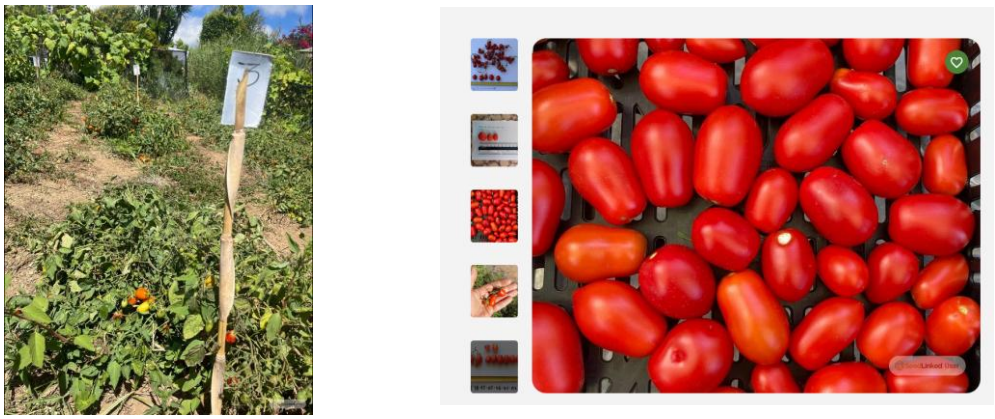


Figure 9: View of field trial (left) and harvested fruits (right) (Photos: LSSV)

Trial Conclusions

Trial data were exported directly from the Seedlinked platform. After analysing the results, two breeding lines were selected for seed multiplication and variety registration in 2026. One line obtained the highest score in productivity and plant vigour, while the second stood out for its flavour, showing balanced performance in the other evaluated characteristics (Figure 10).

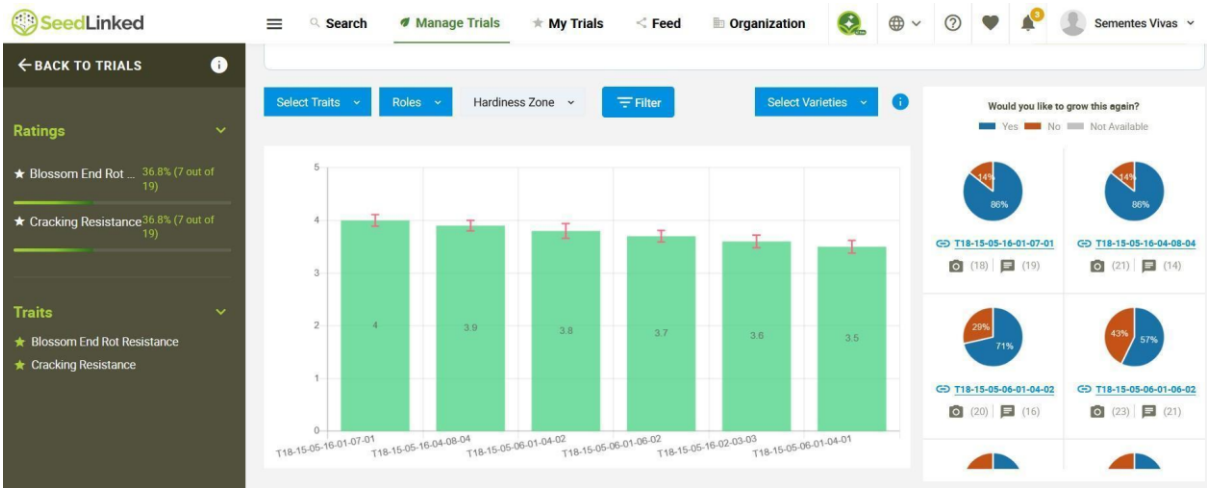


Figure 10: Live results of the LSSV tomato breeding lines trial

Overall Conclusions

Experience from several SeedLinked trials indicates that simplicity is the key to successful participatory PGR evaluation. Trials with too many varieties or evaluation traits tend to show lower completion rates. Clear objectives, concise evaluation criteria, and sufficient guidance—especially for new participants— are essential for generating reliable data. Building and maintaining a committed network of experienced trial participants further strengthens outcomes. In response to these lessons, LSSV implemented two tomato variety comparison trials in 2026, each engaging 33 participants and using simplified trial designs to enhance participation and data reliability.

3.3 PGR characterisation Results on Zenodo

3.3.1 The Zenodo data repository

Zenodo is an open-access digital repository designed to support the sharing, preservation, and dissemination of research outputs. Developed within the framework of the European OpenAIRE initiative, Zenodo enables researchers, institutions, and projects from all scientific fields to upload and publicly share datasets, publications, software, reports, presentations, images, and other research materials. Its main goal is to promote open science by improving accessibility, transparency, and long-term availability of scientific knowledge. Zenodo ensures long-term preservation of research outputs and provides a Digital Object Identifier (DOI), allowing datasets to be cited and reused by the scientific community and stakeholders.

3.3.2 LiveSeeding PGR characterisation Results on Zenodo

The 33 LiveSeeding PGR characterisation datasets (Table 5) are available in the LiveSeeding Zenodo Community, under Resource Type Dataset and Subject Plant Genetic Resources characterisation and directly at this link:

https://zenodo.org/search?q=liveseeding&f=subject%3APlant%20Genetic%20Resources%20Characterization&l=list&p=1&s=10&sort=bestmatch

The datasets deposited in Zenodo (Figure 11) are open access and licensed under Creative Commons Attribution-NonCommercial-ShareAlike 4.0. Some entries are embargoed for usage in scientific publications.

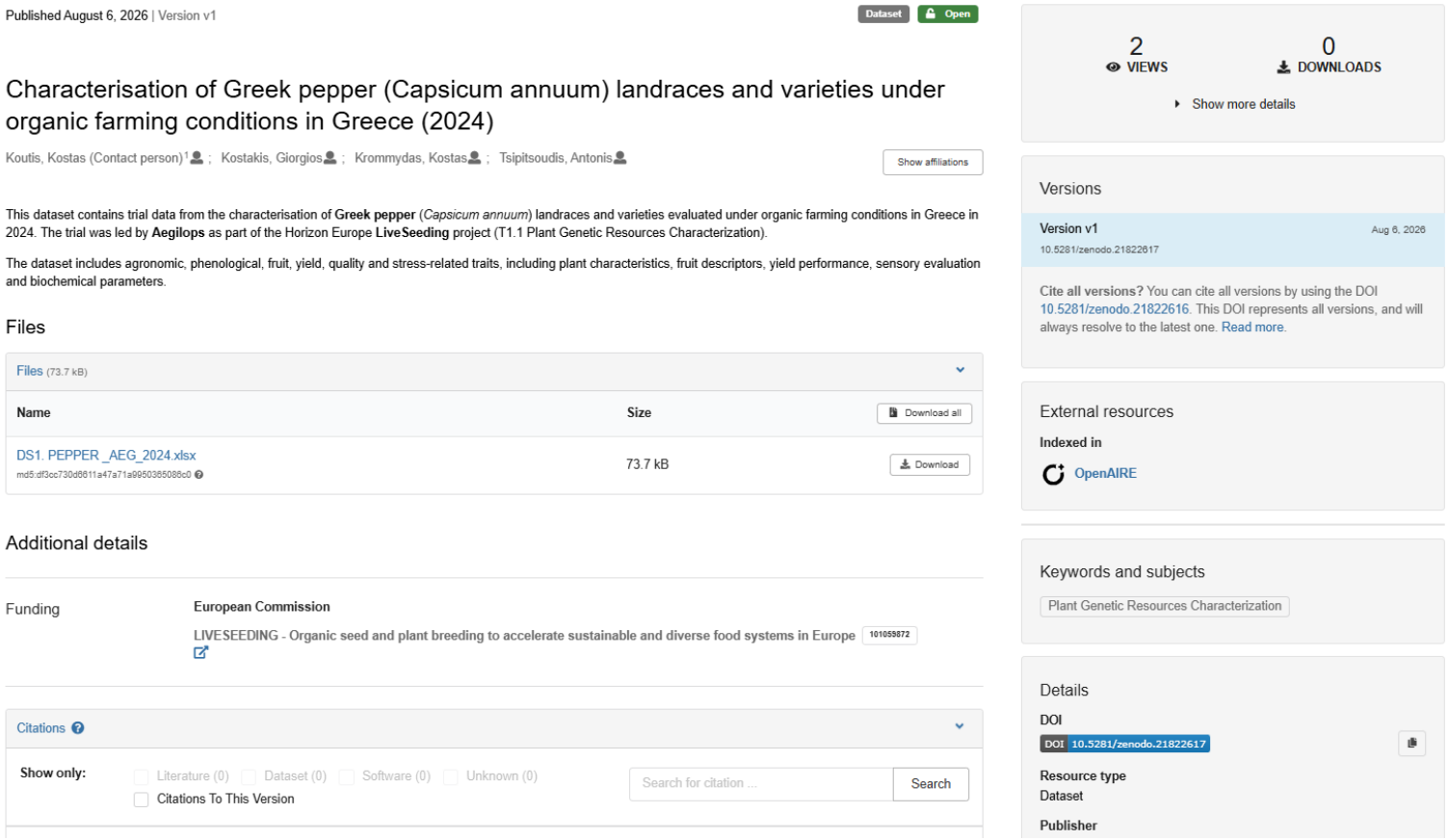


Figure 11: Screenshot of one dataset entry in Zenodo

Table 5: Overview of Task 1.1 datasets published in Zenodo LiveSeeding Community with DOI

Partner(s)[5]	Country	No. of datasets	Crops & datasets DOI
AEGILOPS & OIKOS (for pepper)	Greece	3	*Pepper* https://doi.org/10.5281/zenodo.21822617 *Tomato* https://doi.org/10.5281/zenodo.21825728 *Wheat (Triticum aestivum)* https://doi.org/10.5281/zenodo.21899448
INRAE & FRAB (Living Lab)	France	3	*Millet (Panicum miliaceum, Echinochloa frumentacea)* https://doi.org/10.5281/zenodo.21786531 *Safflower* https://doi.org/10.5281/zenodo.21975790 *Hemp* https://doi.org/10.5281/zenodo.21787687
IPC	Portugal	3	*Pepper* https://doi.org/10.5281/zenodo.21806517 *Tomato* https://doi.org/10.5281/zenodo.22008471 *Phaseolus spp. (Phaseolus vulgaris)* https://doi.org/10.5281/zenodo.21807107
LSSV	Portugal	5	*Tomato* https://doi.org/10.5281/zenodo.21789988 *Pea* https://doi.org/10.5281/zenodo.22024208 *Broad bean* https://doi.org/10.5281/zenodo.22024358 *Cucurbita spp. (Cucurbita pepo, Cucurbita moschata, Cucurbita maxima)* https://doi.org/10.5281/zenodo.21976193 *Cucumber* https://doi.org/10.5281/zenodo.21792431

[5] Subcontractors are also listed here for their contribution to some of the T1.1 activities

Partner(s)[5]	Country	No. of datasets	Crops & datasets DOI
NARDI	Romania	5	*Sunflower* https://doi.org/10.5281/zenodo.21875106 *Alfalfa* https://doi.org/10.5281/zenodo.21875177 *Soybean* https://doi.org/10.5281/zenodo.21875227 *Wheat (Triticum aestivum, Triticum durum)* https://doi.org/10.5281/zenodo.21875252 *Chamomile* https://doi.org/10.5281/zenodo.21875307
PSR	Switzerland	5	*Brassica spp. (Brassica oleracea var. sabauda)* https://doi.org/10.5281/zenodo.21802855 *Swiss chard* https://doi.org/10.5281/zenodo.21874392 *Onion* https://doi.org/10.5281/zenodo.21874589 *Corn salad* https://doi.org/10.5281/zenodo.21874751 *Leek* https://doi.org/10.5281/zenodo.21804147
RSR	Italy	5	*Rice* https://doi.org/10.5281/zenodo.21804893 *Barley* https://doi.org/10.5281/zenodo.21805106 *Wheat (Triticum aestivum, Triticum durum)* https://doi.org/10.5281/zenodo.21805553 https://doi.org/10.5281/zenodo.21805287 *Phaseolus spp. (Phaseolus vulgaris, Phaseolus coccineus)* https://doi.org/10.5281/zenodo.21821380
UPV RASA	Spain	4	*Brassica oleracea var. botrytis* https://doi.org/10.5281/zenodo.22024628 *Carrot* https://doi.org/10.5281/zenodo.22024489 *Pepper* https://doi.org/10.5281/zenodo.22025143

Partner(s)[5]	Country	No. of datasets	Crops & datasets DOI
Villena Coop. Farmers			*Tomato* https://doi.org/10.5281/zenodo.22024765

3.3.3 Example of a LiveSeeding Dataset Published in Zenodo: PEPPER landraces evaluation in Greece

Kostas Koutis and Nektaria Tsivelika (AEGILOPS)

DATASET DOI: https://doi.org/10.5281/zenodo.21822617

An example dataset is the Dataset "Characterisation of Greek pepper (*Capsicum annuum*) landraces and varieties under organic farming conditions in Greece (2024)", Dataset file: PEPPER_EL9LL_AEG_2024.

The uploaded dataset includes:

- Metadata describing the experiment and field trial design (Figure 12).
- A list of measured traits and descriptor definitions (Figure 13).
- Field layout information (Figure 14).
- Raw experimental data collected during the 2024 growing season (Figure 15).

DISCLAIMER: Although these metadata provide the most detailed and accurate information on the associated dataset, it is important to bear in mind that it will always be more reliable and relevant for a proper interpretation of the analyses to contact and exchange with the people who carried out/participated in an experiment in order to fully understand the conditions under which it was carried out, its limits and its specific features, as this information cannot always be reduced to metadata.

LiveSeeding Horizon Europe project LiveSeeding doi: 10.3030/101059872	**Field Trial Documentation**
DATASET name	PEPPER_AEG_2024
Task Number	T1.1
Task Title	Dynamic management of genetic resources through accelerated use
Field Trial Name	Characterisation of Greek pepper PGR
Organisation(s) Involved	Aegilops, Oikos Seeds, GRADONA Organic Farm
Farm(s) involved	GRADONA Organic Farm
People involved	Kostas Koutis, Giorgios Kostakis,Kostas Krommydas, Antonis Tsipitsoudis
Contact Person	Kostas Koutis (koutisresfarm@gmail.com)
Trial Site (address)	Kalochori, Thessaloniki, Greece, 570 09 (GRADONA Organic Farm)
Location (GPS data)	40°39'24.3"N 22°50'37.6"E
Year of assessment	2024
Soil Type	Silty clay loam
Soil Analysis	35-45-20
Average Rainfall per year	549 mm
Average Temperature per year	16,9°c
Management	Certified Organic / Low Input
Year of conversion to organic (if applicable)	2010
Crop rotation	No crop rotation (only solanaceae in this field)
Previous Crop	Tomato, Eggplant, Pepper
CROP Species	Capsicum annuum
Cultivars	Bahovou, F1 orange, F1 Kaptur, Florinis, OS-139, P13, P14
Seed source	Oikos Seeds, Aegilops
Experimental design	RCBD (field plan in tab "field_plan")
Time and way of soil preparation	First week of May 2024. Plowing, Tilling
Time, quantity and type of fertilisation (incl. nutrient concentration)	Manure
Time of sowing and type of sowing machine	22-5-2024. Plants transplanted by hand
Plot size	Plot length 3 m
Total cultivated area	36 m2
Sowing density	4 plants/m2
Frequency and quantity of irrigation	**Frequency:** 2-3 irrigations/week depending on plant age and month **Quantity:** 1-2 lit per plant depending on plant age and month
Frequency, quantity and type of plant protection (incl. concentration of active compound)	No plant protection was applied
Frequency and type of weed control	**Frequency:** 3 monthly weedings **Type:** hand weeding with hand tools
Time of harvest and harvesting equipment	**Period:** July to August **Equipment:** Harvested by hand
Traits assessed	**Traits assesed (codes):** CV, DI, FC, FDc, FDtb, FFi, FFI, Flen, Flob, FOV, FR, FS, FSh, FSL, FT, FW, Fwid, GS, LC, NB, NP, PA, PH, PS, PV, SD, TD (description of the traits in tab "traits") **Period:** July and August **Persons:** Kostas Krommydas, Giorgos Kostakis
Challenges and Limitations	Hot and dry weather during pepper cultivation

Figure 12: Overview of the metadata sheet included in the dataset "PEPPER _AEG_2024", providing information on the project, trial site, participating organisations, experimental setup and dataset characteristics.

Characteristics	Abbreviation	#	Unique Code	Explanation or Method	Unit or Scale	Plant part
Cultivar	CV	1	01_CV_Co	Name of the cultivar or genotype.		N/A
Sowing date	SD	2	02_SD_Co	Sowing date.		N/A
Transplant date	TD	3	03_TD_Co	Transplanting date	days	N/A
Germination rate	GR	4	04_GR_Co	Percentage of seeds that germinated (seeds germinated/seeds sown).	%	Seed
Germination SL	SeedLinked	5	05_GR_SI	Qualitative visual rating of germination speed and proportion.	1-5 scale. 1= less than 50% , 2= 50-75% , 3= about 75% , 4= more than 75%, 5= all or almost all	Seed
Number of plants (or plants per plot)	NP	6	06_NP_Co	Total number of plants per plot or block. If needed plants/plot or plants/block		N/A
Number of blocks	NB	7	07_NB_Co	Total number of blocks in the trial.		N/A
Plant height (cm)	PH	8	08_PH_Tr	Height of the plant measured in centimeters at the middle and end of season	cm	Plant
Plant height SL	SeedLinked	9	09_PH_SI	Qualitative rating of plant height at the middle and end of season.	1-5 scale. 1= very short, 5= very high	Plant
Stem length	SeedLinked	10	10_SI_SI	Qualitative rating of stem length at the middle and end of season.	1-5 scale. 1= very short, 5= very high	Plant
Plant width	SeedLinked	11	11_PW_SI	Visual assessment of plant width.	1-5 scale. 1= narrow/undesirable, 5= broad/ desirable	Plant
Plant vigour	PV	12	12_PV_Tr	Qualitative rating of plant vigour.	1-9 scale. 1= low, 9= very high	Plant
Plant vigour SL	SeedLinked	13	13_PV_SI	Qualitative rating of plant vigour.	1-5 scale. 1= very weak growth, 5= very vigorous and healthy growth	Plant
Plant architecture	PA	14	14_PA_Tr	Qualitative rating of plant branching.	1-5 scale. 1= few branches, 3= medium, 5= highly branched	Plant
Plant structure appearence	PS	15	15_PS_Tr	Qualitative rating of plant structure.	1-5 scale. 1= open, 3= semi-opened, 5= closed	Plant

Figure 13: Excerpt from the traits list included in the dataset "PEPPER_ AEG_2024", presenting the list of recorded traits together with their definitions and measurement

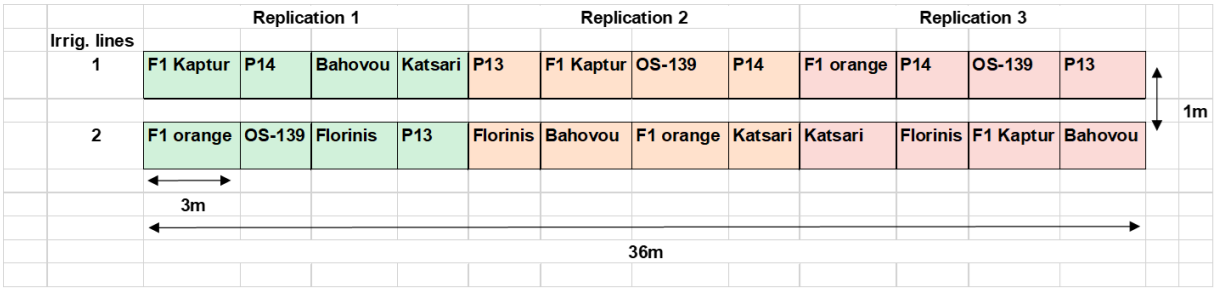


Figure 14: Overview of the field plan sheet included in the dataset "PEPPER _AEG_2024", showing the experimental layout of pepper accessions within the field trial.

Replication	01_CV_Co	02_SD_Co	03_TD_Co	04_GR_Co	05_GR_SI	06_NP_Co	07_NB_Co	08_PH_Tr	09_PH_SI	10_SI_SI	11_PW_SI	12_PV_Tr	13_PV_SI	14_PA_Tr	15_PS_Tr
1	Bahovou	15/3/2024	10/5/2024	88,00	4,00	6,00	3,00	79,30	4	2,00	4,20	7,40	2,70	4,20	3
2	Bahovou	15/3/2024	10/5/2024	88,00	4,00	6,00	3,00	76,00	4	1,80	4	7,10	3,10	4	3
3	Bahovou	15/3/2024	10/5/2024	88,00	4,00	6,00	3,00	70,70	4	2,00	4	6,70	3,30	3,60	3,00
1	F1 bell shaped	15/3/2024	10/5/2024	95,00	5,00	6,00	3,00	84,30	4	3,10	4,80	7,20	4,40	4,00	4
2	F1 bell shaped	15/3/2024	10/5/2024	95,00	5,00	6,00	3,00	83,10	4	3,20	5,00	6,80	4,60	4,20	4
3	F1 bell shaped	15/3/2024	10/5/2024	95,00	5,00	6,00	3,00	88,40	4	2,80	5,00	6,60	4,80	4,20	4
1	F1 Kaptur	15/3/2024	10/5/2024	93,00	5,00	6,00	3,00	86,60	5	2,90	4,00	6,40	4,20	2,80	3
2	F1 Kaptur	15/3/2024	10/5/2024	93,00	5,00	6,00	3,00	91,20	5	3,20	4,00	7,60	4,10	3,20	3
3	F1 Kaptur	15/3/2024	10/5/2024	93,00	5,00	6,00	3,00	94,30	5	3,20	4,00	7,20	3,80	3,10	3
1	Florinis	15/3/2024	10/5/2024	90,00	5,00	6,00	3,00	68,60	4	2,00	3,80	4,80	2,80	1	3
2	Florinis	15/3/2024	10/5/2024	90,00	5,00	6,00	3,00	63,80	4	1,80	4,00	5,20	3,20	1	3
3	Florinis	15/3/2024	10/5/2024	90,00	5,00	6,00	3,00	73,20	4	2,20	4,10	5,40	3,00	1	3
1	Katsari	15/3/2024	10/5/2024	84,00	4,00	6,00	3,00	61,70	3	2,10	2,80	6,60	3,60	2,80	2
2	Katsari	15/3/2024	10/5/2024	84,00	4,00	6,00	3,00	63,30	3	1,90	3,10	7,00	4,20	3,00	2
3	Katsari	15/3/2024	10/5/2024	84,00	4,00	6,00	3,00	70,20	3	2,10	3,20	7,20	4,20	3,20	2
1	OS-139	15/3/2024	10/5/2024	92,00	5,00	6,00	3,00	61,00	3	1	3	4,80	2,60	2,80	3
2	OS-139	15/3/2024	10/5/2024	92,00	5,00	6,00	3,00	67,00	3	1	3	5,20	3,20	3,20	3
3	OS-139	15/3/2024	10/5/2024	92,00	5,00	6,00	3,00	56,00	3	1	3	5,10	3,00	2,80	3
1	P13	15/3/2024	10/5/2024	91,00	5,00	6,00	3,00	80,30	4	2,10	3,60	4,60	2,80	2	3
2	P13	15/3/2024	10/5/2024	91,00	5,00	6,00	3,00	83,00	4	1,90	3,80	5,20	3,20	2	3
3	P13	15/3/2024	10/5/2024	91,00	5,00	6,00	3,00	88,60	4	2,20	4,00	5,10	3,20	2	3
1	P14	15/3/2024	10/5/2024	92,00	5,00	6,00	3,00	75,40	4	3,10	3,80	6,60	3,90	3,60	3
2	P14	15/3/2024	10/5/2024	92,00	5,00	6,00	3,00	81,40	4	3,00	3,90	7,20	4,30	3,80	3
3	P14	15/3/2024	10/5/2024	92,00	5,00	6,00	3,00	85,70	4	2,90	4,00	7,10	4,10	3,80	3

Figure 15: Excerpt from the raw data sheet of the dataset "PEPPER_EL9LL_AEG_2024", showing phenotypic observations collected from pepper accessions and field replicates. Only a subset of the recorded variables (the first 15 out of 76 traits) is presented for visualization purposes. The variables shown correspond to the trait definitions and measurement descriptions provided in the accompanying traits sheet.

3.3.4 Example of LiveSeeding results on Zenodo: focus case on reviving underutilised crops - HEMP (*Cannabis sativa* L.) in Brittany, France

Véronique Chable, Sylvie Nègre (INRAE)

DATASET DOI: *https://doi.org/10.5281/zenodo.21787687*

Info Box 1

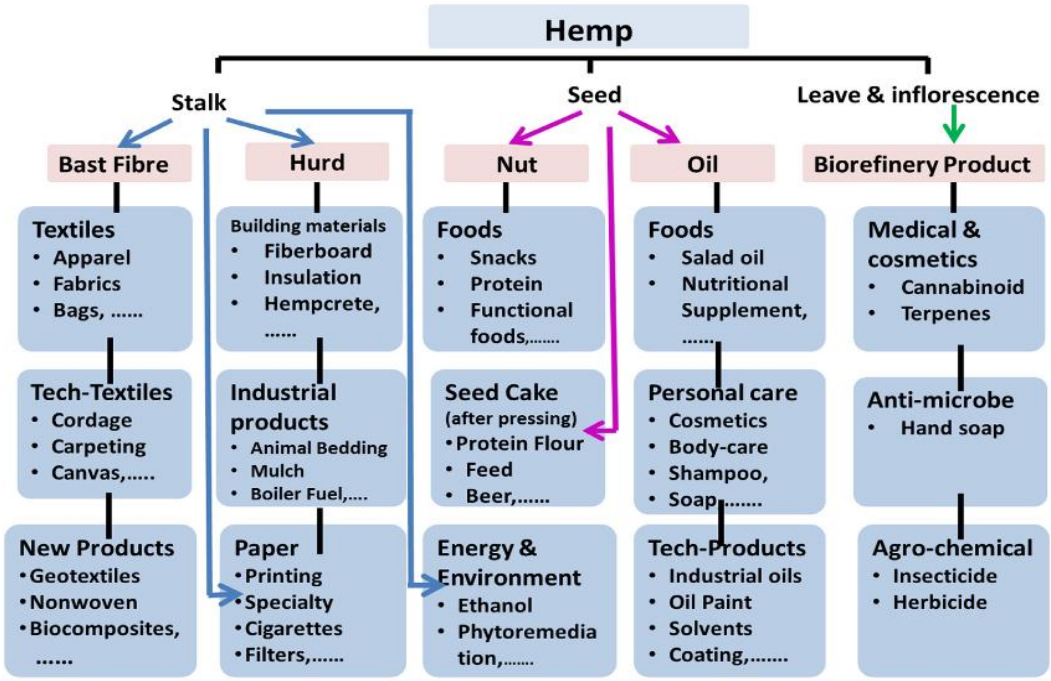
Underutilized crops & role of on-farm work for their revival

Underutilized crops such as hemp, safflower, millet, and other traditional multipurpose species represent valuable but often neglected components of agricultural biodiversity. Underutilized species are often specific to locations and pedoclimatic zones. Historically, many of these crops played important roles in local farming systems by providing food, fibre, oil, animal feed, medicinal products, and raw materials adapted to regional environmental conditions. However, agricultural intensification, market specialization, industrial standardization, and the dominance of a limited number of major crops have led to the marginalization of many traditional and locally adapted crop species. As a result, significant genetic diversity and associated traditional knowledge are increasingly at risk of being lost. On farm selection and further breeding by farmers of underutilized species can help to revive their cultivation. **Characterisation** is a critical first step in the revival process because many underutilized crops remain poorly documented and insufficiently studied. **Participatory organic breeding** further strengthens this revival process by directly involving farmers, researchers, processors, and local communities in selection and improvement activities. Farmers contribute practical knowledge regarding adaptation, resilience, management requirements, processing qualities, and market preferences, while breeders provide scientific tools for selection and population improvement. This approach is particularly important for underutilized crops because commercial breeding investment is often limited or absent. The combination of characterisation and participatory breeding also contributes to the development of **new value chains and market opportunities**. Characterised and locally adapted populations can support niche markets linked to biodiversity, regional identity, organic production, and short supply chains.

INRAE-BAGAP worked with hemp, safflower and millet as relevant underutilized crops in the region of Rennes. These three examples are presented in detail in this report. These crops are historical crops with several uses in the studied region that have been forgotten. For each crop, INARE-BAGAP explored the literature about the cultivation history, biology and recent plant breeding trends. For each species, while selecting the PGR to work with the history of these crops, the high potential they represent for organic agriculture was considered.

Hemp cultivars for specific environments and end-uses

Cannabis sativa L. is a traditional crop used for fibre and seed production. The interest for the diverse uses of this crop is increasing as well for its agronomic quality, mainly for organic production. Because of the psychedelic effect of one of its compounds, the tetrahydrocannabinol (THC), many countries have regulations on *Cannabis* growing, also as fibre or seed crop, but recently these regulations are getting less tight for industrial valorisation (Ingvardsen et al., 2023). Until the 2000s, legal measures against *Cannabis* drug use in Western countries may have discouraged any hemp activities, including research (de Meijer, 1995). The environment has a strong influence on hemp biomass yield and qualities; therefore, hemp cultivars were developed for specific environments and end-uses which are very diverse (Figure 16). The harvest can be performed at different developmental stages depending on the use (Salentijn et al., 2015). According to the length of the cycle and the time of ripening, cultivars can be very different from an area to another.



- *Figure 16: Multipurpose hemp utilization (source : Salentijn et al. 2015, 10.1016/j.indcrop.2014.08.011)*

Hemp biology

Cannabis is dioecious and highly heterogeneous, making traditional breeding complex and time consuming. Cannabis is not an easy to breed because of two major obstacles to genetic improvement. As the plant is usually dioecious, the plants cannot pollinate themselves, and are therefore outcrossing by nature. Moreover, the reaction to day length is another constraint

which affects the phenological development, length of biological cycle, and yield. Besides these reasons, the farmers require the development of a range of varieties to cover different cropping conditions and different end products (Salentijn et al. 2015).

Regarding its sex differentiation, Grishko was the first to understand that all dioecious stands contain monoecious or intersexual types from which monoecious hemp can be bred (Grishko & Malusha 1935 and Grishko et al. 1937 in Salentijn et al. 2015). Hemp plant breeding focuses on managing the genetics of sex determination and sex-ratio bias with the goal of developing varieties optimized for specific end use. Producing sex-ratio-optimized hemp populations is currently expensive or impractical. For example, cannabinoid production relies on costly female clones or feminized seed. In contrast, male plants may have superior fibre quality, but there are no methods to produce all-male populations. For grain production, female-biased populations could increase yields, but a small percentage of males is still needed for pollination (Zahl, 2025).

Current hemp breeding situation

The current hemp varieties are descendant from very few ancestors including three gene pools: Northern and Central European ecotypes, Southern European ecotypes, and East Asian ecotypes (de Meijer, 1995). There is a renewed interest in hemp as a source of cellulose fibre and seed oil in Western European countries where non-food crops are provided profitable incomes such as Australia, the US and Canada. All Western countries, except France, have either never had a hemp industry, or have interrupted it for decades. A substantial hemp industry has survived only in Eastern Europe, the former Soviet-Union and China.

Today, the about 180 currently registered European hemp cultivars were developed starting from a few promising local landraces selected over hundreds of years by peasant farmers in areas of traditional hemp cultivation. Heterogeneous populations were originally grown throughout the world, as they thrived better, but then they were mainly bred for industry to obtain uniform cultivars thanks to monoecy trait.

In Europe, in the first quarter of the last century, cultivars were selected on the basis of the vegetative period length, height, diameter, weight, and in some cases, seed weight. Vegetation period length and stem yield are known to be in strong positive correlation with each other. A type of family breeding led to the development of varieties in Italy, Hungary, and Romania, all of them coming from the famous Italian landrace *Carmagnola*.

Traditional dioecious landraces were easily maintained by local farmers who produced their own seed, but today farmers must purchase sowing seed each year because monoecious cultivars immediately decline without careful selection and breeding (de Meijer, 1995 in Clarke and Merlin, 2016). For farmers, this situation is comparable to the one for all crops marketable as F1 hybrid varieties. Clarke and Merlin (2016) explained the complex management of

monoecious cultivars: "*genetic homogeneity of monoecious cultivars must be maintained each year by careful selection of monoecious parents and the creation of elite monoecious seed. Second-generation crops sown from elite seed consist almost entirely of monoecious plants, and are multiplied by open pollination to produce commercial sowing seed for fibre cropping. Third-generation fibre crops include up to 20% true male and female individuals resulting from inbreeding and natural genetic drift in the absence of human selection*".

Challenges for on-farm hemp breeding for organic agriculture

The situation complexity is demonstrated by the local cultivars' disappearances, the lack of adequate harvesting machinery and the outdated fibre extraction technology (de Meijer, 1995). The main objective of this work is to explore available genetic resources for all traits needed to valorise again the crop in organic for all its potential products, maintaining a low THC content. Availability of genetic biodiversity of cultivated hemp biotypes isn't enough. European landraces, for the most part, are stored in genebanks. Eurisco database counts 1400 accessions but very difficult to obtain because are mainly in Russia and Ukrainia. In USA, USDA database does not allow the distribution of hemp genetic resources. The two opposing factors of regulation aiming at reducing delta-9-THC content, and drug producers selecting from an ever-narrower gene pool have reduced cultivated hemp genetic biodiversity. Finally, the new needs of CBD types producers and the diversification of traditional hemp (for fibres and seed) seem to require an exploration of hemp genetic resources.

Collection of hemp genetic resources in LiveSeeding

Ten genetic resources centres were contacted, but only 5 were allowed to provide genetic resources of hemp, because of the potential use of the species for drug. Several countries answered that the legislation regarding hemp is particularly strict mainly for hemp accessions whose THC content are not known. For Ukrainia and Russia, it was difficult in current political conditions (Table 6).

Table 6: List and origin of hemp accessions characterised in LiveSeeding

Cultivar/ landrace name	Accession n°	Country-Gene bank	Biological statues of Accessions	Crop groups	Acquisition date	Origin	Biology
LKCSD	505 202	Poland	Advanced from landrace (central Russia)	Fibre plants		POL	dioecious

Cultivar/ landrace name	Accession n°	Country-Gene bank	Biological statues of Accessions	Crop groups	Acquisition date	Origin	Biology
LITZAP 12-119	503 007	Poland					
Elatta campana	508 293	Poland	Advanced	Fibre plants		ITA	dioecious
ROMTRA 03-82	505 012	Poland	Traditionnal	Fibre plants	2003		
Rastislavicke	SVK001 X15 00001	Slovakia	Landrace of southern European type	Fibre plants		SVK	
Krajova z Cervenika	SVK001 X15 00002	Slovakia				HUN	
Krajova - Zvolen	SVK001 X15 00003	Slovakia				SVK	
Karpaty 96	SVK001 X15 00004	Slovakia	Traditional		1997	UKN	
Gluchovskaja 33	SVK001 X15 00008	Slovakia				SVK	
Fedrina	SVK001 X15 00009	Slovakia	Advanced		1998	FRA	monoecious
Populacia	SVK001 X15 00012	Slovakia			2001	UKN	
Purini	LVA02775	Latvia	Traditional		October 2019		
Adzelviesi	LVA02636	Latvia	Other		February 2015		
Vietejas	LVA02701	Latvia	Other		May 2017		
USO 31	05X 1500007	Czech Republic CRI prague				UKR	monoecious
Cañamones	BGHZ4298	Spain Cita Zaragoza					
Cañamo	BGE032588	Spain Centre National de recursos					

Cultivar/ landrace name	Accession n°	Country-Gene bank	Biological statues of Accessions	Crop groups	Acquisition date	Origin	Biology
		fitogen eticos					

Characterisation performed during the hemp cycle

The observed traits are described in the related Zenodo dataset, the following scheme (Figure 17) summarises how and when the traits have been collected during the plant cycle.

For measuring the cannabinoids contents, there are the two main methods of testing for cannabinoids are gas chromatography (GC) or high-performance liquid chromatography (HPLC). The former is not able to distinguish between THC-A and THC since it decarboxylates the THC-A during testing, so the value derived from GC would actually be total THC. However, decarboxylation does not occur with HPLC that has been used by Labexan lab[6] which has proceeded to the analysis for our experiment, so separate values for THC-A and THC will be reported. The THC content of cannabis is the concentration of delta-9-tetrahydrocannabinol (THC) expressed as a percentage by weight. THC is the main psychoactive ingredient in the cannabis plant, but the majority of the THC in cannabis exists as a precursor molecule, tetrahydrocannabinolic acid (THCA), a non-psychoactive cannabinoid.

The potential maximal value is therefore calculated from the concentration of the two molecules, according to the following equation: % Total THC = % THC + (% THCA x 0.877).

6 https://www.labexan.com/interview-magazine-soft-secret-labexan-le-laboratoire-specialise-dans-lanalyse-qualitative-du-chanvre/

This conversion factor accounts for the weight of CO2 lost during thermal decarboxylation (Sgrò et al., 2021)

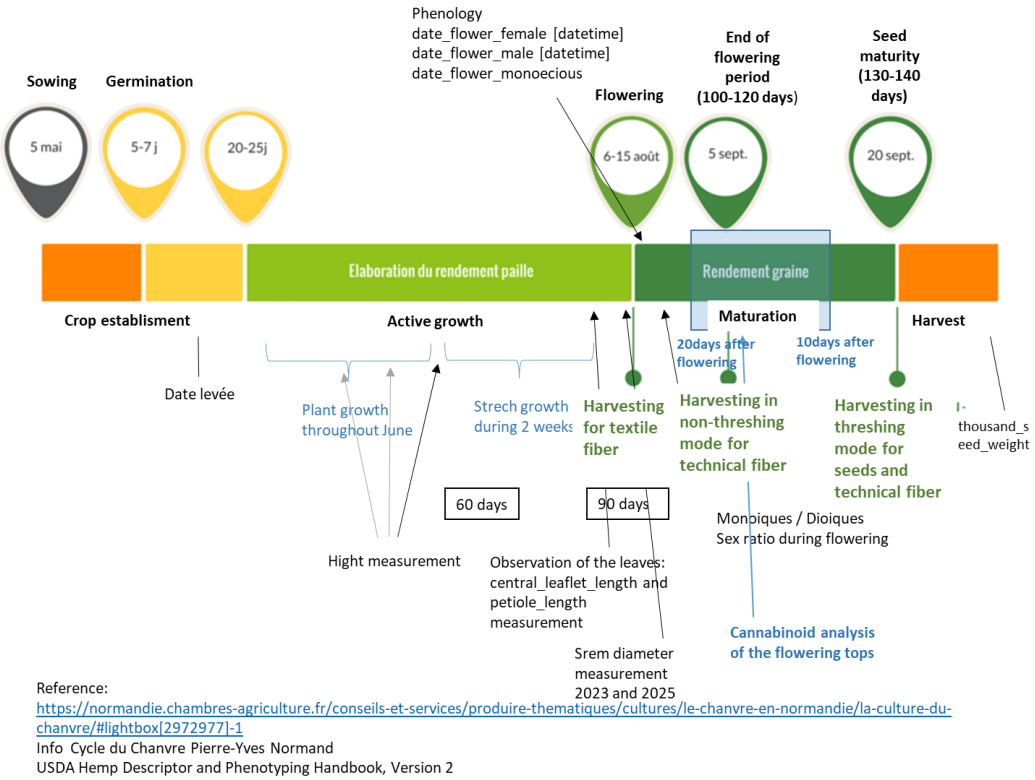


Figure 17: Type and chronology of PGR characterisation for hemp

Results hemp

The main difficulty with seed samples from genetic resources is often the germination rate. Because of this, only few individual plants were observed during the first year in 2023 (Table 7).

Table 7: Number of hemp plants phenotyped each year

Hemp trial	2023	2024	2025
Number of accessions	18	17	17
Range of plants /accession	2 to 19	38 to 177	32 to 115
Total number of observed plants	127	1503	1012

Data for several descriptors has been collected. Here we illustrate the observations for the two most important criteria that influence the plant breeding strategy: sex determination (Figure 18) and THC (tetrahydrocannabinol) contents (Figure 19).

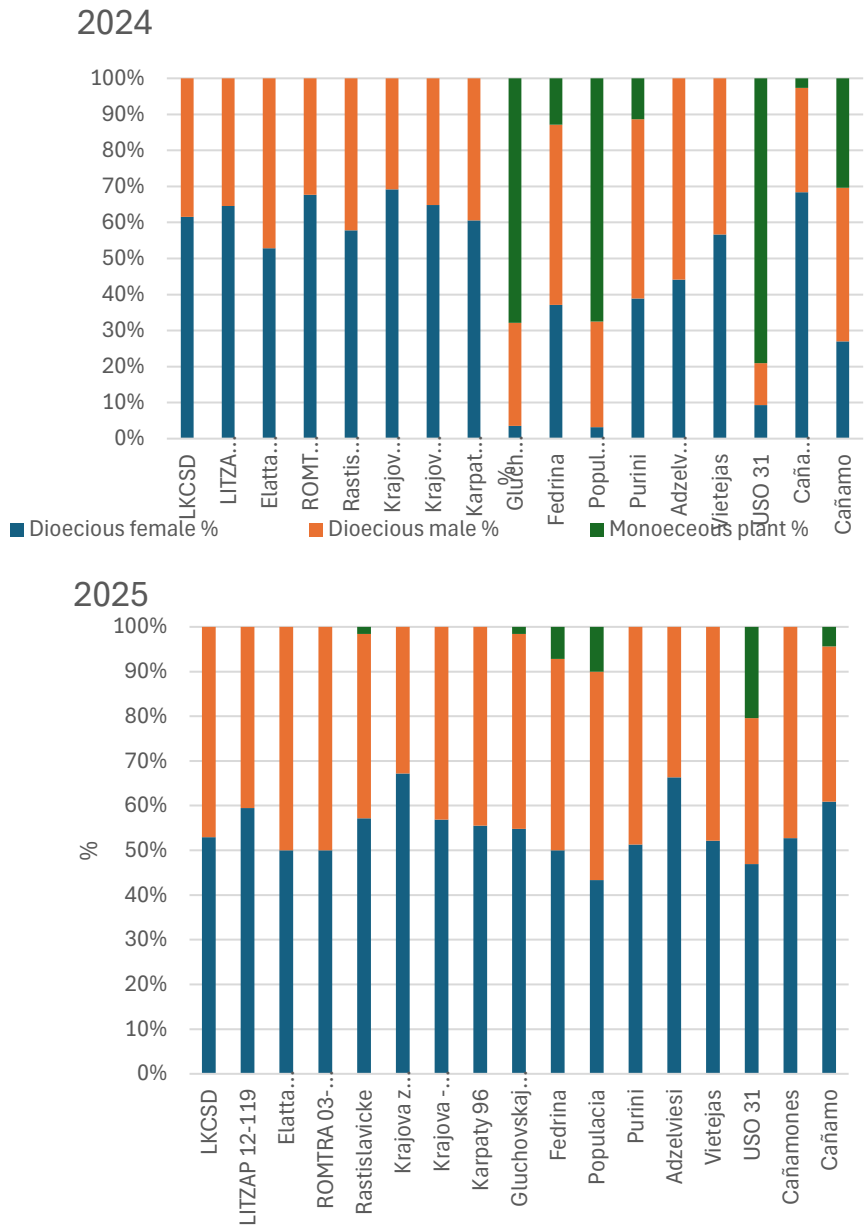


Figure 18: Histogram of the percentage of sexes present (dioecious female, dioecious male, monoecious plants) for each accession in 2024 and 2025

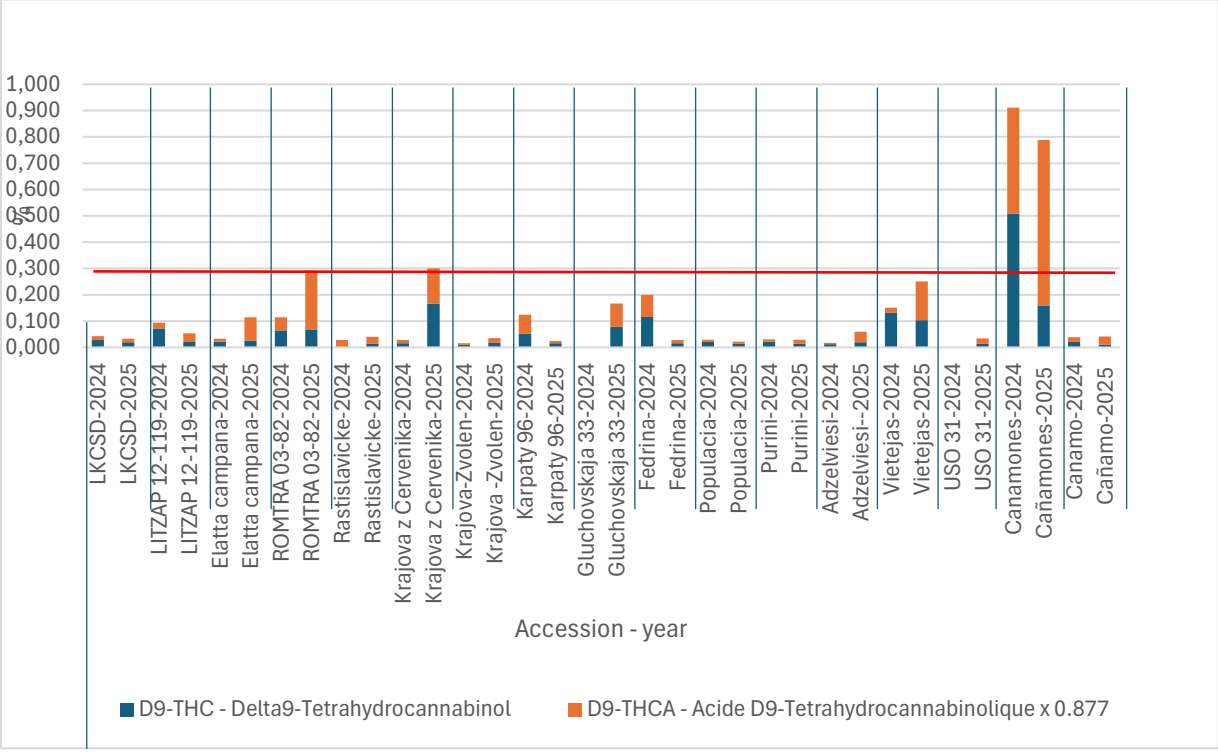


Figure 19: Histogram of the D9-THC values (D9-THC and D9-THCA x 0.887) for the accessions observed during LIVESEEDING project.

All accessions are under the legal threshold (0.3%) except one Spanish accession which can be considered as a *C. indica*, because of the THC content but also of its morphology. Nevertheless, an annual variability is notified for some accessions. A last trial in 2026 will be implemented to observe the most variable accessions.

Discussion of main hemp characterisation results

Given its practical implications in both cultivation and breeding, **sex expression** is considered to be one of the most important factors in the genetic improvement in hemp (Faux et al. 2016). The development of stable monoecious cultivars (hermaphrodite plants, carrying male and female flowers on the same plant) is an important breeding goal for conventional breeders. In dioecious cultivars, male and female plants show different phenological and morphological traits, while the monoecious cultivars are more uniform in plant height, stem and seed production (Salentijn et al., 2015). However, while monoecious hemp is better for dual harvest of fibre and seed, it is considered that dioecious genotypes are superior for fibre production. Monoecious hemp, with the female and male flowers located on the same plant, has generally the female XX karyotype (Faux et al., 2016), but the key factors that are driving this sexual dimorphism are still unknown (Salentjin et al. 2015). The sex determination seems to be more stable and definite in the male XY karyotype, showing the typical male morphology.

However, the ability to develop male flowers on monoecious XX karyotypes shows that the male-determining and/or female-suppressing factors are not necessarily located on the Y chromosome (Faux et al, 2016). This complex genetical determinism is still unknown but seems strongly influenced by the environmental conditions. The relative expression of female and male flowers, or the degree of monoecy, varies across generations with the potential to revert to dioecy (Faux et al., 2016). The development of modern monoecious hemp (low-THC) varieties was initiated by the introduction of the naturally monoecious trait from a Central Russian landrace to a Max Plank Institute breeding program in the 1930's. Then, these monoecious plants were subsequently inbred and used as the pollen donor to create Fibrimon, and related European fibre type varieties (Garcia-de Heer, at al., 2024). Our sample of Febrina has been bred from Fibrimon for its monoecious trait. We can observe that Febrina is losing its monoecious traits during the two years 2024-2025. Without selection to favorise monoecious plants, in 2025, the dioecious sex system is becoming dominant for the accessions.

Fiorentino et al. (2024) have pointed out the influence of environmental and agronomic factors in shaping the **chemical composition** and biological activity of cannabis extracts since its huge chemical complexity (numerous cannabinoids, terpenes, non-cannabinoid phenols, flavonoids, alkaloids, and other secondary metabolites). We have observed a large variability from one year to the other of THC contents, but observing that some accessions increased and other decreased these amounts.

The European Union (EU) allows and subsidizes the growing of fibre and oilseed cultivars of Cannabis sativa L. with respect to the THC (Δ9-tetrahydrocannabinol) content limit of 0.03 g of THC per 100 g (Sgrò et al. 2021), As of January 1, 2023, THC maximum levels in hemp seeds and products derived from them came into force: This maximum level are 3 mg/kg for hemp seeds, hemp seed flour and hemp seed protein and 7.5 mg/kg for hemp seed oil and are set out in Regulation (EU) No . 2023/915[7].

Except one Spanish accession (Cañamones) which also has shown an *C. Indica* phenotype (with a specific branching habitus, as described in McPartland, 2017), the THC contents (even if we added the amount of the precursor molecule, tetrahydrocannabinolic acid (THCA) with the application of the factor 0.887), all accessions were under the maximum threshold.

Overall considerations for hemp organic plant breeding

The hemp industry is a small sector in Europe. For instance, there is only one breeder in France (Thouminot, 2015), but the potential breeding areas are numerous. The only breeder that exists

[7] For the THC level, regulations are evolving, the last one is dated 25 avril 2023 about the 0.3% threshold of THC. The UE regulation had previously established this limit, under the Common Agricultural Policy (CAP), Regulation (EU) 2021/2115, and had applied the limit 0.2% THC since 1 January 2023. But the limit changed in April 2023, because this reduction put Europe at a competitive disadvantage in the industry. it is confirmed in this document: https://agriculture.ec.europa.eu/farming/crops/hemp_en and in this one: https://sanobiotec.com/thc-level-restored-to-0-3-in-the-eu/ .

in France to our knowledge (*Hemp it*), has concentrated the effort on industrial production exploiting monoecy. In fact, the concentration of hemp seed production by one breeder in one area is mainly due to the constraint to control this very unpredictable trait. From our experience, the THC rate is easier to maintain that monoecy.

For the organic sector, this crop with many potentialities from agronomical and productive points of view deserves more attention for breeding. Perhaps, it could be a huge opportunity to redevelop its diversity based on dioecious accessions.

The question then arises: "*Who should decide on the breeding areas for hemp?*" (Thouminot, 2015). Meanwhile, some local initiatives aim to re-localise hemp production to develop industries from the diversity of its products, but adapted cultivars and seeds are missing. We suggested to clarify the conditions to support a multi-actor plant breeding project managed by several actors such as farmers, industrial and local authorities.

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3.3.5 Example of LiveSeeding results on Zenodo: focus case on reviving underutilised crops - SAFFLOWER (*Carthamus tinctorius L.)* in Brittany, France

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DATASET DOI: *https://doi.org/10.5281/zenodo.21975790*

Description of the safflower uses and cultivation history

Safflower (*Carthamus tinctorius L.)* is an underutilized oilseed crop which has been known for thousands of years and has been used for many purposes. For centuries, it was grown for its flowers, which were rich in various pigments, and more recently for its seeds and oil.

Safflower is an erect, spiny, thistle-like, bushy, annual, predominantly self-compatible, day length-neutral or long-day, and diploid (2n= 2x= 24) herb. This species belongs the family *Asteraceae*. Historically, the term *Carthamus* came from the Arabic words "*quartum*", or "*gurtum*" that refers to the natural dye obtained from safflower petals (Singh & Nimbkar, 2006). It is one of the humanity oldest domesticated crops not only due to its high-quality edible oil, but also due to its broad clinical applications. Safflower was indigenous and cultivated as herb in Egypt, then in Morocco, China and India for carthamin, a yellow or red coloured dye material in ancient times, as early as 4500 BC. The oil was used as an unguent and for lightening as well. By the 18th century, Egyptian safflower dye was used in Italy, France and Britain to colour cheese and flavour sausage. In China and many other countries, the yellow type dye has been increasingly used for colouring food, beverages and clothes. Before cheaper aniline dyes became available, Carthamin dye was used extensively to colouring cloth until the 19th century. At present, the safflower corolla pigment, greatly appreciated in Japan, is used for dye cloth (Ekin, 2005).

Safflower was later transferred to Europe and other countries (Majidi & Zadhoush, 2014). Safflower was introduced into North America in the late 19th century (Rabbani, 2026. Nowadays, the safflower products show great potential in the market of the world with its important contribution of edible oil or industrial oil as well as its highly nutritious by-products for animal feed and its petals as colouring for food and textile (Ekin, 2005).

Genetic resources and known info on genetic diversity of safflower

Although safflower has been considered as a "strongly domesticated" crop (Dempewolf et al., 2008), it only demonstrates moderate morphological variability from its wild progenitor(s) and has been subjected to limited breeding effort (Pearl & Burke, 2014). The cultivated safflower was originated from the Middle East, and then introduced into India–Pakistan (as a secondary centre. The population structure analysis performed in recent studies and reviewed in Quin at al. (2025) showed four clusters within the safflower germplasm, with no strong correlation between geographic origin and estimated genetic diversity. Based on AMOVA, the genetic diversity within populations was more pronounced than between populations, and most of the genetic variation was present within populations (Hassani et al., 2020), while there was no strong correlation between geographical origins and estimated genetic diversity. All results have showed high genetic diversity for both agro-morphological and molecular analysis in the examined safflower germplasm.

Safflower in organic agriculture

Rapeseed, sunflower and soybean are among the most important oil seeds crops in the world, and in the EU, they are on the top position[8]. Other species are also produced in smaller quantities (oilseed flax, camelina, hemp)[9]. In the organic sector, sunflower is the most important because it is less problematic than rapeseed. Soyabean is meanly grown for feed, but it is challenged in the Northern hemisphere by a lack of adapted varieties and competition from countries, where it can be grown more easily (Willer et al. 2020). Linseed, hemp, poppy, camelina and oil pumpkin are other oilseeds that merit attention. The interest of health is stimulating the expansion of minor oilseed crops (FiBL, 2023).

A demand exists for varieties or crops with specific adaptation to the organic farming system. Safflower (*Carthamus tinctorius* L.) is a crop that deserves attention because of its versatility (Elfadl et al., 2009). Currently, only a few hundred hectares of safflower are cultivated in southern Europe. Safflower is primarily produced by farmers with own oil processing facilities on-farm, and is sold directly to consumers as niche products. As market opportunities for organic specialty crops are increasing, safflower merits attention to further develop organic production techniques and explore their economic potential in areas with hot and dry summers due to climate change.

Safflower materials tested in LiveSeeding characterisation

Twenty accessions (representing 5 countries of origin) from 2 European genebanks (Institute of Plant Genetic Resources "Konstantin Malkov" in Bulgaria and National Centre for Biodiversity

[8] https://managementjournal.usamv.ro/pdf/vol.19_4/Art37.pdf
[9] https://eng-groupes-filieres.hub.inrae.fr/presentation-of-the-groups/oilseed-group

and Gene Conservation in Hungary) have been grown. Only few plants per accession have been observed (between 2 and 13 individuals) because of poor germination (Table 8).

Table 8: List and origin of safflower accessions characterised in LiveSeeding

Genebank	Accession number	Name	Collected in	Type of cultivar	Origin
National Centre for Biodiversity and Gene Conservation in Hungary	RCAT040144	s. marrakech	1961	Cultivar	Maroc
	RCAT040146	Zailai Beni	1975	Cultivar	JPN
	RCAT040147	mogami beni	1975	Cultivar	JPN
	RCAT040148	jászberényi tf.	1977	Landrace	HUN
	RCAT040150	izsáki tf.	1978	Landrace	HUN
	RCAT040162	nagykátai tf.	1979	Landrace	HUN
	RCAT040169	mosonmagyaróvári tf.	1979	Landrace	HUN
	RCAT040171	nyíregyházi tf.	1980	Landrace	HUN
	RCAT040173	nagykállói tf.	1980	Landrace	HUN
	RCAT040177	mályi tf.	1980	Landrace	HUN
	RCAT040179	törökszentmiklósi tf.	1980	Landrace	HUN
	RCAT040181	adácsi tf.	1980	Landrace	HUN
	RCAT040197	orosi tf.	1981	Landrace	HUN
	RCAT040203	tarnamérai tf.	1981	Landrace	HUN
	RCAT040208	pcn	1981	Cultivar	Inde
	RCAT060656	-	2004	Botanical garden Nancy	FRA
Institute of Plant Genetic Resources	1981-CAR-TI-2	Draa Kaute Tige	1981		
	1981-CAR-TI-3	D 1846/75	1981		
	1981-CAR-TI-5	Inerme RA	1981		
	1989-CAR-TI-26	Rinconada	1987		

In 2023 and 2024 growing seasons, plant phenology traits (date to 50% flowering, days to physiological maturity, uniformity of maturation) and morphological traits (growth habit, plant height, branching, leaf shape, extent of leaf spininess, corolla colour in bloom, *capitulum* shape, seed colour, seed shape and thousand seed weight) have been observed (Figure 20).

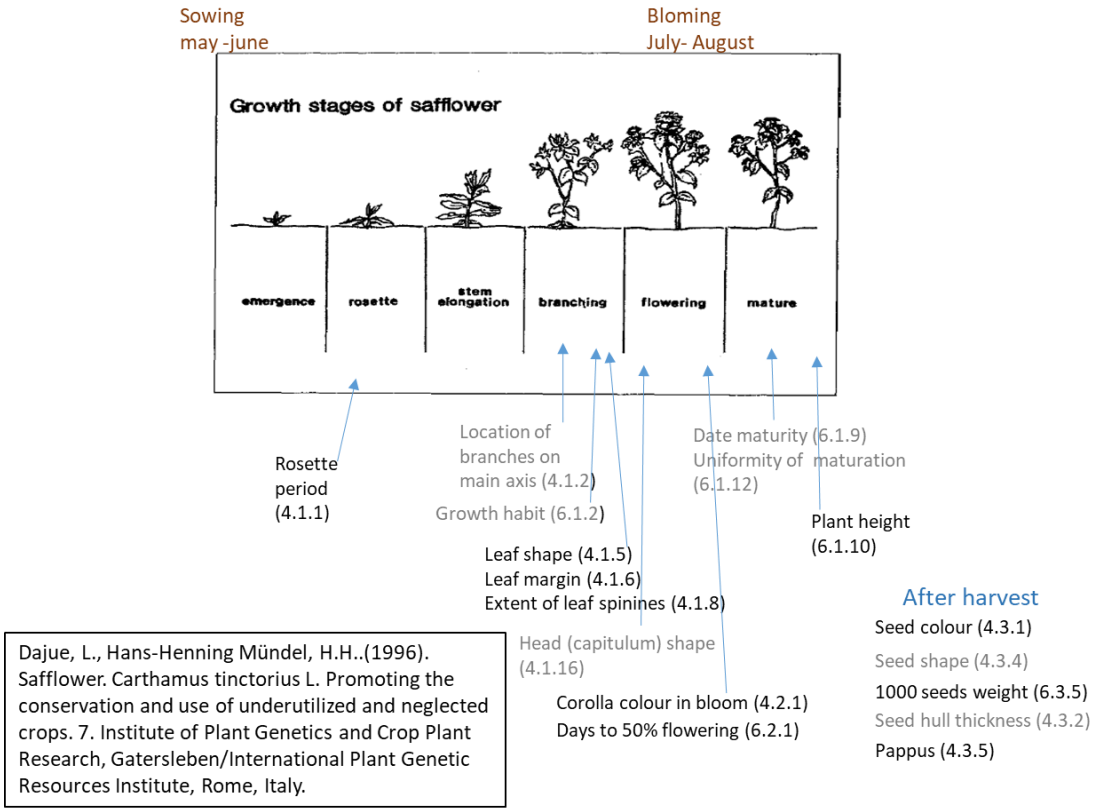


Figure 20: Safflower growing stages and characterisation descriptors

Results- Safflower

Seasons 2023 and 2024 were very different for climate: 2023 summer was very wet and cold, while 2024 summer was very hot and dry. Both seasons were challenging for the safflower crop (Figure 21). The TKW (Thousand Kernel Weight) was very different in 2023 and 2024 harvested seeds. In 2023, the range of the TKW was from 16.6 to 39.4 gr, and only 12.0 to 34.7 in 2024, due to the very dry conditions. In 2024 only one accession exceeded 30gr in TKW (Figure 22). In 2025, no plant germinated from these seeds. If we look at the plant density in 2024 based to the TKW of the sown seeds, we notice that only one plot has more than 10 plants when the TKW is < 30gr, and all plots except one had more than 10 plants when the TKW was > 30gr (Table 9).

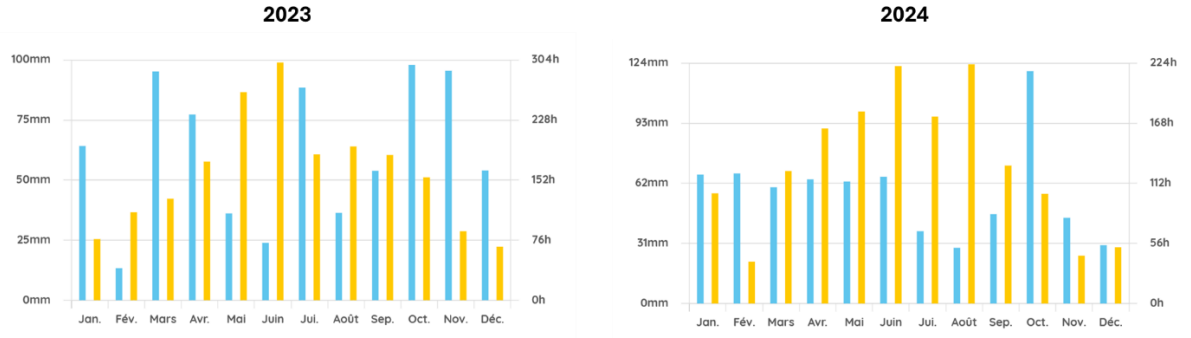


Figure 21: Histogram of rainfall (blue, in mm/month) and sunshine duration (in hours/month) during 2023 and 2024 in Rennes (Brittany, France)

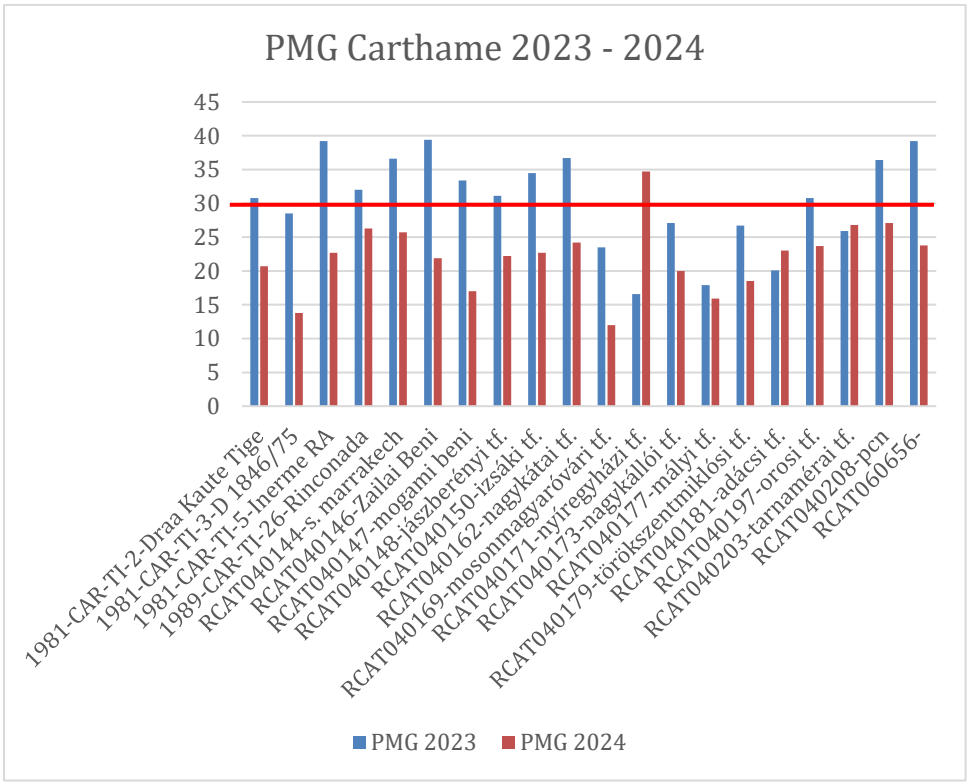


Figure 22: Histogram of the Thousand Kernel Weight (TKW) of safflower collection harvested in 2023 and 2024 in Rennes (Brittany, France)

Table 9: TKW (Thousand Kernel Weight) of safflower accessions in 2023 and respective plant density in 2024 from the seeds harvested in 2023

Accession	TKW g 2023	Plants /m² in 2024
RCAT040171-nyíregyházi tf.	16,6	3
RCAT040177-mályi tf.	17,9	1
RCAT040181-adácsi tf.	20,1	1
RCAT040169-mosonmagyaróvári tf.	23,5	4
RCAT040203-tarnamérai tf.	25,9	24
RCAT040179-törökszentmiklósi tf.	26,7	4
RCAT040173-nagykállói tf.	27,1	3
1981-CAR-TI-3-D 1846/75	28,5	6
1981-CAR-TI-2-Draa Kaute Tige	30,8	28
RCAT040197-orosi tf.	30,8	43
RCAT040148-jászberényi tf.	31,1	24
1989-CAR-TI-26-Rinconada	32,0	4
RCAT040147-mogami beni	33,4	25
RCAT040150-izsáki tf.	34,5	14
RCAT040208-pcn	36,4	11
RCAT040144-s. marrakech	36,6	32
RCAT040162-nagykátai tf.	36,7	39
1981-CAR-TI-5-Inerme RA	39,2	16
RCAT060656-	39,2	15
RCAT040146-Zailai Beni	39,4	40

From the morphological point of view, some farmers have drawn our attention to one criterion: the presence or absence of spines on the leaves. In fact, their ambition is also to crop safflower for animals to graze the crop as it is described in semi-arid region and Italy (Leshem, et al, 2001; Danieli et al., 2011). For winter type, the crop is capable to grow after grazing and to still produce seeds. Only four out of twenty accessions have met this requirement (Table 10).

Table 10: Safflower accessions classified by the number of spines on the leaves

Non spiny/ very few spines	Few spiness	Spiny	Heterogeneous
RCAT040162 RCAT040171 RCAT040197 1981-CAR-TI-3	RCAT040144 RCAT040179 RCAT040181 1981-CAR-TI-2 RCAT040148 RCAT040177	RCAT040146 RCAT040169 RCAT040147 RCAT040208 1989-CAR-TI-26	RCAT040173 RCAT040203 1981-CAR-TI-5 RCAT040150

Discussion and general considerations – Safflower

Previous experiences in Switzerland (Frick et al, 2005), in Germany (Elfald et al., 2009) were very positive and were encouraging for exploring the potential of the species in Brittany. An organic farmers organisation (FRAB, *Fédération régionale des agrobiologistes de Bretagne*) reported in their magazine a two years trial in Brittany: "In 2016, a dry year, yields were around 8 quintals per hectare at most, while in 2017, with a wet summer, we had no yield at all. We realized after harvesting that the seeds hadn't been fertilized; they were empty. The flowering period is very fragile in case of excess water! (Choupault, 2018)". In the LiveSeeding experience with this crop, we have faced also the problem of a very dry summer that had the same consequences as the wet summer of 2017.

Therefore, we have to explore two directions: (1) enlarging the panel of observed accessions, and (2) exploring agronomical conditions such as autumn sowing to allow the plant to be more developed before adverse conditions in summer.

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3.3.6 Example of LiveSeeding results on Zenodo: focus case on reviving underutilised crops - Proso millet (*Panicum miliaceum*) and Indian banyard millet (*Echinochloa frumentacea*) in Brittany, France

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DATASET DOI: *https://doi.org/10.5281/zenodo.21786531*

General info on "millet" crop

"Millet" is a generic name for various cereals characterised by their small grains generally cultivated in dry tropical regions. They are annual monocotyledons belonging to the *Poaceae* family (formerly known as *Gramineae*) and the *Panicoideae* subfamily, and are used for human and animal consumption.

Despite their historical significance, millet cultivation has declined due to the dominance of major cereals like wheat and rice, driven by the development of industrial agriculture. However, recent global challenges such as climate change, water scarcity, malnutrition and health awareness have renewed interest in these nutrient-dense grains (Muskan et al., 2025). Millet is recovering an interest worldwide. Through the Millet Year in 2023, FAO[10] wished to raise awareness of the multiple benefits of millets, from nutrition and health to environmental sustainability and economic development, since it can be cultivated in various adverse climates and arid regions with minimal external inputs.

[10] https://www.fao.org/millets-2023/about/en

Millet in Europe

In 2024, it was mainly produced in Asia and Africa, with less than 2% of the production in Europe. However, millet has been cultivated in Europe for millennia. In Europe, millets were consumed as porridge and used in bread until the 18th century, when millet was still a staple food (Muskan et al, 2025). During the second part of 20th century, millet production was reduced by more than 90%, falling to 4,568 tons in 1984. It began to increase at the start of the 21st century.

In France, according to Poissonnier (1994), millet still held some importance in the *Talmondais* region of *Vendée* during the 20th century. Millet production in this region accounted for nearly half of the national production in 1934. Between the 1950s and the end of the 20th century, millet almost disappeared from French regions. At the end of the 20th century, no millet acreage was recorded by the FAO in France.

Millets are C4 plants, meaning they can grow in harsh or even arid climates (Nielsen and Merle, 2017). Common millet (*Panicum miliaceum*) can be grown as a rainfed crop in arid lands with only 200–500 mm of average annual rainfall. Millet therefore has a very short growing cycle of 80 to 111 days to maturity when grown in hot, dry European climates in Italy (Calamai et al., 2020). The cycle is even faster in semi-arid or arid zones, with a growing season of 60 to 90 days.

However, millet requires significant heat to complete its growth cycle. Indeed, the base temperature for millet growth is 10°C, considerably higher than that of maize, which is 7°C (Calamai et al., 2020). When the temperature is below this base temperature, the plant cannot grow. Below this temperature, the cumulative degree-days required for plant growth have been estimated for millet to be between 581 and 899°C (Calamai et al., 2020). Sowing temperatures must be sufficient, between late April and mid-June, with a soil temperature of at least 12°C (Chambre d'Agriculture Centre-Val-de-Loire, 2019).

Consumer perception plays a pivotal role in the market expansion of millets, yet a lack of awareness, confusion in terminology, and competition with mainstream grains continue to limit their adoption. Addressing these issues is crucial to positioning millets as a viable and attractive alternative to conventional staple crops. The global expansion of the millet market is constrained by multiple factors, with limited consumer awareness being a key impediment Muskan et al., 2025).

Materials tested in the LiveSeeding project

There is a large number of genetic resources of millets at ICRISAT (International crop research institute for semi-arid topics)[11] where the genebank has played a pivotal role in the distribution

[11] https://genebank.icrisat.org/IND/orderGermplasmDashboard

and dissemination of small millet germplasm in the world. For the project we planned to observe the European GR from this collection. The curator advised us to explore also the Banyard millet which is a very tasty millet. They conserved 849 Proso millet and 749 Banyard millet. Nevertheless, our request for Proso millet and Barnyard millet germplasm was delayed due to pending approval from the Focal Point of the Government of India. Because of the issuing of revised guidelines by the Treaty Focal Point, ICRISAT was not able to send these seeds before the end of 2025. Meanwhile, INRAE got a smaller collection of both species by IPK genebank in Gartersleben Germany, where 185 Proso millet and 15 Banyard millet accessions are listed.

The first steps of millet characterisation from 2022 to 2024 have been funded by the Foundation of a local organic food company (Olga Triballat). An amendment added millet in LiveSeeding WP1 for 2025 et 2026 experimental seasons (replacing flax in the original plan).

For the first exploration, we evaluated 38 accessions of Proto millet (*Panicum miliaceum*) and 14 accessions of Barnyard millet (*Echinochloa frumentacea*) in Breton conditions and for culinary qualities (Figure 23). In 2026, a second set of 150 accessions from ICRISAT will be evaluated. We will also investigate European origins et a large set of Russian accessions.

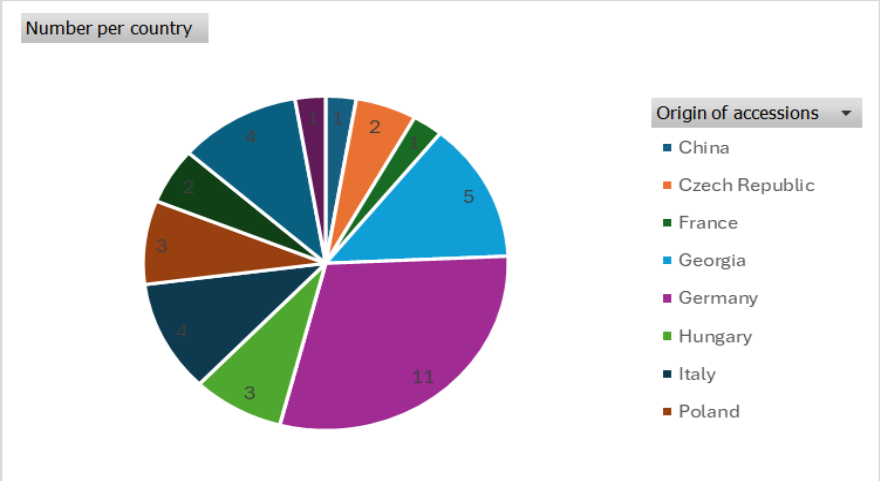


Figure 23: Origin of the millet PGRs characterised in 2023 and 2024 in Rennes (Brittany, France)

Results of millet characterisation 2023-2024

The millet WP1 activities will cover the prolongation of the agronomical and culinary evaluation of millet accessions until 2026. The evaluation of millet genetic resources needed at least two years, the first year allowed the morphological/phenological characters and the seed amplification in order to enough raw grain for several culinary preparations (Table 11 and Table 12).

Table 11: Morphological and agronomical traits of IPK proso and banyard millets

Trait	mean	min	max
Plant height (cm)	135	69	175
Panicle length (cm)	25	11	42
Yield (kg/ha)	2649	96	4944
Accumulated temperature index (ATI)/growing degree days (GDD) (°C)	647	352	1005
Cycle length (days)	110	97	120
Thousand kernel weight (TKW)	5.3	3.1	8.1
Number of tillers including main stem, tillering	3.7	1.4	7.4
Number of grains per panicle	739	32	1718

Table 12: Phenological traits of IPK proso and banyard millets

	Proso millet (*Panicum miliaceum*)		**Banyard millet *(Echinochloa frumentacea)***	
	number	**heading period**	**number**	**heading period**
Early	**7**	Heading before July 15th	**1**	Heading before August 1st
Medium	**24**	Heading occurs between July 15th and August 15th	**9**	Heading occurs between August 1st and September 15th
Late	**7**	Heading after August 15th	**4**	Heading after September 15th

The culinary and end-use values have been explored on several aspects: the raw grains (forms, colour, regularity), the cooked grain (water absorption, time of cooking, agglomeration of the grains, texture in the plate, bitterness ...), and aptitudes to specific recipes such as galette, porridge, pound cake or bread).

All the aspects have been combined in order to create new populations (PEPS, Evolutive populations with pre-selected characters) (Table 13).

Table 13: PEPS composition and traits from IPK proso and banyard millets

Code PEPS	Number of accessions in the PEPS	TKW	Earliness	"Pre-selected" Criteria
PEPS_GG_M	4	6,7	Medium	Grain size with TKW>6
PEPS_GG_P	5	6,7	Early	Grain size with TKW>6
PEPS_poly_MT	7	5,7	Late	Accessions with the best taste qualities, whether in salty or sweet preparations. Accessions with opposing qualities (e.g., good in sweet, bad in salty) are not included.
PEPS_poly_P	6	5,9	Early	Accessions with the best taste qualities, whether in salty or sweet preparations. Accessions with opposing qualities (e.g., good in sweet, bad in salty) are not included.
PEPS_sucre_M	11	5,7	Medium	Accessions with the best results in the sweet recipes of porridge and pound cake
PEPS_sucre_P	6	6,0	Early	Accessions with the best results in the sweet recipes of porridge and pound cake
PEPS_sucre_T	8	5,8	Late	Accessions with the best results in the sweet recipes of porridge and pound cake
PEPS_Pandiffus	22	5,7	All precocity	All accessions with a diffuse panicle, regardless of earliness. Its main objective is to be a highly diversified PEPS with 22 accessions.
PEPS_pain	5	6,2	All precocity	All accessions identified as interesting in the tasting trial for bread (Napping[12])

Further work in 2025-2026 and general considerations on safflower value chain

Two objectives for the years 2025/2026: (1) to validate the PEPS strategy checking that the selected traits will be maintained through generations and (2) to explore the 150 ICRISAT accessions in the same way as IPK accessions explored from 2022.

For the point 1, the PEPS have been multiplied in one site in 2025, and the second multiplication will take in 2 sites in 2026 before evaluation for culinary traits. The ICRISAT accessions will be observed for phenological and morphological traits, and multiplied in order to proceed to culinary evaluation in 2027.

[12] Vindras C., Sinoir N., Coulombel A., Taupier-Letage B., Rey F. (2018) Tasting guide: Tools to integrate organoleptic quality criteria into breeding programs. Technical booklet. Diversifood Project. https://organic farmknowledge.org/tool/38095

General consideration on safflower activities

Our work suggests working in parallel on all aspects from seed to plate with all stakeholders involved, from breeding to marketing. The objective is also to leverage the ecological benefits of this crop to promote the diversification and resilience of food systems (C4 plants, ground cover, and allelopathic effects). Some farmers also appreciate the ability to re-select within mixtures and populations. Organic farmers are often seeking local value through direct or short-supply-chain sales. However, there are a few companies that collect millet in France, such as the CORAB cooperative, ID Grain, AgroLogic, and Biograin (a subsidiary of the Pays de la Loire Agricultural Cooperative) (Joubrel, 2020) and no one in Brittany where LL FR1 experimentation took place.

To encourage the consumption of millet by the general public and create and develop a market, a culinary approach will be maintained to raise awareness and also to properly characterise the "technological" potential of each PEPS and its organoleptic qualities, particularly taste and texture, especially for bread. PEPS can evolve as new farmers' cultivars or notified as OHM "organic heterogeneous material". This legal framework provides a space for diverse cultivars such as PEPS for organic agriculture.

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3.1.7 Example of LiveSeeding results on Zenodo: Reviving traditional vegetable varieties in Geneva, Switzerland

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Info Box 2

Landraces and farmer populations

Landraces and farmer populations constitute some of the most important components of agricultural biodiversity and represent a valuable reservoir of genetic variability, local adaptation, and traditional knowledge. Developed and maintained by farmers over generations through continuous selection under specific environmental and cultural conditions, these heterogeneous plant populations are closely linked to local food systems, rural heritage, and agroecological resilience. Unlike uniform commercial cultivars, landraces and traditional populations often display high levels of intra-population diversity, enabling them to adapt dynamically to changing environmental conditions, biotic stresses, and low-input farming systems. Despite their importance, many landraces and traditional farmer populations have experienced severe decline during the last decades due to agricultural intensification, market standardization, replacement by modern hybrids, rural abandonment, and the erosion of traditional farming knowledge. As a result, numerous locally adapted populations are now underutilized, endangered, or maintained only by a small number of farmers. Their revival increasingly depends on effective strategies that connect conservation with practical utilization in contemporary farming systems.

Characterised landraces and farmer populations can support the development of niche markets, local gastronomy, short supply chains, and regional identity. Increasing consumer interest in heritage foods, biodiversity-friendly production, and traditional varieties creates new opportunities for the economic valorisation of local genetic resources. Documented information on origin, adaptation, quality traits, and cultural relevance can enhance the visibility and market recognition of traditional populations.

ProSpecieRara (Figure 24) *is an organisation dedicated to the conservation and promotion of cultivated biodiversity and livestock breeds in Switzerland. We are a national foundation that has been active since 1982; we are mostly funded by our members. The strategies for conserving agrobiodiversity differ depending on whether we are talking about animal breeds – that is, registers and genealogy – or fruit varieties, where trees live longer than humans and varieties can be grafted; or vegetable varieties, where the focus is on seed propagation.*

Our conservation work takes place in situ, under dynamic conditions, and complements the Swiss Confederation's efforts under the action plan for the conservation of plant genetic resources. Conservation alone is not enough, so we are also committed to the dissemination and promotion of these varieties and animal breeds.

Introduction

As part of the LiveSeeding project, ProSpecieRara has supported the amelioration, characterisation and propagation of some vegetable regional selections from Geneva, with a view to promoting their production and marketing on the local market. The collaborative selection work was carried out by Semences de Pays in collaboration with the organic farmers involved, whilst genetic characterisation and research aspects were handled by the Hepia High-School of Agronomy.

For centuries, the selection of the cultivars has been the fact of the farmers only. The interspecific relation between a plant, who wanted to grow, humans, who wanted to eat it, and the earth, who gave specific pedoclimatic context and constraints has produced, with the participation of the bees, the so-called "Land-Races", varieties who were reflection of the land, of its inhabitants, of their taste.

The agronomic selections, the registration of the varieties, the standardization of the production, the modern technologies, the globalization of the markets, have made these landraces almost history in a big part of the western world. They are now mostly in the hands of conservation institutions, either national action plans for the preservation of PGR according, or NGOs, like ProSpecieRara in Switzerland, supported by the society for the preservation of cultivated biodiversity,.

Conservation and selections

The region of Geneva, Switzerland, and the Plainpalais plain in particular, is universally recognised as the 'cradle of market gardening in Switzerland'. Seed selection has been practised here since the 16th century. The significant contribution of the Huguenot market gardeners of the Refuge, who came from the south of France with their varieties and expertise, and the creation of guilds such as the 'Plantaporrets' form part of Geneva's history and national myth. The importance of this heritage is reflected in many street names in the Jonction district, or in the motto of the municipality of Plainpalais: "We cultivate the fields we know how to defend!"

Compared to other regions, particularly in Switzerland, there is a deeply rooted tradition of varieties here that is a source of pride. Most of these varieties bear a local name.

The family Grosjean, in the Geneva suburb of Chêne-Bougeries, have been selecting and propagating vegetable seeds for selling companies and for their own use, for three

generations, in farmers' conditions. Most of their varieties were regional specialties, bearing local names.

Founded in 2009, 'Semences de Pays' is an association dedicated to the selection, preservation and propagation of seeds from vegetable varieties sourced mainly from local farmers, or from local varieties obtained from gene banks or conservation networks.

It is a modest yet professional organisation that provides access to nearly 100 varieties across 46 species, for both amateur gardeners and professional growers. Both the City Council and the State of Geneva have provided continuous support to 'Semences de Pays' since its inception, whether through access to land and premises, machinery and equipment, or through direct financial support, particularly to fund the selection work.

Semences de Pays works in close collaboration with a seedling producer, giving access to their varieties to the professional producers as well as to the broader public audience, through seasonal seedlings' markets. In 2012 François Grojean retired, ceasing his activity after passing on his selected varieties to Semences de Pays.

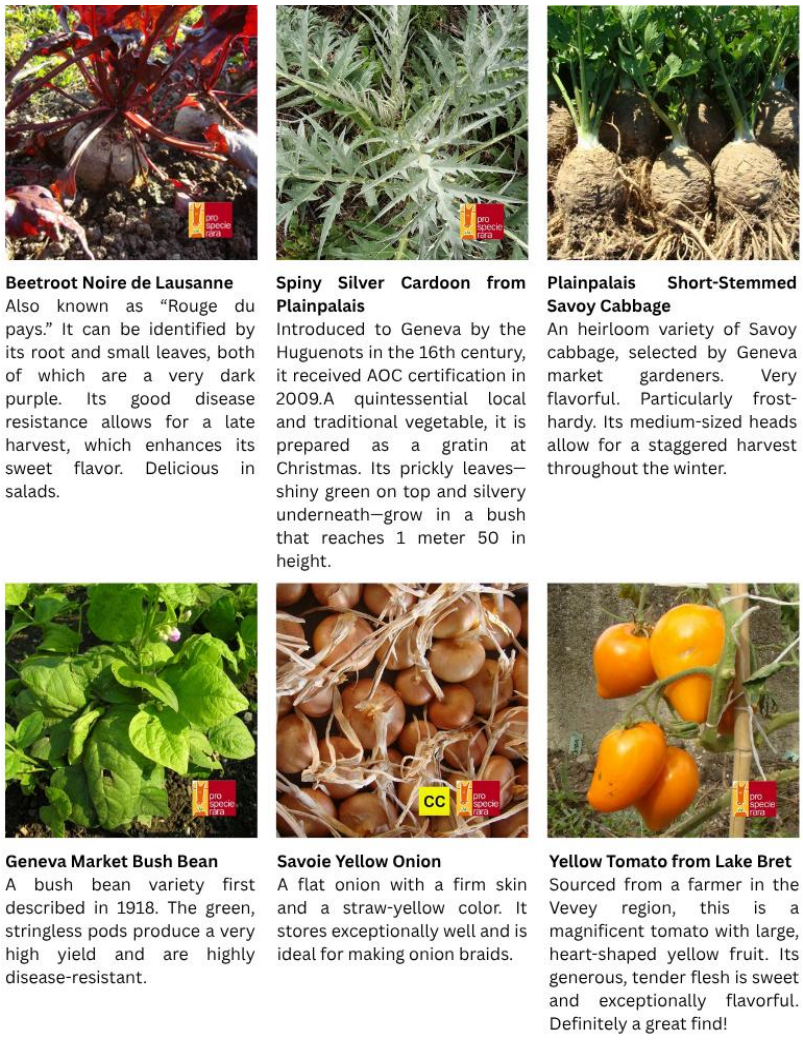


Figure 24: Examples of PSR conservation and selection varieties

Conclusions

The preservation and promotion of these landraces is now the aim of a global strategy involving the stakeholders with the support and participation of the Cantonal Office for Agriculture of the State of Geneva. The access of these varieties to the field, the market and the plate is therefore supported by funding programmes and public policies, as well as public events and promoting campaigns to come. The marketing channels under consideration are, naturally, local markets and direct sales rather than large-scale retail. The seeds of the varieties in question, along with many other, can be bought on the website of Semences de Pays. www.semencesdepays.ch

4.1.8 Example of LiveSeeding results on Zenodo: Participatory Breeding and Agro-ecological Adaptation of Organic Rice in Northern Italy

Matteo Petitti, Giuseppe De Santis, Daniela Ponzini (RSR)

Italy occupies a pre-eminent position in the European rice sector, acting as the primary producer with 226129 ha cultivated in 2024 corresponding to 61% o of the total European rice production area. Fully converted organic rice covered 20500 ha in 2023 and is projected to expand further. Despite the growth of the organic sector organic growers remain hindered by a systemic lack of genetic material specifically adapted to Organic Rice Farming Systems (ORFS). The contemporary Italian rice sector is characterised by a rigid adherence to genetic uniformity. Roughly 70% of seed production is dominated by a mere 20 varieties. Furthermore, approximately 40% of registered varieties are specifically engineered for conventional systems using herbicide-resistant technologies such as Clearfield®, Provisia®, and FullPage®. These varieties are fundamentally ill-suited for the complex ecological demands of organic production. As certified-organic seed availability is virtually non-existent, organic farmers are forced to rely on derogations to use untreated conventional seeds or resort on farm-saved seeds of older, non-protected varieties, often better adapted to organic management.

To address these technical gaps, the Italian Seed Network NGO Rete Semi Rurali (RSR), togegher with the organic rice growers' network of the "Piedmontese Rice Biodistrict", in Rovasenda (VC), established a "Seed to Fork" Living Lab (LL) within the LiveSeeding Project. The organic rice growers of the LL adopt and promote the "green mulching" technique, as a sustainable alternative to dryland stale-bed sowing or traditional continuous flooding. This method requires sowing rice directly into a cover crop—typically *Lolium multiflorum* (Italian

ryegrass)—which is subsequently rolled/mulched and flooded. Precise water management mediates biological interactions: the natural inhibitory allelopathic effects and the fermentation process of the Italian ryegrass mulch suppresses weed germination and development, allowing a competition-free headstart to the newly planted rice crop.

Operating as an innovation broker RSR facilitated the co-creation of organic cultivars capable of dynamic adaptation to these specific agroecological conditions. The foundational germplasm was sourced through the multilateral system of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). This included a significant rematriated Italian rice germplasm collection of 214 accessions from the International Rice Research Institute (IRRI).

The organic participatory breeding programme started in 2018 with multi-environmental trials (MET) showing strong Genotype by Farm Interactions (G x E) for all entries, suggesting that uniform cultivars cannot provide the stability required across diverse organic landscapes and inter-annual climatic variability.

In 2019 a participatory selection was conducted over a collection of 264 rice accessions, focusing on farmers' preferences and performance under organic management with the aim of creating dynamic populations (DP). Agronomic trait of interest for the participatory selection where: (i) yield (perceived); (ii) plant health (absence of rice blast and bakanae symptoms); (iii) maturity (early types preferred); plant height (higher plants offer better weed suppression).

Qualitative traits evaluated post-harvest were: (i) grain type (round, medium, long A, long B); (ii) dehulling efficiency, (iii) cooking time and (iv) sensory parameters (consistency, flavour).

Based on the participatory selection's results, time of maturity and grain type, three DPs were assembled with equal number of seeds per accession:

- **Short Grain Mixture:** 11 accessions.
- **Medium Grain Mixture:** 16 accessions (Figure 25).
- **Long A Grain Mixture:** 25 accessions.



Figure 25: Diversity of ears and plant heights in the medium-grain rice DP

The evolutionary adaptation ability of these populations is maintained through the natural cross-pollination rates of *japonica* rice, which exhibit ranges of 0–0.6% and 3.9–4.3%. This facilitates a slow but constant on-farm evolution, allowing the population to adapt to the specific environmental and management conditions of the farm over successive generations. The medium-grain rice DP has been successfully notified as Organic Heterogeneous Material (OHM) in 2026 under European Organic Regulation (EU) 2018/848 under the name "Riso Resiliente – Popolazione Risi Medi" (Resilient Rice – Medium-Rice Population). The long-grain DP OHM notification is planned for 2027.

Recognising that commercial success requires involving citizens / consumer, the LL integrated sensory and culinary assessments. The harvested paddy was processed into a semi-brown format. The medium-grain rice population reached the market in November 2023, providing a concrete example of a diversity-based value chain. The sensory/culinary evaluation followed three progressive steps, each depending on the successful outcome of the previous one:

- **Panel Testing:** Quantitative Descriptive Analysis (QDA) tests were conducted with growers in 2021 and consumer group representatives in 2022. In these tests the rice DP were compared to standard uniform rice cultivars.

- **Citizen Engagement:** during "open farm days" in 2022, the project engaged the public directly, with risotto preparation by a professional chef and tasting by participants, with the aim of inform and assess their appreciation for a novel rice product.
- **Consumer Survey:** 400 medium grain rice DP packets (500 g) were distributed to consumer groups for real-life home-cooking evaluation in 2023 and 200 long-grain rice DP packets 1kg) in 2026. All packets had an informative label, with a QR code leading to the consumer survey.

All the sensory evaluation faired favourably for the rice DPs, leading further in the evaluation process. The consumer survey data (complete replies: 63 for medium-grain and 58 for long-grain) showed a very positive response for both DPs highlighting its excellent sensory and culinary quality and suitability for traditional Italian dishes, such as risotto (Figure 26).

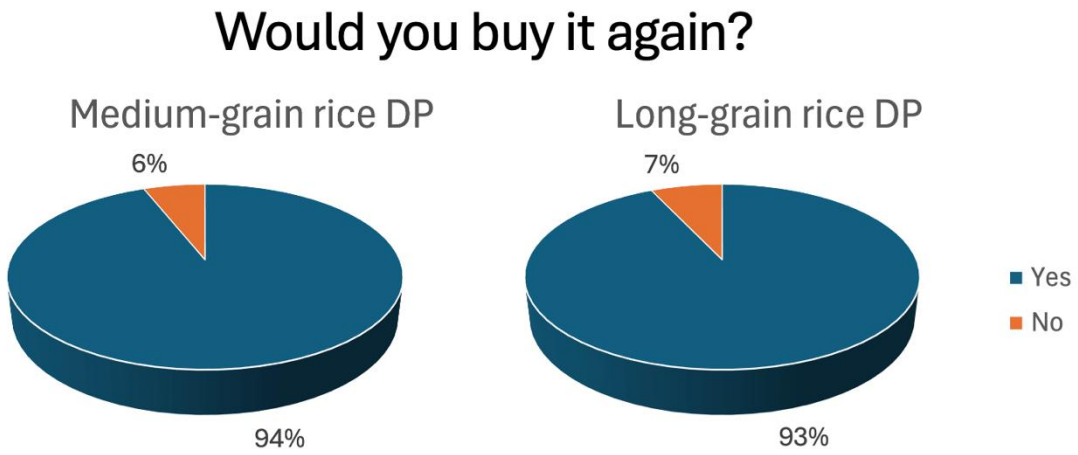


Figure 26: Results of the consumer surveys of 2023 (medium-grain, n = 63) and 2026 (long-grain, n = 58) to the question: "would you buy it again?"

Following these encouraging results, the LL rice growers launched a commercial trial to validate the value chain feasibility of rice DPs. Since 2023 a 1-hectare medium-grain DP field is grown within the LL and, following excellent consumers' response, since 2026 an additional 1 ha of long-grain DP. Preliminary yield data indicate good agronomic performance in the farm's context, placing the medium-grain with its 3.8 t/ha between the highly prized traditional cultivars Carnaroli Classico (2 t/ha) and Rosa Marchetti (6 t/ha).

The "Seed to Fork" Living Lab has provided a solid proof of concept for population-based seed systems and organic participatory breeding based on plant genetic resources valorisation. By integrating genetic diversity with participatory breeding and consumer-driven quality

standards, the programme has successfully established the first functional value chain for Organic Heterogeneous Material in the Italian rice sector (Figure 27).



Figure 27: The Medium-grain rice (left) and long-grain (right) DPs processed as semi-brown rice and packaged with the Italian OHM "Materiale Eterogeneo Biologico" logo developed by Rete Semi Rurali.

Considerations about traits for selection in organic rice breeding

Organic rice breeding in Italy is virtually non-existent. Organic rice growers rely on old/traditional robust rice varieties or modern conventional varieties that show good adaptation to organic system. In conventional breeding the main breeding objectives are: grain yield, herbicide tolerance (Clearfield®, Provisia®, and FullPage® gene introgression), cold tolerance for early direct dryland seeding, draught tolerance, salinity tolerance, rice blast resistance and grain quality for culinary purposes. Even though there are some similarities and

overlapping with breeding objectives and target traits between conventional and organic rice breeding, in organic rice breeding the selection environment and methods are quite different. In the organic participatory breeding process, the following key agronomic and qualitative traits were considered:

Plant Height: in conventional breeding, similarly to other cereals breeding efforts go towards contain plant height, to avoid lodging under high Nitrogen fertilisation. The current target plant height for Italy is in the ranges between 75-100 cm for paddy rice, (80-90 cm for Provisia®, varieties; 75 cm for dryland). Under organic management, the targets plant heights are on the higher end of this spectrum, however since selection occurs under lower nitrogen availability, genotypes selected would grow much taller under conventional conditions. As herbicides are not an option to control weed pressure, a sufficient plant height is necessary even when optimal agroecological practices are adopted. In rice population breeding, this trait should be carefully monitored in its evolution, as inter-population competition will favour higher plants and subsequent negative selection might be necessary establish a balance. It is however also true, that in a rice population with plants of different heights, the shorter plants support the taller and risk of lodging is reduced.

Earliness: Early maturing genotypes are preferred in organic selection, as very early sowing in dryland is not a suitable practice. Earlier flowering and maturing and harvest reduced potential yield reduction from fungal diseases.

Disease resistance: the main fungal rice diseases are rice blast (*Magnaporthe orizae*) and bakanae (*Fusarium fujikuroi*). In organic participatory selection, selection is conducted with negative selection against susceptible types and in favour of polygenic horizontal resistance, rather than single gene resistance. This is particularly true for organic rice population breeding, where also the intra-population diversity can play an important a role in slowing down the rice blast progress. Attention should be placed in introducing source sources of resistance for both disease in new populations' design, and careful monitoring of seed health for seed-born bakanae disease from the early stages of selection.

Grain yield: in organic rice population breeding, yield stability overtime is more important than absolute high yield. As organic rice prices are significantly higher than conventional rice, the gap-yield between conventional and organic does not constitute a major issue, especially when savings from chemical inputs (fertilisers, weedkillers and fungicides – insecticides are forbidden even in conventional) are taken into the equation. All that said, average yield should be at the same level of the standard varieties, i.e. in within a range of 3-6 t/ha.

Grain size: as rice grains are hulled, dehulling efficiency is a very important parameter in determining the final marketable yield of the rice cultivar. In rice population this determines

that in population design and selection at early stages of the population's evolution, particular attention should be placed in grain type (short, medium, long-A and long-B) and grain size. Dehulling tests need to be carried out at the earliest possible stage and results should be comparable with those of the other standard varieties cultivated in the area (>80% optimal).

Culinary quality: Amylose and Amylopectin content and their ratio influence the rice texture and response to cooking, while a plethora of volatile aromatic compounds is responsible for the aroma. Determining which parameters are best depends on cooking methods and regional preferences. As many trains are involved, for organic rice population breeding, the best most efficient and cost-effective to assess these parameters as a whole is to conduct cooking- and panel tests at the earliest possible stage to assess whether the culinary and sensory qualities are at a comparable level with standard varieties cultivated and marketed in the area.

Further reading – rice case

De Santis, G., et al. (2022). Participatory Evaluation of Rice Varieties for Specific Adaptation to Organic Conditions in Italy. *Sustainability*, 14(17).

EUROSTAT (2023). The Statistical Office of the European Union.

Petitti, M., et al. (2024). Rice Diversity from Seed to Fork: a Living Lab for Organic Rice in Northern Italy. *Journal of Integrated Field Science*, 21.

Wolfe, M. S. and Ceccarelli, S. (2020). The increased use of diversity in cereal cropping requires more descriptive precision. *Journal of Science of Food and Agriculture*, 100(11).

Zhu, Y.Y., Fang, H., Wang, Y.Y., Fan, J.X., Yang, S.S., Mew, T.W. and Mundt, C.C., 2005. Panicle blast and canopy moisture in rice cultivar mixtures. Phytopathology, 95(4), pp.433-438.

3.4 PGR characterisation Results Dissemination via PGR Cards

The LiveSeeding PGR Cards (21 as of publication of this report) are available on OrganicEprints and Organic Farm Knowledge (Table 14).

3.4.1 PGR cards for disseminating the results of best materials among farmers

A Plant Genetic Resources (PGR) Description Card is a 1-page description used to record key results about PGR accessions of high potential interest for cultivation and use based on the LiveSeeding characterisation results.

The template contains the following information of an interesting PGR characterised within T1.1 of the project

a) Cultivar history and general info
b) Technical characteristics
c) Useful quality traits and uses
d) Calendar of cultivation phased and agronomic management
e) Seed availability info

The purpose of the PGR cards with their useful information and photos of the accession is to boost the use of these materials by gardeners, farmers and breeders.

Table 14: List of Plant Genetic Resources Cards published until August 2026 in OrganicEprints repository and Organic Farming Knowledge platform

Crop	Species	Cultivar	PGR Category	Language	OrganicEprints	OFK link
Pepper	*Capsicum annuum*	Bahovitiki	Traditional variety	EN, GR	https://orgprints.org/id/eprint/58005/	https://organic-farmknowledge.org/tool/58005
Tomato	*Solanum lycopersicum*	Lotos (or Patera)	Traditional variety	EN, GR	https://orgprints.org/id/eprint/57976/	https://organic-farmknowledge.org/tool/57976
Wheat	*Triticum aestivum*	Skliropetra	Traditional variety	EN, GR	https://orgprints.org/id/eprint/57977/	https://organic-farmknowledge.org/tool/57977
Common bean	*Phaseolus vulgaris*	Agrária de Coimbra 201	Variety	EN, PT	https://orgprints.org/id/eprint/57978/	https://organic-farmknowledge.org/tool/57978
Pepper	*Capsicum annuum*	Agrária de Coimbra 301	Population	EN, PT	https://orgprints.org/id/eprint/57979/	https://organic-farmknowledge.org/tool/57979
Common bean	*Phaseolus vulgaris*	OHM KIS Deodat	OHM	EN, SL	https://orgprints.org/id/eprint/57983/	https://organic-farmknowledge.org/tool/57983
Common bean	*Phaseolus vulgaris*	OHM KIS Bogo	OHM	EN, SL	https://orgprints.org/id/eprint/57984/	https://organic-farmknowledge.org/tool/57984
Lettuce	*Lactuca sativa*	Brune de Genève	Traditional variety	EN, FR, DE	https://orgprints.org/id/eprint/57985/	https://organic-farmknowledge.org/tool/57985
Savoy cabbage	*Brassica oleracea var. sabauda*	À Pied Court de Plainpalais	Traditional variety	EN, FR, DE	https://orgprints.org/id/eprint/57997/	https://organic-farmknowledge.org/tool/57997
Onion	*Allium cepa*	Jaune de Savoie	Traditional variety	EN, FR, DE	https://orgprints.org/id/eprint/57994/	https://organic-farmknowledge.org/tool/57994
Onion	*Allium cepa*	Rouge de Genève	Traditional variety	EN, FR, DE	https://orgprints.org/id/eprint/57992/	https://organic-farmknowledge.org/tool/57992

Crop	Species	Cultivar	PGR Category	Language	OrganicEprints	OFK link
Corn salad	*Valerianella locusta*	Hâtive de Genève	Traditional variety	EN, FR, DE	https://orgprints.org/id/eprint/57996/	https://organic-farmknowledge.org/tool/57996
Leek	*Allium porrum*	Dubouchet Grosjean	Traditional variety	EN, FR, DE	https://orgprints.org/id/eprint/57998/	https://organic-farmknowledge.org/tool/57998
Tomato	*Solanum lycopersicum*	Chancy	Traditional variety	EN, FR, DE	https://orgprints.org/id/eprint/57999/	https://organic-farmknowledge.org/tool/57999
Tomato	*Solanum lycopersicum*	Jaune du Lac de Bret	Traditional variety	EN, FR, DE	https://orgprints.org/id/eprint/58000/	https://organic-farmknowledge.org/tool/58000
Rice	*Oryza sativa*	Medium-grain rice population	OHM	EN, IT	https://orgprints.org/id/eprint/58002/	https://organic-farmknowledge.org/tool/58002
Runner bean	*Phaseolus coccineus*	Copafam bean	Landrace	EN, IT	https://orgprints.org/id/eprint/58003/	https://organic-farmknowledge.org/tool/58003
Wheat	*Triticum turgidum subsp. durum*	Evoldur terre frumentarie	OHM	EN, IT	https://orgprints.org/id/eprint/58006/	https://organic-farmknowledge.org/tool/58006
Sunflower	*Helianthus annuus*	Neagră de Cluj (ECO 15)	Landrace	EN, RO	https://orgprints.org/id/eprint/58007/	https://organic-farmknowledge.org/tool/58007
Pepper	*Capsicum annuum*	Blanco de Villena	Landrace	EN, ES	https://orgprints.org/id/eprint/58020/	https://organic-farmknowledge.org/tool/58020
Carrot	*Daucus carota*	Morada de Villena	Landrace	EN, ES	https://orgprints.org/id/eprint/58019/	https://organic-farmknowledge.org/tool/58019

3.4.2 PGR Cards Examples

Here are some examples of different material characterised and described in PGR cards: Traditional varieties of pepper (AEG) and lettuce (PSR), OHM common bean (KIS), rice dynamic population (RSR**).** All PGR cards are available in the national language(s) of the organisation that conducted the characterisation and in English (Figure 30).

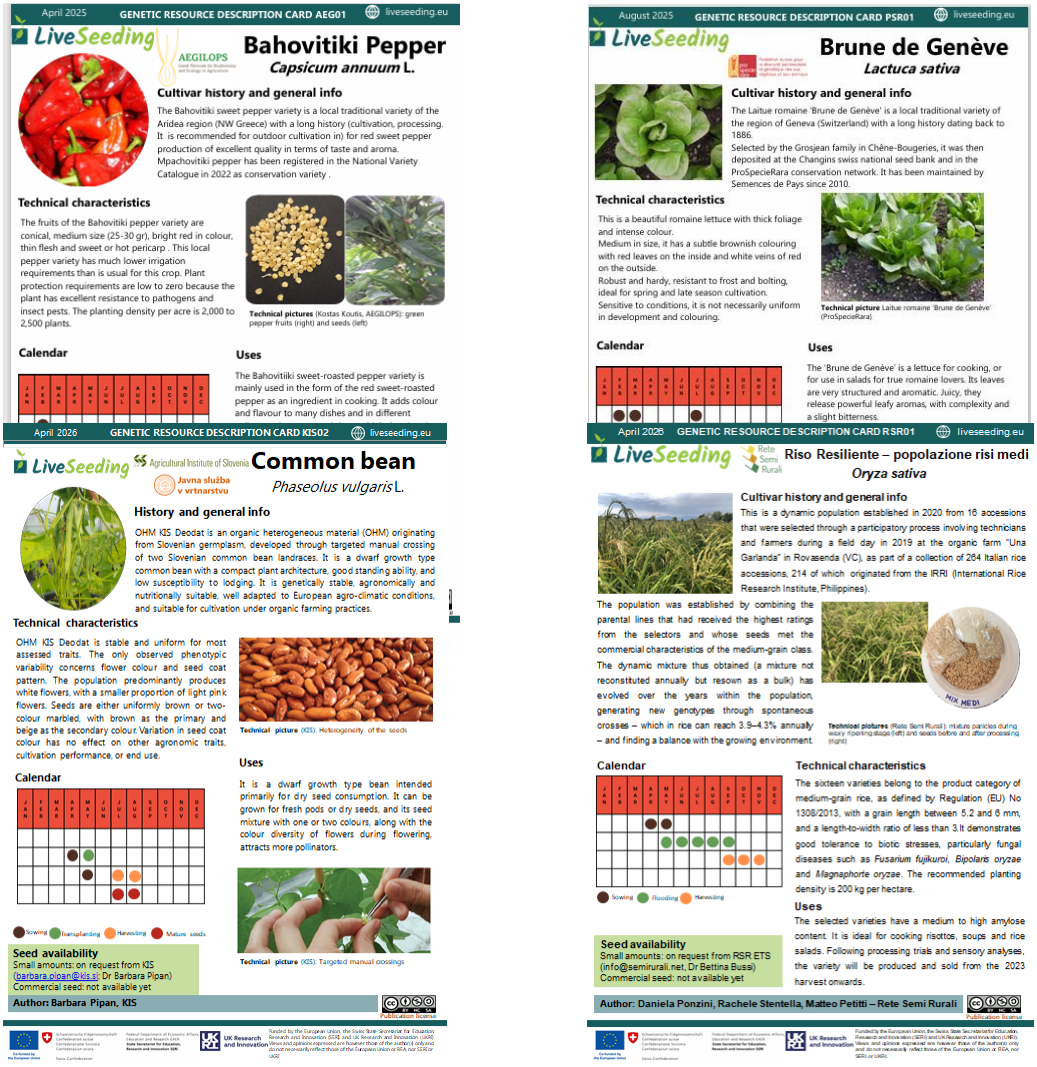


Figure 28: Example of PGR cards

3.4.3 Results in synergy with LiveSeeding breeding and cultivar testing efforts

Data from PGR characterisation (T1.1) fed into new cultivar development (T1.2). In some cases, the PGR task was in synergy with the on-farm cultivar testing networks activities (T2.3) and seed multiplication activities (WP3). In the chapters above we have reported only the results of

the specific activity directed to PGR characterisation to mobilize use of landraces, traditional and neglected crops cultivation and use in further breeding.
The direct outputs in terms of breeding are reported in D1.4 "Summary of breeding progress for OHM and OV". The outcomes linked to cultivar testing approaches and methods are reported in D2.5 "Synthesis of cultivar evaluation case-studies, recommendations and follow-up plans".

Info Box 3

Organic Plant Breeding and new cultivar types OHM and OV

Basic principles of Organic Plant Breeding

Organic Plant Breeding (OPB) is a process-oriented breeding approach in which all stages of breeding — crossing, selection, maintenance and propagation of plant reproductive material — are conducted under certified organic conditions. It is based on natural reproductive processes and respects species-specific crossing barriers. All techniques applied must be transparent and comply with the IFOAM position on compatibility of breeding techniques in organic systems, excluding genetic engineering approaches such as GMO and new genomic techniques (NGT), as well as other interventions below the cell level (e.g. cell fusion, induced mutations, and in vitro techniques, except for meristem culture). OPB aims to develop varieties adapted to organic farming systems.

More info: European Consortium for Organic Plant Breeding (ECO-PB) eco-pb.org

Variety: Term used for officially registered cultivars according to the UPOV definition which meets the DUS and VCU criteria. More info: cpvo.europa.eu

Cultivar: In LiveSeeding, the term "cultivar" is used as a generic reference to varieties, breeding lines, landraces, populations and heterogeneous cultivars, including those falling under the category of Organic Heterogeneous Material.

Organic Heterogeneous Material (OHM)

OHM is characterised by its high phenotypic and genetic diversity and its capacity to evolve over time and adapt to local growing conditions. OHM may only be marketed after it is notified by means of a descriptive dossier, which is sent to the competent authorities together with a representative sample.

More info: Guidelines for OHM notification https://orgprints.org/56459

List of notified OHM in Europe: https://www.geves.fr/variety-seed-expertise/organic-agriculture/organic-heterogeneous-material/

Organic variety suitable for organic production (OV)

Variety bred under organic conditions and characterised by enhanced disease tolerance, adaptability to diverse environments, and a strong focus on genetic diversity and natural reproductive capacity. OVs derive from organic breeding approaches that prioritise agronomic performance, resilience and local adaptation.

More info: Policy brief, September 2025 – Definition of Organic Plant Breeding for registration of Organic Varieties suitable for organic production https://orgprints.org/id/eprint/56308/

Bioverita

Boverita (https://bioverita.ch/) is a private label for Organic Breeding. public awareness of the time-consuming production and invaluable breeding.

Bioverita was founded in Switzerland in 2011 as a non-profit association and has developed into a Europe-wide platform connecting organic and biodynamic breeders, seed producers, processors, traders, and other actors within the organic food sector (Bioverita, 2021). Bioverita certifies vegetable, cereal, fruit, ornamental, herb, and fodder varieties bred in organic conditions. Through its certification activities, the association supports breeding organisations that are committed to organic principles and strengthens the market position of organically bred varieties.

List of bioverita certified varieties:

For vegetables: https://bioverita.ch/en/varieties/vegetable-varieties/

For arable crops: https://bioverita.ch/en/varieties/cereal-maize-and-fodder-plant-varieties/

4. PGR Characterisation and data sharing impact

This chapter presents the impacts of the project, focusing on the contribution of plant genetic resources (PGR) characterisation, open data sharing, and participatory approaches to sustainable agriculture, organic breeding, and rural development.

4.1 General impact

The publication of datasets, including standardized metadata, in open-access in Zenodo and SeedLinked platforms ensure long-term accessibility and reuse.

By characterising landraces and locally adapted varieties, it supported the identification of traits relevant to low-input and organic farming systems, such as tolerance to abiotic stress, pest resistance, and stable performance under variable conditions.

The integration of characterised PGR into breeding pipelines promotes the development of varieties better suited to organic systems and marginal environments.

Through knowledge exchange and participatory approaches, it enhances the capacity of farmers to select, manage, and utilize plant genetic resources effectively.

Training activities and on-farm trials strengthen practical skills and promote knowledge co-creation between farmers, researchers, and other stakeholders. This contributes to increased farm resilience, diversification of production systems, and the creation of new market opportunities based on local and traditional varieties.

Moreover, the promotion of landraces and underutilized crops can support niche markets, local value chains, and short supply systems, thereby enhancing rural livelihoods and economic sustainability. On the policy level, thanks to the process generated by LiveSeeding (T6.2) with the support of the Spanish City Network for Agroecology, Resolution 5/2025, adopted at the 11th Session of the Governing Body of the International Treaty on Plant Genetic Resources for Food and Agriculture (Lima, November 2025), explicitly incorporates collaboration with municipalities and municipal networks in urban and peri-urban food systems as key actors in **the conservation and sustainable use of plant genetic resources for food and agriculture**; and promotes their participation in its Ad Hoc Technical Committee on Conservation and Sustainable Use. In this process the examples used to show the importance of PGR in local food policies were actual examples from the field characterisation in the experimental part of the project.

Additionally, the project activities supported both *in situ* (on-farm) and *ex situ* conservation strategies by linking field-level data with broader conservation frameworks. This contributes to the preservation and sustainable use of agrobiodiversity.

4.2 Impact in connecting formal and informal seed systems

Diversified seed systems: how can formal and informal systems be connected? - example of Rete Semi Rurali in Italy

Francesca Gori, Matteo Petitti, Riccardo Bocci (RSR)

- **What is a seed system?**

A seed system is defined as the set of activities involved in the selecting, producing and exchanging seeds (Almekinders et al., 1999). This framework, which is now widely adopted in agricultural policy and international research, recognises that the process by which seeds reach a farmers' field is not simply a commercial transaction, but a complex socio-technical process embedded in ecological, economic and cultural contexts. Seed systems encompass a wide range of interconnected activities, including the management of genetic resources, plant breeding and selection, seed multiplication, quality assurance, storage, distribution and, finally, the use of seeds by farmers. These activities are carried out by a diverse range of actors, including multinational seed companies and national research institutes to individual smallholder farmers, community seed banks and farmer networks. Understanding how these actors interact, and how germplasm and knowledge circulate among them, is essential for designing interventions that genuinely support sustainable agriculture and food security (Louwaars et al., 2012)

Before considering how formal and informal seed systems can be connected, it is important to clarify the distinction between them.

- **Formal vs. informal seed systems**

The management of diversity differs fundamentally between formal and informal seed systems. Formal systems tend to produce uniform varieties (DUS) through centralised selection processes. By contrast, informal seed systems tend to generate, exchange and conserve less uniform, locally adapted material. However, modern varieties originating from formal systems may also circulate within them. This divergence has significant implications. Combining the strengths of both systems could broaden the genetic base of our crops and promote greater genetic diversity in the field, which is increasingly recognised as essential for climate resilience and sustainable food systems.

"It is impossible to completely replace farmers' seed systems, nor would it be wise to attempt to do so. These systems represent an important component of food security, a vital refuge for diversity, and a space for the further evolution of plant genetic resources. Policy makers must recognize this and carefully balance incentives and regulations to safeguard an optimal and continuously evolving mix of private, civil, and public roles." (FAO, 2009)

At the same time, formal and informal systems respond differently to policy objectives. The two are not neutral alternatives: every policy objective creates different — and sometimes conflicting — pressures on seed systems. For example, if the goal is to support a community's cultural identity and the dynamic management of biodiversity, interventions will tend to strengthen informal systems and their local mechanisms. Whereas if the goal is to promote

seed commercialization, they will tend to reinforce the formal system. A clear understanding of this dynamic is essential for effective policy design.

- **Diversified seed systems: how can formal and informal systems be connected?**

In order to overcome the dichotomy of the formal/informal seed systems — and to avoid the ambiguity of the term "integrated seed systems", Rete Semi Rurali has adopted the term "diversified", emphasizing the importance of having different approaches, actors and visions operating within the same framework. A **diversified seed system** (Figure 29) distinguishes between two broad categories of farmers: those who are primarily consumers of the seed market, and those who produce and develop diversity in their own fields. This is, of course, a simplification: as previously mentioned, the same farmer may assume both roles depending on the crop. The model is designed to accommodate and support this fluidity.

The model sets out three parallel circuits:

- The local/informal circuit is characterised by a circular flow of seeds involving direct use, on-farm selection, and re-sowing. This is linked to community seed banks, public gene banks, research institutes and small seed businesses where relevant. This circuit is supported by public funding and private foundations.
- The formal commercial circuit, which develops linearly from public and private breeders through the registration, certification, multiplication and market distribution of Distinct, Uniform and Stable (DUS) varieties, and is regulated by royalty structures.
- An integrated circuit which encompasses participatory plant breeding (PPB) linking the two systems that work on different breeding lines. It is here that formal and informal systems connect most meaningfully. PPB produces relational capital in the form of sustained working relationships between farmers, breeders, researchers, and civil society organisations, forming the connective tissue of a diversified seed system.

Community Seed Banks (CSBs) play an important role in bridging the gap between informal and formal seed systems. RSR operates a CSB to facilitate the decentralized conservation, multiplication, and characterisation of seeds and plant material. CSBs represent an exemplary model of a diversified seed system because they connect the informal networks of farmer seed systems with formal networks, including gene banks, research institutes, and seed companies.

This approach of diversified seed system was applied by Rete Semi Rurali to link the PGR characterisation in LiveSeeding with the overall transformation of the seed systems

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CSBs provide the infrastructure through which the informal flow of plant genetic resources can be documented and multiplied on a large scale, making them accessible to a wider community of farmers, researchers, and breeders, as well as to the formal seed system.

The financial architecture of the diversified system is equally important. Innovative activities, such as community seed banks and participatory breeding programmes, require funding that the commercial seed market cannot provide. Public funding, Horizon Europe project funds and private foundations all play a role in supporting these activities. Therefore, mapping financial flows is just as important as mapping germplasm flows when designing or evaluating a local seed system.

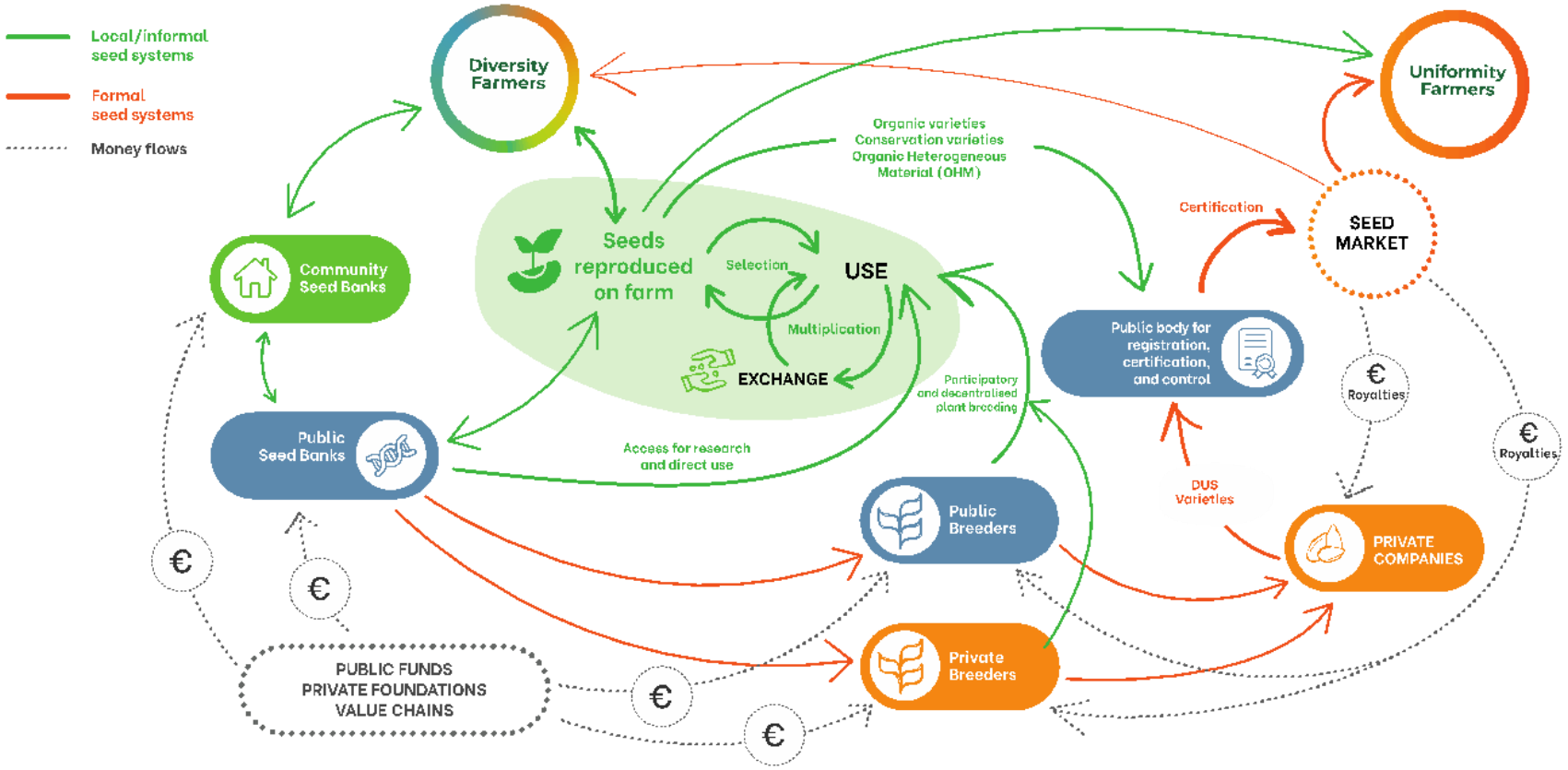


Figure 29: Diversified seed systems (Source: RSR's own elaboration)

- **Designing and mapping local diversified seed systems**

Designing a local seed system requires participatory inquiry and multi-stakeholder workshops to produce a visual representation of the actors involved, how germplasm, knowledge and financial resources flow between them, and all the activities undertaken within the system. The analysis proceeds by identifying and linking the various actors and mapping their relationships with one another and with the wider community. These methods can be supplemented by interviews with knowledgeable stakeholders.

The main components to be mapped are:

- ➔ Actors and their roles: those involved in accessing germplasm, selection, production, multiplication, distribution and marketing.
- ➔ PGR in circulation: local, indigenous and modern varieties, and the pathways through which they enter the system — including access to gene banks, research collaboration, informal sharing or commercialization.
- ➔ The policy and regulatory context: the rules and legislation that enable or restrict activities within the system, and how actors manage or seek to resolve regulatory constraints.
- ➔ Seed flows and reproduction: seed sources, exchange mechanisms, production, distribution and storage.
- ➔ Breeding and genetic improvement activities: both conventional and participatory approaches, as well as the traits and characteristics prioritised by stakeholders.
- ➔ Financial and knowledge flows between actors: these enrich the overall picture and inform the design of targeted interventions.

There is no single strategy that can be apply in all the contexts: the most appropriate combination of interventions depends on the objectives being pursued and the environmental, social, and regulatory context in which the system operates.

- **The importance of diversified seed systems in the new policy framework**

Public policy plays a key constitutive role in enabling diversified seed systems. Legal frameworks must actively create space for the full spectrum of seed system actors and types of material — rather than merely tolerating them.

In the current regulatory context, the introduction of OHM under EU Regulation 2018/848 provides diversified seed systems with what they have long lacked: a legal identity. Material that was previously confined to informal trade — heterogeneous and adapted to local conditions but unable to meet conventional DUS requirements — can now enter the market through a simplified notification process (Figure 30). This effective implementation of this concrete policy instrument depends on the kind of multi-stakeholder collaboration that diverse seed system networks are uniquely positioned to ensure.

The strategic importance of diversified seed systems is further reinforced by the European Organic Regulation and it is anticipated that the forthcoming new EU seed legislation will reinforce it further. The recognition of heterogeneous organic material and the growing acceptance of participatory plant breeding approaches, signal a broader and welcome shift in policy thinking, as does the proposed reform of EU seed legislation — which explicitly introduces concepts such as dynamic biodiversity management and the value of genetic diversity in agricultural systems.

In this context, it is becoming increasingly important to recognise and strengthen the complementarity between formal, informal and integrated seed systems in order to support the resilience, adaptation and conservation of agrobiodiversity across European agriculture.

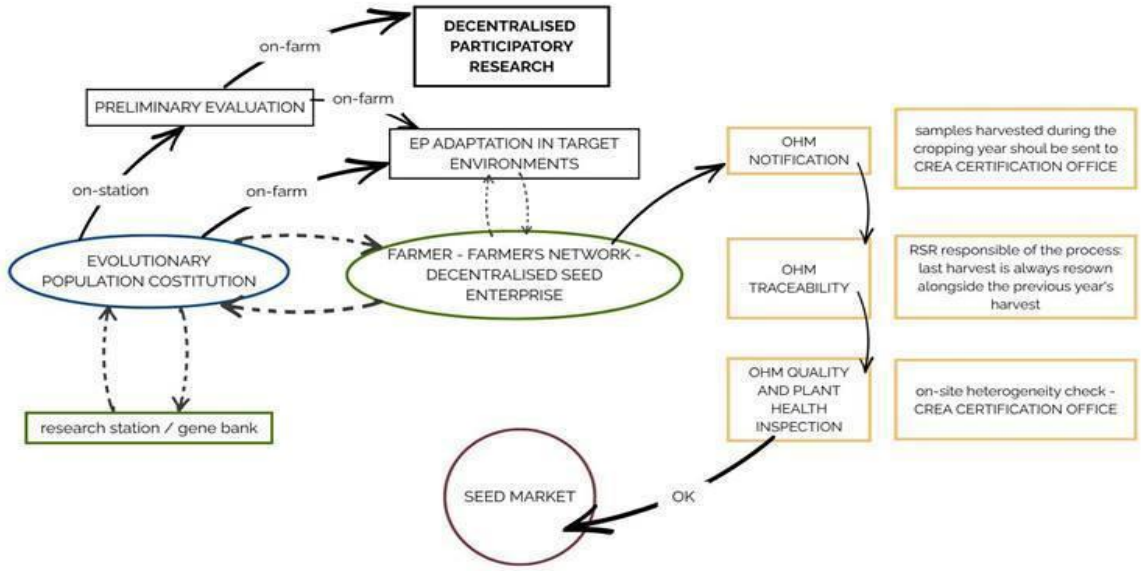


Figure 30: Example of Furat Dynamic Population (registered as OHM Furat in 2025)

References – Diversified seed system

Almekinders & Louwaars (1999), Farmers' Seed Production, 1999

Louwaars N., de Boef W. (2012), Integrated Seed Sector Development in Africa: A Conceptual Framework for Creating Coherence Between Practices, Programs, and Policies, Journal of Crop Improvement, 2012.

Info Box 4

Accelerating the Development of Organic Seed Systems though integration of formal and informal seed system in Greece

AEGILOPS PGR characterisation activities integrated participatory evaluation, on-farm testing, and organic-specific selection environments (Figure 31).

As development of the participatory activities developed in LiveSeeding, the plan emerged of setting up a social cooperative dedicated to organic seed and plant reproductive material production to further strengthen local seed supply chains. Such a structure can facilitate seed multiplication, quality assurance, knowledge transfer, and market access while maintaining farmer participation and collective ownership.

These developments will contribute to a more diverse seed system in Greece capable of better interactions between the formal and informal systems.



Figure 31: Valorisation of wheat PGR resources for direct use and OVs development (Photos: AEGILOPS)

5 CONCLUSION

On-farm characterisation of plant genetic resources represents a powerful approach that bridges conservation, research, and practical application. Through its participatory nature, it enhances the relevance and adoption of genetic resources, while also supporting innovation in breeding. Its contributions to pre-breeding include the identification of adaptive traits, the selection of valuable germplasm, and the expansion of the genetic base. For organic breeding, it is indispensable, as it ensures that selection takes place under real production conditions and reflects the diversity and complexity of organic systems.

The effective combination of **on-station, on-farm, and participatory approaches** in the dynamic management of plant genetic resources (PGR) represents an integrated methodology that links conservation of landraces with current agriculture practices adaptation and value chain-driven local innovation.

The integration of phenotyping data production, and stakeholder engagement ensures that project results are not only scientifically robust but also relevant and applicable in real-world contexts, thereby maximizing their long-term impact. Characterisation is a critical first step in the revival process because many underutilized crops remain poorly documented and insufficiently studied.

The integration of informal and formal systems also strengthens dynamic conservation of plant genetic resources. Landraces and heterogeneous populations maintained by farmers can serve as valuable breeding material for developing resilient varieties adapted to climate change, organic farming, and low-input systems.

The main outcomes [13]of this work are:

- >700 PGR accessions newly characterised
- 33 datasets published in Zenodo
- 34 trial records published on SeedLinked
- 21 dissemination flyers (PGR Description Cards) of highly relevant materials that proved of high interest for cultivation by organic and agro-ecology oriented farms in Europe.

[13] Some datasets are embargoed until they are published in scientific journals. Additional datasets will be published alongside related scientific publications. As some trials will only conclude at the end of the summer season in 2027, the full dataset will not be ready for publication by the time this report is published. More records in SeedLinked and PGR cards may be published.