Platform for on-farm cultivar testing in EU accessible on web and mobile app stores

Authors: **Amritbir Riar (FiBL CH)**

Nicolas Enjalbert (SeedLinked)

Remi Bethouart (SeedLinked)

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Contact	Riar Amritbir amritbir.riar@fibl.org

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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

App	(Computing) application
ICT	Information and Communications Technology
EU GDPR	European Union General Data Protection Regulation
FTUE	First Time User Experience

Summary

SeedLinked (https://seedlinked.com/) is a platform for decentralized cultivar evaluation designs and inclusion of real-time multi-actor feedback (from farmer to consumer) and allows for high and heterogeneous data inputs by smartphone. 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 free of charge to support informed decision-making and amplify the overall project's impact.

LiveSeeding project Task 2.4 - European Interactive Platform for Cultivar Testing (T2.4) is adapting the existing crowdsourcing platform (SeedLinked) into a European interactive and collaborative platform for cultivar testing. This tool amplifies the impact and outreach of Task 2.3 - Advancing on-farm cultivar evaluation (T2.3) by creating a digital platform that serves as a European infrastructure for organic on-farm cultivar evaluation. By integrating information and communication technology (ICT), Seedlinked provides a low-cost, highly inclusive and representative method. This method allows for the management of diverse sources of information and the connection of various on-farm cultivar evaluation networks across Europe. The platform is now accessible to researchers, organic breeders, and seed savers associations and can be utilized for trials involving farmers, gardeners and consumers.

Under Task T2.4 the app is been localised for use in the European Union, Switzerland and the United Kingdom. After a year of dedicated effort and the invaluable support of Liveseeding partners, SeedLinked is now officially available in 16 European countries and offered in 8 languages, all while maintaining full compliance with the European data protection legislation currently in force (EU GDPR).

17 trial managers have successfully tested the platform. Furthermore, we have implemented significant new features and improvements to enhance its functionality.

To build capacities of LiveSeeding partners to use the platform, five webinars have been conducted and numerous tutorial videos created and made available on the project collaborative workspace (SharePoint).

1. Collaborative breeding & Information and Communications Technology (ICT)

Conventional breeding and trialling methods are costly and often lack essential performance data needed by seed banks, breeders, and small-scale growers. Conversely, there is a wealth of knowledge among thousands of small-scale growers regarding variety assessment and needs. To address this, novel testing approaches that are more decentralized in nature have been explored to enhance growers' participation and provide greater flexibility. An outcome of collaborative testing is that the physical environment and phenotyping closely resemble the target conditions (Falconer 1981, Ceccarelli 1996). However, broadening end-user participation has faced challenges, primarily due to the limitations of many participatory methods, including time, training, communication, facilitation and cost (Hellin et al. 2008; Morris and Bellon 2004). In the last five years, the SeedLinked platform has leveraged digitization to overcome these hurdles, resulting in significantly reduced testing costs, improved accuracy and higher adoption rates.

1.1 The SeedLinked platform

SeedLinked (https://seedlinked.com/) is a platform for decentralized cultivar evaluation designs and inclusion of real-time multi-actor feedback (from farmer to consumer) and allows for high and heterogeneous data inputs by smartphone. 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 free of charge to support informed decision-making and amplify the overall project's impact.

SeedLinked utilizes innovative crowdsourcing technologies, including novel statistical models, Plackett-Luce ranking (Bradley,1952; Turner et al, 2019), human-centric feedback models and cloud computing. These technologies are combined with deep expertise in plant genetics, data science and farming.

Over the course of five years, SeedLinked has successfully connected more than 8,500 growers in North America to over 45 agricultural organizations, including independent breeders, seed companies, and universities. This achievement demonstrates a genuine need, potential for adoption and willingness to participate while providing granular reviews. The results from 750 trials encompassing 44 speciality crops, featuring a total of 2,750 varieties and 405,000 reviews reveal highly significant differences between tested varieties and across traits. This approach produces better on-farm performance predictions compared to current expensive, centralized trialling models. (Hoidal et al., 2021; 2023; Van Etten, 2017; 2019; de Sousa et al, 2021).

1.2 2023 SeedLinked pilots in Europe

In 2023, 17 Trial managers from 13 organizations tested the platform to collect as many feedback as possible to make it better for the European context. Table 1 features the full list of organisations and coutries involved.

Table 1 SeedLinked pilots carried out in Europe in 2023

Organisation Name	User name	Country
AGROBIO35	Jérémy Bellanger	France
AGROBIO35	Clémentine Fayol	France
FIBL	Mariateresa Lazzaro	Switzerland
Living seeds	Jorge Baptista	Portugal
Prospercirara	Philipp Holzherr	Switzerland
Biokutatas	Judit Feher	Hungary
Sativa	Sibylle Brassel	Switzerland
Sativa	Paul Gruner	Switzerland
RSR	Matteo Petiti	Italy
Uma única Localização	Adrien Burruezo	Spain
Esac	Pedro Pereira	Portugal
Itab	Alix Bell	France
Grab	Andrea ADAMKO-SEVESTRE	France
Pole Bio	Aurelie Belleil	France
Agrosemens	Mathieu Conseil	France
Sativa	Charlotte Aichholz	Switzerland

2. Features and Functionalities:

2.1 SeedLinked fully available in 8 languages

Deploying a digital platform to new geography is extremely complex and requires an intense amount of work on many fronts: localization- building a structure for new users to register in their own local/country; translation and constant translation up-dates, and finally onboarding all those users to create the best first-time user experience.

2.1.1 Localization

As part of the Liveseeding project, we built the infrastructure and added 16 European countriesindicated below (Table2):

Table 2: list of countries and languages available for SeedLinked

	Country	Languages
1	Ireland	EN
2	UK	EN
3	France	FR
4	Italy	IT
5	Belgium	FR
6	Switzerland	FR-DE-IT
7	Greece	EL
8	Spain	ES
9	Portugal	PT
10	Hungary	HU
11	Germany	DE
12	Croatia	EN
13	Poland	EN
14	Romania	EN
15	Slovenia	EN
16	Sweden	EN

2.1.2 Translation

The platform was initially available only in English and Italian. 6 additional languages (FR, DE, ES, PT, HU, EL) have been added for a total of 8 languages (see Table 2). In order to do so, the translation platform "Lokalise" was used to translate all the strings, and native speakers among project partners revised and edited the initial translations for higher language accuracy.

Webinars and tutorials wereprovided to all translators on their task. A first edit has been done on all languages. However, translation is a constant work and will need to be edited throughout the project whenever new features are added, bugs are found and to include user request feedback.

2.1.3 Onboarding and tutorials

Since March 2023, 5 demo/tutorial webinars and dedicated video tutorials have been made available to Liveseeding partners for a full integrated First Time User Experience (FTUE).

Here the list of the specific online webinars with dates:

1. Onboarding webinars for Portugal: 4th April 2023 and June 2023 on Whatsapp
2. Hungarian tutorial: 8th March 2023
3. EU-wide onboarding webinar: 13th July 2023

4. Tutorials for Spain: 13th June 2023, August 2023, 29th November 2023
5. Tutorials for France: 8th September 2023, Nov 2023
6. Tutorials for Switzerland: Prosperara, 11th oct 2023

Video tutorials

- SeedLinked Tour
- SeedLinked Trial creation
- SeedLinked use cases
- Youtube channels

Platform embedded walkthrough and FTUE

- Embedded tutorials (ex : Link): mini videos to guide users on a specific functionality;
- Walkthrough : clickable interative boxes with step-by-step demonstration on how to use the platform;
- Tool tip: pop-ups about new features;
- Embedded text : short captions under boxes to exemplify what users can type into them or standard phrases used to reassure the user that s/he has successfully completed a step.

2.2 SeedLinked is fully compliant with EU data protection legislation; GDPR

In order to complyiant with European data protection legislation, the following issues have been identified and addressed:

- 1) Sign up
- 2) Account Deletion
- 3) Data Privacy
- 4) Data Storage

As a result, Seedlinked is compliant from the 1 st of July 2023.

2.2.1 Sign Up

The sign-up screen has been reviewed to propose to all users before any sign-up the Privacy Policy and Term of services and to ask for consent (see Figure 1).

Fig. 1. SeedLinked sign up page

The current Privacy policy will be updated during Q1 of 2024 in order to factor latest modification (data model, features, etc …) and to further clarify to users data usage for the following data:

- Name
- First name
- Nickname (use for all the exchange on seedlinked)
- Adress: To receive seed for trials
- Email for account Conexion

2.2.2 Account Deletion

In case a user decides to delete its delete an account, all the personal data of the user (email, name, etc …) will be deleted. Comments, trials date, evaluations and pictures done in a trial will be anonymized. Furthermore, users can send simple email to SeedLinked and also anonymized information will be fully deleted.

Figure 2 shows the warning to the user on what will happen in case of account deletion.

Fig. 2. *Account deletion warning*

2.2.3 Data Privacy

Users are able to customise their privacy settings both in terms of image, comment and location privacy as shown in the figure 3 below:
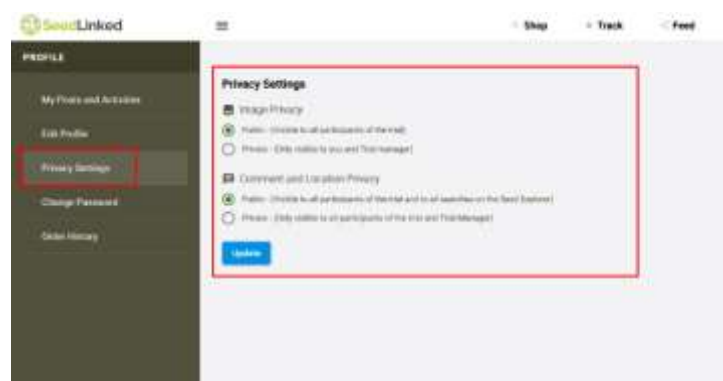

Fig. 3. *Data privacy settings*

2.2.4 Data Storage in UE

All personal data and trials data were migrated to a cloud based in the EU, and more precisely in AWS in Germany.
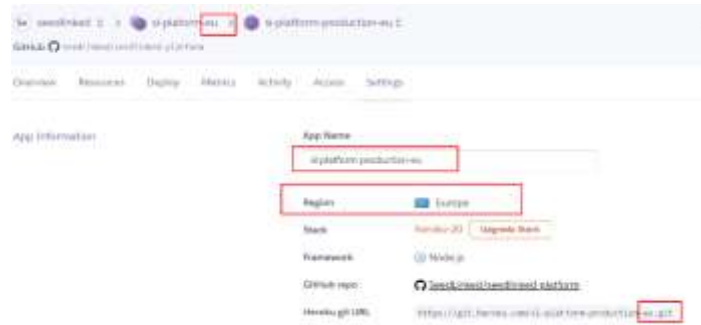

Fig. 4. *Data storage location*

Some modules (see table 3) that do not contain or use personal data yet, are still temporarily stored in a US-based cloud. As soon as they will use personal data they will be migrated to EU.

Seedlinked data migration to a EU-based cloud is close to being finalized, as indicated in Table 3.

Table 3. Seedlinked data migration to a EU-based cloud:

Name	Project Applications	Worker and Python	Data Base	LogDna / Mezmo	Images are stored in the AWS S3 bucket	Google Firebase	Azure App Insights	AWS Simple Email Service
Role	Production app, Staging app, PR apps (For each PR),	worker apps (Staging and Production), Python app for scraping, Redis Worker	Production DB, Staging DB and PR app testing DB's	Which is an addon provided by Heroku to load the last store logs	User file storage	Realtime notifications (web and mobile)	User activity / visits / IP addresses, geolocation, user ids	Send platform emails (user signups, trial notifications)
Hosted by	Heroku managed, backed by AWS	Heroku managed, backed by AWS	Heroku managed, backed by AWS	Heroku managed	AWS	Google	MS / Azure	AWS
Can be made compliant by...	Move to EU Region	No need to Move	Move to EU Region	Move to EU Region	Move to EU Region	Move to EU, and invalidate IDs upon login (for migration)	Move to EU Region in a second step to be able to use it	Move to EU Region
Status	Done	Done	Done	Done	Ongoing Planned for Dec. 2023	No need to migrate yet. Planed for Q2 2024	No need to migrate yet. Planed for Q2. 2024	Done

2.3 Seedlinked localization maintenance year 1

SeedLinked (https://seedlinked.com/) is constantly evolving and being improved both in terms of creating strings for all new vocabulray, upload to Lokalise Platform, and managing and uploading translations. All enhancements are being localized and translated in line with the table 1.

Six core improvements have been done in 2023:

2.3.1 Results page improvement:

- Error bars
- Improve filters
- Walkthrough
- Shareability and privacy

2.3.2 Trial manager account onboarding

- Many embedded tutorials (see 2.1.3 Onboarding and tutorials for more details)
- Walkthrough trough all main functionality

2.3.3 Variety management

Trial managers can now add and fully manage their germplasm into SeedLinked, with the possibility of including pictues of the variety and selecting its public / private status (i.e make it visible to all SeedLinked users or only to trial participants). Trail managers can organise the order of varieties in the trial, i.e. in which order they appear on the app when users are doing the evaluation in the field. This feture is particularly important in trials with many varieties, as the variety order on the app must reflect the spatial organisation of the varieties in the trial.

2.3.4 Internal interaction tools for the user community (SeedLinked social media)

All SeedLinked user have now a full peer to peer space to communicate and discuss anything related to trialing, varieties, sourcingand growing. Users can share text and image content and comment on each other's post within the trial.

2.3.5 Mobile app improvements

- Full onboarding and walkthrough are now available to guide users
- Improvements in UX and UI
- Bugs fixed

2.3.6 Image tagging

All image in trial can be tagged with a trait for better image usage

2.4 Feasibility assessment of the qualitative traits per crop

Data model is completed. Feature specifications is done. Many more crops were added, including lupin, honeyberry, apple trees, soybean. Also, new traits like saltiness, Umami have been added.

3.   Outlook on futher work

Further enhancements of Seedlinked, planned in the LiveSeeding contract for the years to come and described in the parapgraphs below requrie.Further change in SeedLinked data model. Since January 2023 we have been working to redo it and start adapting the database architecture to be compatible.

3.1   Bayesian trial model

The Bayesian hyerarcical model is used in a trial network of satellite and regional farms. The model is based on Bayesian statistics and is described in Rivière et al. (2015). The specificity of the model is that the residual term in each environment follows a normal distribution centered on zero with a variance specific to the environment but that is assumed to come from a common distribution of residual variances in all trials of the network. This is reasonable because of the similar structure of the trials in all environments of the network. From an agronomical point of view, the assumption that trial residual variances are heterogeneous (i.e. follow an inverse gamma distribution) is consistent with organic farming: there are as many environments as organic farms and farmers' practices, leading to a high heterogeneity.

The preliminary work required to implement this experimental design for cultivar trial was started and the following tasks completed:

- Data model edit completed;
- User specification done.

3.2   Geographic filter search and trial feature

In Seedlinked, a "Search" function allows users to find variety insights and trial results, using a number of filters, such as crop, variety, traits (yield, flavour, appearance) type, distributor and bioregions. Under LiveSeeding work assignment, two new filters have been added: country and states/regions. These country/region filters can be used both in a general search and in the trials and varieties.
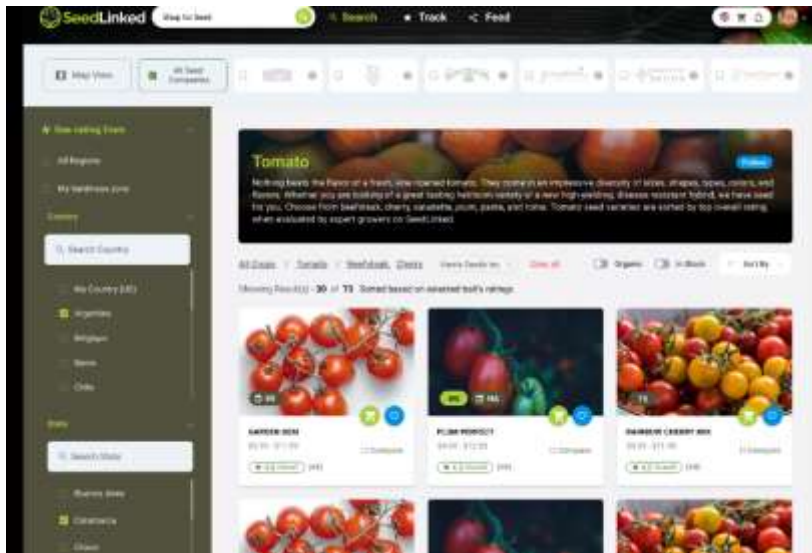
Fig. 5. Geographical filters and trial features

3.3 Development of a pilot feature for quantitative yield;

We completed the data model design to edit SeedLinked database architecture. We also comleted the first wireframe iteration (see below)
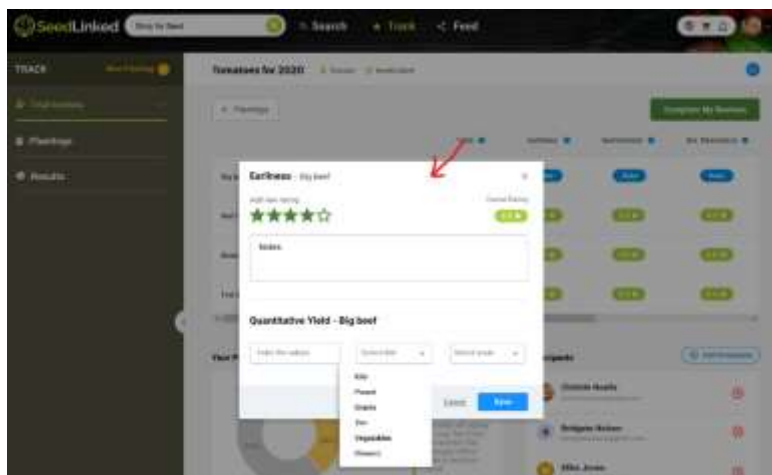

Fig. 6. Quantitative yield filter search

3.4 Seedlinked architecture interoperable with Shinemas and OHM track;

In order to ensure interoperability among the main LiveSeeding IT tools, work is currently being carried out to update the data model to be in compliance with Brapi on the following topics:

- Germplasm and variety: Be able to support Germplasm and to evaluate at a Germplasm level
- Study (be able to have several evaluations at the same address)
- Trait by crop : be able to manage different traits for each crop.

The two figures below (Figure 7 and 8) show the design of Data model under implementation:
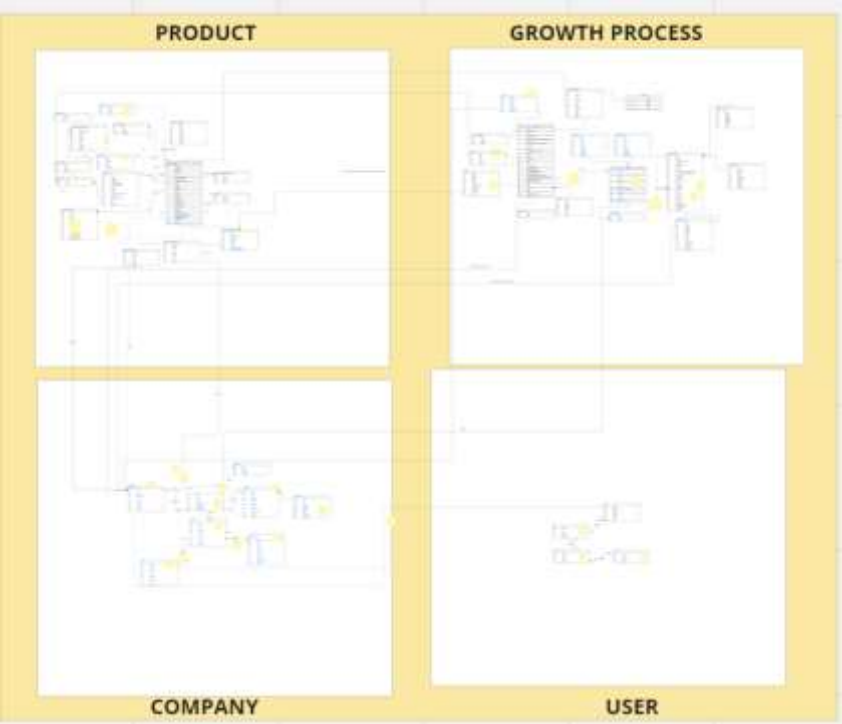

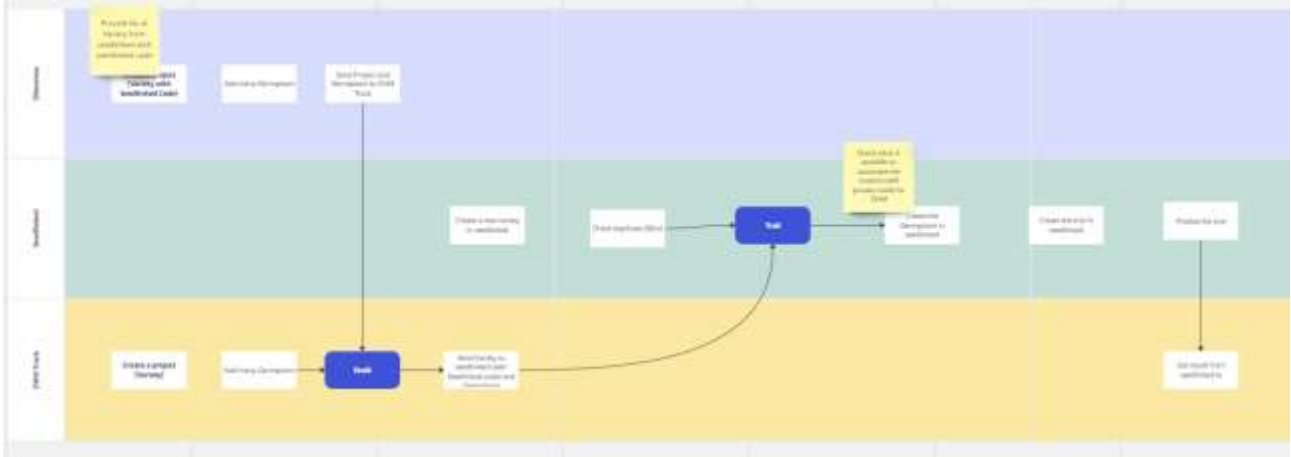*Fig 7.* First version of uses cases defined for OHM and Seedlinked integration (detailed overview).

Fig 8. First version of uses cases defined for OHM and Seedlinked integration (macro overview)

3.5   Conclusions

Work to adapt the existing crowdsourcing platform (SeedLinked https://seedlinked.com/) into a European interactive and collaborative platform for cultivar testing is progressing in line with the terms of reference of the Subcontracting contract. The app is available for researchers, organic breeders and seed savers

associations for trials with farmers, gardeners and consumers in th EU, UK and Switzerland. Work will continue to improve the use experience, to fix bugs and maintain the web based tool and to enhance some features, also in line with the contract ToRs until the end of the project (Sept 2026).

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Annex 1 SeedLinked subcontracting -Terms of Reference

Reports To:

For the scientific aspects and tasks validation:

Monika Messmer and Amritbir Riar

FiBL Switzerland

Ackerstrasse 113, Postfach 219

CH-5070 Frick

Telephone: +41 62 865-0443

Email: monika.messmer@fibl.org; amritbir.riar@fibl.org

For contract and payment aspects:

Mariano Iossa, LiveSeeding Project Manager,

FiBL Europe

Rue de la presse, 4

B – 1060 Brussels

Telephone: +32 496 559872

Emailail: Mariano.iossa@fibl.org

Background information

LiveSeeding - Organic seed and plant breeding to accelerate sustainable and diverse food systems in Europe (Project no. Project 101059872) - is a 4-year Horizon Innovation Action (IA) responding to Call and Topic: HORIZON-CL6-2021-BIODIV-01-14. LiveSeeding is focusing on technology transfer, market uptake and policy changes in the organic seed and breeding sector. It officially starts on 1 October 2022 and coming to an end on 30 September 2026 and is co-funded by the EU under the Horizon Europe programme, SERI and UKRI.

The services that are the object of the present contract fall under Task 2.4: European interactive platform for cultivar testing (Months 1 to 48).

SeedLinked (sub-contractor) will adapt its existing crowdsourcing platform for the needs of European on-farm cultivar testing networks (T2.3). The platform will be made available to researchers, organic breeders and seed savers associations for trials with farmers, gardeners and consumers by localizing the app in EU, Switzerland, and UK with respective changes of four code bases: iOS, Android, Web UI, and the API (T9.3) and translation of the user interface in 6 EU languages. SeedLinked will add crop specific ontology, new trial designs and enable the integration of quantitative data

collection and pedo-climatic data (e.g. soil maps or bio- climatic variables such as temperatures and rainfall).

FiBL Europe Accounting Code: **9054102**

LIVESEEDING contributes to the upscaling of organic production in Europe through (i) improving availability of organic plant reproductive material of organic cultivars (Organic Heterogeneous Material, Organic Varieties, landraces) of a large range of crops, bred for improved diversity and adaptation to local conditions, and (ii) strengthening and diversifying the organic seed sector informed by market demands. LIVESEEDING contributes to the transition towards environmentally friendly, climate-neutral, healthy and fair food systems through further developing (i) cultivars suited for organic and low external input production, (ii) novel governance models linking breeders with value chain actors and citizens with local food production, and (iii) awareness around the importance of biodiversity for our food and health. LIVESEEDING focuses on the main drivers for (i) the supply and demand of organic seed and cultivars, (ii) the supply and demand of food products derived from them, and (iii) enabling frameworks and roadmaps through active policy dialogue with national and European authorities and policymakers by providing science-based evidence and best practice solutions to achieve 100% organic seed. LIVESEEDING addresses the topics in a holistic multi-actor, multi-stakeholder participatory approach involving organic and public research institutes (with proven competencies in breeding, seed multiplication and health, socioeconomics, extension and outreach), variety examination offices, private breeders and seed companies, organic production and civil society associations. Additional stakeholders along the value chain are involved in the local Living Labs (LLs) and the 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.

The LiveSeeding project brings together 37 partners i.e. 31 Beneficiaries (BEN) , 1 Affiliate entity (AE) and 5 Associated partners (AS), from 16 countries, and makes use of several subcontractors. It adopts a robust multi-actor approach involving partners from all the major actor groups, namely researchers, organic breeders, seed producers, seed savers, examination officer, ICT experts and socio-economists and representatives of NGOs.

Below are shortly described some of the project tasks that are closely related to the specific tasks listed in Annex 2 to be carried out by the Subcontractor, which constitute the object of the present contract:

Task 1.1 (T1.1) - Dynamic management of genetic resources through accelerated use: will collect and characterize genetic resources on-farm for a large range of species from Living Labs (e.g. wheat, tomato, pepper, Brassica vegetables, onion, red beet) and outside LivingLabs (e.g. chamomile and other medicinal plants, hemp, flax, safflower, carrot, beans, cowpea, faba bean, Cucurbita vegetables). The characterization of the genetic resources and seed will be shared via the European digital platform for cultivar testing (T2.4).

Task 2.3 (T2.3): Advancing on-farm cultivar evaluation: Case-studies of existing pilot experiences of multi-actor, decentralised cultivar evaluation on cereals and vegetables will be advanced and expanded also by applying existing or testing new ICT tools linked with T2.4

Task 2.4 (T2.4) - European interactive platform for cultivar testing: this task will increase the impact and outreach of T2.3 activity via the development of a collaborative digital platform as a European infrastructure for organic on-farm cultivar evaluation (SeedLinked). ICT integration will facilitate low-cost, highly inclusive and representative methods, enable management of diverse sources of information and connect different on-farm cultivar evaluation networks in Europe. SeedLinked (sub-contractor) will adapt its existing crowdsourcing platform for the needs of European on-farm cultivar testing networks (T2.3). The platform will be made available to researchers, organic breeders and seed savers associations for trials with farmers, gardeners and consumers by localizing the app in EU, Switzerland, and UK with respective changes of four code bases: iOS, Android, Web UI, and the API (T9.3) and translation of the user interface in 6 EU languages. SeedLinked will add crop specific ontology, new trial designs and enable the integration of quantitative data collection and pedo-climatic data (e.g. soil maps or bio- climatic variables such as temperatures and rainfall

Task 9.3 (T9.3) - Internal and external interoperability of LIVESEEDING digital tools: will focus on ensuring interoperability of LIVESEEDING digital tools (SHiNeMaS, SeedLinked, OHMTrack and EU wide router database). Each tool will be improved/developed and tested in a dedicated task (T1.2, T2.4, T3.1, T4.3), while the current task will define a set of documented APIs and procedures to access the relative data with specific focus on the first 3 tools listed. The APIs will allow the access to phenotypic data and degustation results from SeedLinked

Specific tasks for the Subcontractor:

Task 1: European Localisation: SeedLinked will provide multi-locale support to expand access to their platform to European countries. Internationalization (the capability to support locales) will require changes to four code bases: iOS, Android, Web UI, and the API that supports all three user interfaces (hereinafter together: "The Apps"). SeedLinked will be localized and made available in 6 new languages (on the top of the available ones, i.e EN; FR, DE, IT) and across EU countries including Switzerland and UK and update string files for 4 years. The 6 new languages will be chosen from FiBL Europe and LiveSeeding Consortium parties. The Lokalise platform will be used to streamline translation and editing of SeedLinked.

Any LIVESEEDING partners and third parties involved in the LiveSeeding project activities (for example but without limitation to Living labs, field trials or case studies) in Europe will be able to use SeedLinked free of any change in any language. (For example, a German or Swiss association can use it in German to organize a trial with 20 farmers in Germany or Switzerland; equally a Romanian association can use it in English to organize a trial with 10 farmers in Romania and

they can add their location even if Romanian might not be one of the 6 languages chosen by the Consortium parties).

Milestone 1.1: SeedLinked available in 4 languages (HU, EL, PT, ES) in "The Apps";

Milestone delivery deadline: **end of July 2023**, at least 10 countries will be available in "The Apps" to organizations/project partners that will run field trials in 2023.

Milestone 1.2: SeedLinked fully available in 6 languages (2 more to add) in "The Apps";

Milestone delivery deadline: **end of December 2023**, all project countries will be added. The other EU countries (non-covered by project will be added on demand before the end of the project and contract)

Task 2: Data protection compliance (GDPR): SeedLinked operations will be fully compliant with EU data protection legislation in line with "Declaration on Data protection compliance (Non-EU provider)" signed on 5 Dec 2022. Cloud of SeedLinked will be migrated in the EU.

Milestone 2.1: SeedLinked is fully compliant with EU data protection legislation;

Milestone delivery deadline: **end of July 2023**

Task 3: Localization maintenance: Maintenance of SeedLinked as well as its localised features will be delivered throughout the 4 years of the project. Updates to address bugs and glitches inter alia, as well as all new SeedLinked features developed (e.g. Search engine, Breeding architecture, some statistic tools, mobile app updates, Social feed) will be made available in the 6 languages. String files will be updated and uploaded to the Lokalise translation platform every month during the 4 yrs of the project. Translators will then edit the machine translation of new words.

Milestone 3.1: Seedlinked localized platform maintenance year 1

Milestone delivery deadline: **December 2023**

Milestone 3.2: Seedlinked localized platform maintenance year 2

Milestone delivery deadline: **December 2024**

Milestone 3.3: Seedlinked localized platform maintenance year 3

Milestone delivery deadline: **December 2025**

Milestone 3.4: Seedlinked localized platform maintenance year 4

Milestone delivery deadline: **September 2026** (but payable already end of July 2026)

Task 4: Bayesian trial design: integrate a Bayesian trial design with replicated check base on Rpackage PPBstats model. SeedLinked full set and subset trial design will allow adding a check repeated twice. We will not add the R package in SeedLinked. We will only design and build the structure to crowdsource data in the right form on mobile and web apps. Data will be exportable and also included on the results page as a regular average. The fully-fledged version will be developed on the basis of an initial pilot (due by spring 2024)

Milestone 4.1: Bayesian trial model

Milestone delivery deadline: **July 2026**

Task 5: EU Geographic filters: Integrate geographic boundaries within SeedLinked Seed Search and Trial to refine selection within local regions. When a grower runs a seed search they will be able to filter by their country and region/state. A trial manager will be able to export data and have region information to run further analysis. This part will be done by the summer 2024. We will then assess the possibility to include a bioregion layer such as the Biogeographical Regions of Europe from Cervillini et al. 2020.

Milestone 5.1: Geographic filter search and trial feature

 Milestone delivery deadline: **July 2026**

Task 6: Interoperability: Improve SeedLinked database architecture to fit interoperability with Shinemas and OHM track. It will require some significant changes to be able to have seed lot architecture for OHM requirements as well as trait ontology to be in line with Brapi to send performance data to Shinemas and OHM track. The interoperable architecture accomplished under milestone 3.1 will be a version subject to be tested and improved until end of subcontract assignment

Milestone 6.1: Seedlinked architecture interoperable with Shinemas and OHM track;

Milestone delivery deadline: **end of August 2024**

Task 7 - Ontology: Develop and quantitative yield data with an open field to type yield numbers and pick units on the basis of an assessment and piloting exercise. That data will be exportable and pulled from API. The feasibility of including it and merging it with scoring data on the results page will be assessed. We will have a first pilot for the 2024 growing season and then a new version will be improved on basis of the feedback gathered. The scope of the quantitative yield data feature will vary on the basis of results of the assessment and piloting exercise. This feature will be limited in terms of the number of crops, measurement units and crop management system.

Milestone 7.1: feasibility assessment of the qualitative traits/characteristics of crops;

Milestone delivery deadline: **end of December 2023**

Milestone 7.2: Development of a pilot feature for quantitative yield;

Milestone delivery deadline: **May 2024**