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DIVINFOOD

Co-constructing interactive short and mid-tier food chains to value agrobiodiversity in healthy plant-based food

Deliverable D3.2

Report on NUCs agronomic performances in specific environments of the first selected varieties (season 1&2)

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Executive summary

Deliverable 3.2 - "*Report on NUCs agronomic performances in specific environments of the first selected varieties (season 1&2*)" aims to present the results of the on-farm trials carried out in the 9 Living Labs of the DIVINFOOD project in season 1 (2022-2023) and season 2 (2023-2024). DIVINFOOD focuses on 16 legumes and minor cereals that are NUCs (Neglected and Under-utilised Crops) in the partner countries, and considers a wide range of biophysical and socio-economic environments**.**

This report is primarily based on the on-farm trials carried out during the first two seasons of the DIVINFOOD project but national statistics on the agronomic performance of NUCs have also been collected in 7 European countries to provide a comprehensive picture and state of the art of NUC production.

The selection of farms to be included in the on-farm trials was based on DIVINFOOD NUC Farm typology presented in Deliverable 3.1 - *Repertoire of local farms and farming systems using NUCs in agroecology.* Compared to the SALSA farm types (Guarín *et al.,* 2020) DIVINFOOD NUC Farm typology takes better into account the agroecological practices applied by NUC farms and the diversity of farms producing NUCs. Using DIVINFOOD NUC farm typology, the on-farm trials could be extended to cover and include the widest possible range of farm types present in the 7 European countries where the 9 DIVINFOOD Living Labs (LLs) are located.

The results and conclusions are addressed to the DIVINFOOD consortium and to all value chain actors, including not only farmers, but also processors, policy makers, researchers, consumers and all promoters of "more agrobiodiversity in use in farming systems".

Authors: The core text was made by the Hungarian Research Institute of Organic Agriculture (OMKI) based on the individual input from each LL and from members of the DIVINFOOD project with the main contribution from Laurane Desoutter (LL Bean-Lyon and LL Bean-Cast), Axel Wurtz and Dylan Clair (LL Bean-Cast and LL Cer-Occ), Luca Colombo and Mariateresa Lazzaro (LL Leg-ItSwitz), Carlotta Vaz Patto (LL GPea-Port), Dylan Wallman and Inger Bertelsen (LL Faba-Nord, LL Leg-Nord), Zsofia Veér and Júlia Horváth (LL Leg-Hung), Fruzsina Szira and Katalin A. Fekete (LL Cer-Hung).

Internal reviewers: The deliverable has been reviewed by Mariateresa Lazzaro (FiBL), Yuna Chiffoleau (INRAE) and Vincent Troillard (IT).

1. Introduction

This deliverable presents the results on the agronomic performance of a set of Neglected and Underutilised Crops (NUCs) from on-farm trials carried out in the 9 DIVINFOOD LLs. Collecting, processing and standardising the data gathered in these LLs took longer than expected, which explains the 2 month-delay compared with the due date: the DIVINFOOD partners have different skills and the instructions given at the start of the task were in some cases interpreted differently. This experience will make it easier and quicker to produce the deliverable D3.3 (M57) for seasons 3 and 4. This delay is without prejudice to the other tasks that will use this deliverable.

1.1. The nine DIVINFOOD Living Labs in the context of the specific environments

Living Labs (LLs) have been widely used in different contexts since the 1990s, when the EU began to fund a number of large-scale Living Lab projects. As defined by the European Network of Living Labs (ENoLL), LLs are "user-centred, open innovation ecosystems based on a systematic user co-creation approach, integrating research and innovation processes in real communities and settings".

The design of the DIVINFOOD project includes different types of activities to be carried out by each LL. In the DIVINFOOD WP3 Task 3.2, LL are supposed to try and assess farming systems to be incorporated into short and mid-tier value chains.

DIVINFOOD LLs aim to perform multi-actor experiments in different geographical contexts within the timeframe of the four growing seasons included in the project lifespan. The size, number of members, farms involved, spatial distribution and other features are influenced by a number of external factors (like institutional background of the LL coordinator, regional rules, economic situation of the country where LL is located, etc.) and other characteristics (such as maturity of the LL) which makes each LL in DIVINFOOD unique. Therefore, in the DIVINFOOD project, we use the term 'specific environment' (NUC x LL) for a type of Genotype-Environment interactions (GxE) where the environment (E) is no longer limited to the Biophysical environment (Be) (soil, climate), but enlarged to agricultural Management practices (M), processing/cooking Technologies (T), marketing Channels (Ch), Social organisations (S) and regulations (R) (Desclaux et al., 2008).

However, LLs in DIVINFOOD share the aim to investigate and analyse the cultivation potential of at least one Neglected and Underutilised Crop (NUC) under real operational and economic conditions (through on-farm trials) in close cooperation with various stakeholders.

To ensure that the NUCs farms involved in on-farm studies and trials include the widest possible range of specific environments, DIVINFOOD **NUC Farm typology** introduced in Deliverable *D3.1-Repertoire of local farms and farming systems using NUCs in agroecology* was used to invite farms to be involved in field trials and to evaluate NUC agronomic performances.

Compared to the SALSA farm types (Guarín *et al.,* 2020), the DIVINFOOD NUC farm typology describes better the characteristics and diversity of NUC-producing farms in a regional context. In addition, the level of use of underutilised crops is considered a criterion for establishing the typology, as it is an essential prerequisite for the DIVINFOOD project.

The main characteristics of each LL including the farm types that are active partners of the LL are summarized in **Table 1.**

Table 1. The main characteristics of the nine LLs in DIVINFOOD

Name of the LL (GxE)	NUCs considered (G)	Specific challenges	Size and location of the LL (E)	Farm types that are active partners of the LLs (E)	Climatic zone(E)
Bean-Lyon	'Meat bean', *(Phaseolus vulgaris)*	Rehabilitation of local and traditional, yet forgotten, bean cultivars	69.700 km² **Lyon** and its nearby departments including Ain, Rhone and Isère	• Small scale vegetable farms in advanced agroecology • Mixed-farms with livestock and vegetables production • Diversified arable farms in advanced agroecology and with registered trademark	Continental
Bean-Cast	Lingot bean (*Phaseolus vulgaris)*	Cultivars adapted to organic conditions	2.400 km² **Lauragais-Castelnaudary** in region Occitanie, Southern France	• Artisanal peasant processors • Farms in collective organisations or linked to local patrimonial networks	Mediterranean
Cer-Occ	Einkorn *(Triticum monococcum)* Rivet wheat *(Triticum turgidum)*	Cultivars better adapted to drought	72.700 km² Region **Occitanie**, Southern France	• Artisanal peasant processors • Farms in collective organisations or linked to local patrimonial networks	Mediterranean
Leg-ItSwitz	White lupin (*Lupinus albus*)	Development of new varieties with increased stress and disease	191.300 km² Central and Northern Italy and Switzerland	• Custodian growers • Diversified mixed or arable farms • Innovative pioneer farms	Humid Continental - Mediterranean

		tolerance and low alkaloid content. Conservation of landraces. Optimisation of cultivation.			
GPea-Port	Grass pea *(Lathyrus sativus)*	New varieties and intercropping	160 km² Region **Alvaiazere**, Central-Northern Portugal	• Innovative grass pea farms • Innovative grass pea farms with food product	Mediterranean
Faba-Nord	Faba bean (*Vicia faba*)	Adapted varieties	292.900 km Denmark, Sweden	• Organic farms contracted to intermediaries • Diversified organic farms cultivating modern legume cultivars	Oceanic, humid continental
Leg-Nord	Narrowleaved Lupin (*Lupinus angustifolius*), Grey pea (*Pisum Sativum subsp. Arvense*), Lentils (*Lens culinaris*)	Adapted varieties	292.900 km² Denmark, Sweden	• Innovative organic farms with direct sales • Organic farms contracted to intermediaries	Oceanic, Humid continental
Leg-Hung	Lentil (*Lens culinaris*)	Adapted and drought tolerant cultivars	93.000 km² Hungary	• Small-scale vegetable gardens in advanced agroecology • Medium-sized arable or mixed farms in advanced agroecology	Dry Continental-Mediterranean

	Dry pea or yellow pea (*Pisum sativum ssp. sativum convar. sativum*) Cowpea *(Vigna unguiculata*) Chickpea *(Cicer arietinum)*			• Vegetable farms	
Cer-Hung	Emmer (*Triticum dicoccum)* Einkorn *(Triticum monococcum)*	Adapted cultivars selected from landraces	93.000 km^2 Hungary	• Diversified organic farms with occasional market outlets • Diversified organic farms connected to local food network • Conventional farmers aiming for conversion to organic practices	Dry Continental-Mediterranean

1.2. The Neglected and Underutilised Crops (NUCs) in DIVINFOOD and the first list of interesting varieties

NUCs "are domesticated plant species that have been cultivated or consumed as food by local communities throughout human history, but have been reduced in importance over time and not widely used by mainstream agriculture and with many of them actually disappearing" (IPGRI, 2002). The name also refers to the untapped potential of these crops and is seen as a way to increase the diversity and sustainability of agriculture.

The DIVINFOOD NUCs studied in relation to agronomic performance using the on-farm methodology are introduced in the Deliverable 3.1- *Repertoire of local farms and farming systems using NUCs in agroecology* and listed in the **Table 2**, which also presents the specific environments where they are studied in season 1 & 2.

To ensure the involvement of a wide range of local stakeholders and to engage seed multiplication and NUC cultivation in WP3 (on agronomic practises) a collaborative selection of interesting NUC varieties, a participatory evaluation exercise was carried out by each LL in 2023 (1st participatory selection workshops) in the frame of WP4 (on selection and breeding). After validation in WP2 (on food products development) and WP3, the final list of interesting varieties will be presented in Deliverable 4.2- *Final list of new varieties of legumes and minor cereals with high regional adaptation and suitable for specific products, after validation in WP3 and WP2*. However, the information collected during the 1st participatory selection workshops was processed, summarised and evaluated by the LL coordinators leading directly to the first list of interesting NUC varieties that were used to select NUCs for inclusion in on-farm trials.

Table 2. List of NUCs (G) and specific environments (E) considered in DIVINFOOD on-farm trials during season 1&2

List of NUCs (G)	Taxonomy	Production systems considered (E)	Farm types considered (E)	DIVINFOOD Living Lab concerned (GxE)
Grain legumes	Family: Fabaceae			
'**Meat bean'** heirloom bean cultivars (*Phaseolus vulgaris)*	Genus: Phaseolus	• organic • conventional	• Small scale vegetable farms in advanced agroecology	**LL Bean-Lyon** Region Auvergne Rhône-Alpes (France
'**Lingot bean'** - heirloom bean cultivars (*Phaseolus vulgaris)*	Genus: Phaseolus	• organic • conventional	• Farms in collective organisations or linked to local patrimonial networks	**LL Bean-Cast** Lauragais - Region Occitanie (France)
White lupin (*Lupinus albus*)	Genus: Lupinus	• organic • integrated management system	• Innovative pioneer farms • Custodian growers • Diversified mixed or arable farms	**LL Leg-ItSwitz** Italy, Switzerland
Grass pea *(Lathyrus sativus)*	Genus: Lathyrus	• conventional • organic • integrated management system	• Innovative grass pea farms • Innovative grass pea farms with food product	**LL GPea-Port** Portugal
Faba bean (*Vicia faba*)	Genus: Vicia	• organic • conventional	• Small-scale vegetable gardens in advanced agroecology	**LL Faba-Nord** **LL Leg-Hung** Denmark, Sweden, Hungary

Lentil (*Lens culinaris*)	Genus: Lens	• organic • conventional	• Innovative organic farms with direct sales • Diversified organic farms cultivating modern legume cultivars	**LL Leg-Nord** **LL Leg-Hung** Denmark, Sweden, Hungary
Grey pea (*Pisum sativum)* ssp. *arvense)*	Genus: Pisum	• organic	• Innovative organic farms with direct sales	**LL Leg-Nord** Denmark, Sweden
Common bean (*Phaseolus vulgaris*)	Genus: Phaseolus	• organic • conventional	• Small-scale vegetable gardens in advanced agroecology	**LL Leg-Nord** **LL Leg-Hung** Denmark, Sweden, Hungary
Chickpea *(Cicer arietinum)*	Genus: Cicer	• organic • conventional	• Small-scale vegetable gardens in advanced agroecology • Medium-sized arable or mixed farms in advanced agroecology	**LL Leg-Hung** Hungary
Dry pea or yellow pea (*Pisum sativum* ssp. *sativum*)	Genus: Pisum	• organic • conventional	• Small scale arable farms in advanced agroecology	**LL Leg-Hung** Hungary
Cowpea *(Vigna unguiculata*)	Genus: Vigna	• organic	• Small-scale vegetable gardens in advanced agroecology	**LL Leg-Hung** Hungary

Minor cereals species	Family: Poaceae			
Einkorn *(Triticum monococcum)*	Genus: Triticum	• organic • conventional • conversion to organic	• Organic farms contracted to intermediary • Diversified organic farms connected to local food network • Conventional farmers aiming for conversion to organic practices • Diversified organic farms with occasional market outlets	**LL Cer-Hung, LL Cer-Occ** Hungary, Region Occitanie (France)
Emmer (*Triticum dicoccum)*	Genus: Triticum	• organic	• Diversified organic farms connected to local food network • Conventional farmers aiming for conversion to organic practices • Diversified organic farms with occasional market outlets	**LL Cer-Hung** Hungary

1.3. On-farm experiments

On-farm research is a type of a participatory research method that engages farmers as active participants with multidisciplinary teams in the research process on their farms. It is always conducted on farms bringing researchers and farmers together to collaborate and seek solutions to problems faced by farmers. On-farm research usually refers to trials conducted in farmers' fields on plots larger than those used in standard on-station research and involving the active participation of the farmers including the use of their machinery (Behera and France, 2023). Yet results of small-plot trials on-station can also be suitable and useful in certain contexts.

On-farm experiments were already taking place in the 1970s in the Sustainable Agriculture Research and Education (SARE) program of the USA. This research method has also been used widely in Europe for a long time and it became an essential tool for organic research institutions with a long tradition such as the Swiss DIVINFOOD project partner FiBL (Forschungsinstitut für Biologischen Landbau, established in 1973). Other DIVINFOOD project partner's, ÖMKi's on-farm research network in Hungary was established in 2012 to improve and develop new organic practices and at the same time boost the transition to agroecology.

Restructuring farmer–researcher relationships and addressing complexity and uncertainty through joint exploration are at the heart of on-farm research. It describes new approaches to agricultural research and innovation that are embedded in real-world farm management. It reflects new demands for decentralised and inclusive research that bridges sources of knowledge and fosters open innovation and supposed to help to transform agriculture globally (Lacoste *at al*, 2021). During on-farm research the following principles are taken into consideration:

- The whole farm is viewed as a system—the research is conducted with recognition and emphasis on choice of priorities that reflect the whole farm.
- It avoids complex procedures that require research staff to collect and analyse data.
- It provides a mechanism for re-focusing agricultural research to solving problems that directly affect farmers.
- Cultural practices can be optimized to local conditions, resulting in farm output optimization and proper management of natural resources for sustainable management (Ganpat, 2012).
- On-farm research provides an opportunity to test findings from on-station research under more realistic or representative production conditions.
- It can help scientists better understand the complex dynamics and interactions among elements of working socioeconomic and agroecological systems, and how actual outcomes from new farming management approaches can be shaped by the biophysical, cultural, and socioeconomic attributes of specific farming landscapes and communities (Wojcik et al. 2019).
- It can also provide a more intimate venue for deeper interactions and collaboration between farmers and scientists, where participants can deliberate and reflect on the connections and dissonances between experiential and expert scientific knowledge (Baars 2011).
- It can be used to demonstrate to the broader farm community that new innovations or practices actually work under realistic farming conditions (Jackson-Smith, 2023).

The on-farm experiments that is used by the DIVINFOOD LLs is an open innovation process to improve agricultural and agroecological practices and evaluate NUC agronomic performances in real-life farm settings, namely on the farm. This process is piloted by a multi-actor approach and involves farmers (and other end users) in all the steps, therefore they become active participants in the co-creation of the research from the first steps.

The method is essentially based on mutual exchange and collaboration to ensure a win-win balance between researchers, farmers, and other stakeholders. The real environment is the actual farm of the producer and the experiments are adjusted to the farmers' production or environmental goals.

One of the main advantages of the on-farm method is that the knowledge generated on-farms flows directly back into agricultural practice and the definition of the research problem always reflects to practical problems and market needs (**Figure 1)**.

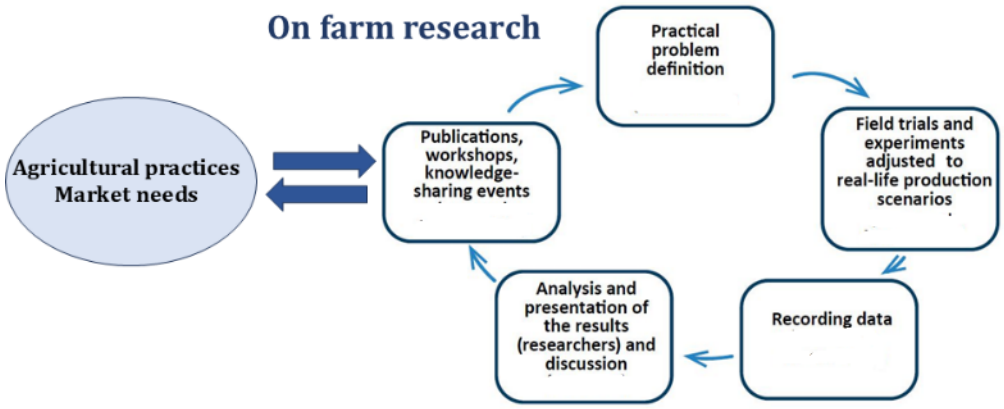

Figure 1. Scheme of the on-farm methodology (source: ÖMKi)

2. On-farm trials in DIVINFOOD LLs - Results of the first two seasons

This section is a first summary on the NUC agronomic data collected in the frame of WP3 during the first two seasons (2022/2023 and 2023/2024) of the on-farm trials. However, as part of WP4 on selection and breeding, NUC genotypes performance was also recorded from breeding nurseries of cultivar trials carried out at research stations or through participatory breeding activities. In this report priority is given to agronomic data collected in the real environment (in on-farm trials) that should help to adjust and optimise the agronomic management and agro-ecological practises for the targeted NUCs. For this purpose, the raw data from the on-farm trials reported here will feed the DIVINFOOD GxE database.

According to DoA DIVINFOOD LLs will conduct on-farm trials in at least two consecutive seasons to evaluate the agronomic performance of LL-specific NUCs under diverse agroecological farming systems. This report introduces the results of the on-farm trials (**Figure 2, Table 3**) performed in season 1 (2022/2023) and season 2 (2023/2024). Therefore, a more detailed analysis of the on-farm trials will be possible in the later phase of the project when data from all 4 seasons and at least 2 seasons per LL will be available. These results will be presented in the upcoming deliverable (DIVINFOOD D3.3 due at M57).

The term agroecological farming system refers here to the agroecology as a set of practices related to crop management and applied on a particular field or farm for at least on one year. The full diversity of agroecological practices used on NUC farms in 7 European countries was presented in *Deliverable D3.1 - Repertoire of local farms and farming systems using NUCs in agroecology*, which diversity also served as the basis for the NUC farm typology that took also into account the different agroecological practices used on NUC farms. The agroecological farming systems therefore also refers to NUC farm typology introduced in *Deliverable D3.1.* The selection of the most promising agroecological farming systems or practices to be included in the DIVINFOOD on-farm trial network was based on the results and outcomes of the stakeholder meetings (1st stakeholder meeting in WP3), where the results of *Deliverable D3. 1* were discussed with the different actors of the NUC value chains in each LL.

While the *Deliverable D3. 1* aimed to collect and present all types of farms using NUCs and existing in the LL regions, not all have been systematically included in the on-farm trials as not all were considered as developing promising agroecological farming systems or practises (based on the 1st stakeholder meeting in WP3), depending on the LL. Farm types with the most promising AE practices tested so far in each LL are listed in **Table 3**.

The use of both the NUC farm typology and stakeholder feedback for the selection of farms to be included in the on-farm pilot network allows us to include the most relevant and broad range of agroecological farming systems present in the 7 European countries where the 9 DIVINFOOD Living Labs (LLs) are located. This approach will also facilitate the practical application of the results.

The overview of the DIVINFOOD trial network (including the location of the on-farm trials of WP3 and garden-scale seed multiplication sites and experimental stations of WP4) and the summary

of the on-farm trials carried out in season1&2 in 7 of the LLs of the DIVINFOOD are shown in **Figure 2**. and **Table 3.** Two LLs (Bean-Cast and Cer-Occ) will start the on-farm trials in season 3&4 due to a lack of seeds to implement on-farm trials on larger plots in season 1&2. Yet data collected on research and experimental stations involved in these 2 LLs is useful to understand NUCs agronomic performances, then they are included in this deliverable, even if they have to be considered in a different way.

Figure 2. Overview of the DIVINFOOD trial network (the dots represent the location of the on-farm trials, garden-scale seed multiplication sites and experimental stations)

Table 3. Overview of the on-farm trials carried out in 7 LL of the DIVINFOOD in season1&2

The farm types developing the most promising agroecological farming systems or practises, which were selected during the 1st stakeholder meeting in WP3 and tested so far in LL specific context, are highlighted in bold.

LL	NUC Crop	Farm types tested	Agroecological system/practice tested	Size of the trial	No. and size of the farms participated	Actors involved
Bean-Lyon	Meat bean	• **Small scale vegetable farms in advanced agroecology** • Diversified arable farms in advanced agroecology • Mixed-farms with livestock and vegetables production	• **Intercropping** • Heirloom variety • Diverse crop rotation	• garden-scale: 5-20 m²	7 farms 1,3-120 ha	farmers, researchers, chefs
Leg-ItSwitz	White lupin	• Diversified mixed or arable farms (Italian-sub-LL) • Innovative pioneer farms (Swiss sub-LL) • Diversified arable or mixed farms (Swiss sub-LL)	• Relay **intercropping** • Diverse crop rotation • Heirloom variety • Resistant variety	• farm-scale:0.1-2ha	5 farms 15-36 ha	farmers, researchers, breeders
GPea-Port	Grass pea	• Innovative grass pea farms • **Innovative grass pea farms with food product**	• **Intercropping** • **Weed management without herbicide treatment** • **Weed management with different interrow spacing**	• small-plot:24-92.5 m² (total size)	4 farms 0.5-10 ha	farmers, researchers, municipality, processors
Leg-Nord & Faba-Nord	Lentil, Grey pea, Faba bean	• Diversified organic farms cultivating modern legume cultivars	• Intercropping • Weed management with different plant density	• small-plot:18 m²/ variety • farm-scale 100-1000 m²	9 farms 26-580 ha	farmers, researchers, raw material producer, processors,

		• **Innovative organic farms with direct sales** • **Organic farms contracted to intermediaries**				
Leg-Hung	chickpea, yardlong bean, cowpea, nungbean	• **Small-scale vegetable gardens in advanced agroecology** • Small-scale arable farms • **Medium-sized arable or mixed farms in advanced agroecology** • Mixed farms in advanced agroecology	• Diverse crop rotation • Drip irrigation • Heirloom variety • Organic farming	• garden-scale: 50-200 m^2 • farm scale:1-3 ha	12 farms 0.25 -160 ha	farmers, researchers, chefs
Cer-Hung	Einkorn, emmer	• Organic farms contracted to intermediary • Conventional farmers aiming for conversion to organic practices • **Diversified organic farms connected to local food network** • Diversified organic farms with occasional market outlets	• Landrace • Resistant variety • Diverse crop rotation • Low-till	• farm scale: 0.5-3 ha	9 farms 53-500 ha	farmers, researchers, processors, breeders

2.1 LL Bean-Lyon – 'Meat bean' or 'Haricot-Viande'

Introduction and background

NUC tested: The LL specific NUC of LL Bean-Lyon is a type of lingot-bean called 'meat bean' or '*Haricot-Viande*' (*Phaseolus vulgaris*). It's a climbing type, white bean variety that renowned for local dishes preparation and traditionally cultivated in the mountainous part of the Auvergne-Rhône-Alpes region in France.
The creamy white seeds are spotted with purple and the stems can reach up to 3 metres in height so this local variety needs to be staked. One of the interesting factors in the meat-bean cultivation is the altitude, as it is a variety that comes from two massifs in the AuRA region.
As the LL Bean-Lyon is dealing specifically with the conservation and re-introduction of this heirloom bean variety, **the Meat-bean,** this is the only variety that **has been tested.**

At the beginning of the project, the main limiting factor for the cultivation of the heirloom variety '*Haricot-Viande*' (i.e meat bean) was that only 300 g of seeds were available. Therefore, the first season of the on-farm trials was devoted to produce raw material for culinary test (WP2) and to gaining experience in growing this bean variety mainly by selecting and comparing the most suitable support plant (sunflower or maize) or support system in monocropping (bamboo cane, wooden stick, plastic net).

When intercropping is used, the companion crop must have the same maturity time as the '*Haricot-Viande*' so that the two crops can be harvested at the same time. This will minimise labour costs and also increase profit of the farms, bean production costs are higher if artificial stakes are needed to support the bean.

Farmers motivation to join the on-farm trials

The motivation for farmers to participate in the on-farm trials and their interest in the '*Haricot-Viande*' can be attributed to a number of factors, including the desire to preserve a local genetic resource, curiosity about this local variety, the possibility of introducing a new crop into the rotation, the opportunity to join the DIVINFOOD research project, and the aspiration to achieve a greater degree of regional self-sufficiency in food production.

Overview of the on-farm trials

A total of seven farms participated in the on-farm trials of LL Bean-Lyon in season 1. The farms are located at different altitudes, making it possible to collect information from several biophysical environments: two farms in Collonges at Mont d'Or (at the foot of the mountain ranges at an altitude of 250 m), one farm respectively in Duerne (at an altitude 800 m), Dracé (on the riverside, at an altitude of about 100m), Sainte Consorne (on the slopes of mountains at an altitude of 400 m), Péronnas (on the plain) and Saint-Paul en Jarez (at higher altitudes than 800 m) (**Figure 3, Table 4**).

Figure 3. Location of the on-farm trials in LL Bean-Lyon: Duerne (1), Collonges au Mont d'Or (2, 3), Sainte Consorce (4), Dracé (5), Péronnas (6), Saint Paul en Jarez (7)

Table 4. Overview of the on-farm trials carried out in LL Bean-Lyon in season1&2

No. of farms	Location	NUC Farm type	NUC Crop	Experiment	AE system/ practice applied	Annual precipitation, altitude and soil fertility*	Aim of the trial	Learnings at farm level
1	Collonges au Mont d'Or (season 1)	Small scale vegetable farms in advanced agroecology	Meat bean	farm-scale	• Heirloom variety • organic farming	- 850 mm - 256 m - low	Seed multiplication at medium altitude	• The quantity and quality of seed harvested was medium or low
2	Collonges au Mont d'Or (season 1)	Small scale vegetable farms in advanced agroecology	Meat bean	farm-scale	• Heirloom variety • organic farming	- 850 mm - 256 m - high	Seed multiplication at medium altitude	• No yield could be harvested (due to slug, drought and heat wave during early plant development)
3	Duerne (season 1)	Diversified arable farms in advanced agroecology	Meat bean	farm-scale	• Diverse crop rotation • Heirloom variety • organic farming	- 750 mm - 800m - high	Test meat bean with different staking option	• The quantity and quality of seed harvested was excellent
4	Dracé (season 1)	Small scale vegetable farms in advanced agroecology	Meat bean	farm-scale	• Heirloom variety • organic farming	- 850 mm - 100m - medium	Seed multiplication at low altitude	• The quantity and quality of seed harvested was excellent
5	Sainte Consorne (season 1)	Small scale vegetable farms in advanced agroecology	Meat bean	farm-scale	• Heirloom variety • organic farming	- 750 mm - 400m - high	Seed multiplication on slope	• The quantity and quality of seed harvested was medium or low

6	Péronnas (season 1)	Diversified arable farms in advanced agroecology	Meat bean	small-plot	• Heirloom variety • organic farming	- 1134 mm - 265m - high	Seed multiplication at medium altitude	No yield could be harvested (due to drought during germination)
7	Saint-Paul en Jarez (season 1)	Mixed-farms with livestock and vegetables production	Meat bean	farm-scale	• Heirloom variety • organic farming	- 750 mm - 800m - medium	Seed multiplication in the mountain region	No yield could be harvested (due to late sowing)

* Source of data - annual precipitation: national weather services or weather stations, soil fertility: farmer's self-declaration, altitude: online map service (Google maps)

Trial design and management

Based on previous experience and through farm visits, CRBA selected 5 farms for raw material production and yield assessment. Once the farms were selected, ca 300 g of seed available in the CRBA conservatory was shared with them and sowed in May 2023. In addition, two other farms also conducted on-farm trials in the first season, using seeds from their own production.

The largest area sown was 20 m^2 in Duerne where 1 kg of additional seed for the trial came directly from the farmer's own production. However, the other farmers sowed a total of 1-4 rows of beans (with 50 cm interrow spacing and 30 cm sowing distance) (**Figure 4**).

Figure 4. Sowing of the *Phaseolus vulgaris* heirloom variety '*Haricot-Viande'* - Meat Bean trial in Duerne and Collonges au Mont d'Or (photo: CRBA)

Three farms cultivated the heirloom variety '*Haricot-Viande'* - Meat Bean in greenhouses and four in open-field beds. No farms used any plant protection, but five farms applied mechanical weed control. The most common cultivation practices used were to grow the meat bean with a supporting plant (maize or sunflower) or to support it with wooden stakes or plastic nets (**Figure 5**). Two farms used hoeing and weed control fabric and one farm used mulching. The harvest was mainly done manually from end of July till September.

Figure 5 Different options for staking the meat *Phaseolus vulgaris* heirloom variety '*Haricot-Viande*' - Meat Bean (maize-bean intercropping, left, and plastic net, right, photo: CRBA)

List of traits accessed

- Yield

Main results
The first season of the on-farm trials in LL Bean-Lyon was devoted to produce raw material for culinary test (WP2) and to gaining experience in growing this bean variety. In season 1, two farms achieved excellent results, harvesting seed of good quality and quantity, with yields of 18.5 kg from 0.5 kg of seed (Drace) and 20 kg from 1 kg of seed (Duerne). Two other farms harvested a yield of 850g (Collonges au Mont d'Or) to 1000g of beans (Sainte Consorce), which was close to the amount sown. There was no harvest on the other three farms.
This quantity provided a sufficient raw material for the kitchen experiments and tasting carried out in WP2 of the project and for on-farm trials in the following year.

Main limitation or problem during the season

Following discussions with farmers and an evaluation of the season 1, the most significant negative factor for meat bean production that all farmers selected for seed multiplication agreed on was the climbing nature of this variety. This firstly can act as hindering factor because of high labour cost for a low productivity potential. Another crucial problem highlighted by farmers is lack of mechanisation during the harvest of climbing bean.

Other farm specific problem identified during one farm trial can be the risk of wind-related lodging, the slug attacks during germination, and the drought and heatwave during sowing.
As a further suggestion, it is also noted that, in the case of greenhouse cultivation, it is only recommended to grow in buildings with higher ceilings, as the beans can reach 2 m and good ventilation is important.

Take-home message and next steps

The most important achievement is that the first season's harvest provided sufficient raw material for the culinary and tasting experiments in WP2 of the project, while also providing seeds for the agricultural experiments (in WP3 and WP4) for the following year. One part of the first season's harvest was therefore used for the culinary experiments and another part was used for the on-farm or small plot experiments in the following year.

As meat-bean is climbing type and needs supporting plant or artificial stakes, small plot trials with different staking options were also carried out in season 1 at the CRBA Experimental Station (WP4 activity, in parallel to on-farm trials in WP3) and maize-bean intercropping was selected as the most promising agricultural practice to be tested at farm-scale. In season 2 (as a preparatory step for on-farm trials in season 3&4), maize variety screening (WP4 activity) was also carried out at the CRBA Experimental Station and three maize accessions were selected (based on maturity and growth habit) for farm-scale bean-maize intercropping trials.

Therefore, on-farm trials in LL Bean-Lyon will continue in season 3&4 with bean-maize intercropping and the results of small plot trials with different staking options (season 1) and maize varieties screening (season 2) at the CRBA Experimental Station will be reported in more detail in Deliverable - D4.2.

2.2 LL Bean-Cast – Lingot bean around Castelnaudary

Introduction and background

The region of this LL is "Lauragais", whose “capital” is Castelnaudary and which is part of the Occitanie region. The ‘*Lauragais*’, a rural area, is a historical and cultural region in the south-western part of France and associated with the wealth of its agricultural production. It is also famous for its dried or lingot beans, the ‘*lingots de Lauragais*’, which are one of the traditional white beans used in French or Castelnaudary Cassoulet. (Office de Tourisme de Castelnaudary, 2024).

The NUC tested: The Lingot bean, the NUC of LL Bean-Cast, is a special type of bush bean, about 50 cm high, with white seeds and the advantage of retaining its shape after cooking.
Based on desk research and screening of INRAE germplasm collection, 10 lingot type bean varieties were pre-selected for their phenotypic characteristics that could meet the criteria of lingot bean, i.e white seeded, can be used for cassoulet, and mainly dwarf but can be climbing bean too.

Take home message and next steps

In LL Bean-Cast, season 1 was the first year of trials to evaluate the agronomic performance of the lingot bean varieties. At the start of the project, seed availability was limited and seasons 1&2 were dedicated to phenotypic characterisation and garden-scale seed multiplication (**Figure 6**) of the 10 pre-selected lingot bean varieties. These activities are related to WP4 and will be reported in Deliverable - D4.2 while on-farm trials with lingot bean will start in season 3&4.

Figure 6. Garden-scale multiplication of lingot bean varieties in season1&2 (photo: BIOCIVAM11)

2.3 LL Cer-Occ – Minor cereals in Occitanie

Introduction and background

The report on the state of agriculture in Occitanie confirms the region as the second most important agricultural region in France (DRAAF Occitanie, 2020), with almost one in five farms certified organic and many different pedo-climatic contexts.

LL Cer-Occ considers einkorn and rivet wheat as NUCs in the LL specific sense. However, only einkorn landraces will be evaluated in on-farm trials (in WP3), while rivet wheat is the subject of a participatory breeding programme in WP4.

The informal name of the most popular and widely used einkorn cultivar in Occitanie is "IGP" and it is originated from an area in Provence where many agricultural products with PGI (Protected geographical indication) designation are produced. However, based on Farm & Expert Interviews (see Deliverable 3.1) and the results of previous field trials, this variety does not seem to be well adapted to Occitanie. Farmers in the LL region have therefore expressed a need for a diversified range of varieties to be grown.

The NUC variety tested:
In season 1&2, 12 einkorn cultivars (9 landraces, 1 commercial varieties, 2 populations) have been sown in small-plot design, and assessed in 2 research stations (and in 2 high schools in agriculture) in the LL region. These varieties have been participatory evaluated by farmers, small-scale processors, technicians, citizens, researchers and students during field visits (in WP4) and allowed us to identify the most interesting varieties in order to be assessed in a processed final product (in WP2) and their subsequent inclusion in on-farm trials in season 3&4 (in WP3).

Take home message and next steps
In the experimental network of LL Cer-Occ 12 einkorn varieties have been tested in research centres and agricultural schools (part of WP4) in season 1&2. In 2023, the LL also organised participatory meetings and field visits (**Figure 7**) to define the selection and breeding criteria, not

only for quality traits for pasta products, but also for which varieties could be proposed for inclusion in on-farm trials. The LL decided to focus on 6 criteria: yield, precocity, disease resistance, quality (taste), lodging resistance and weed competition. Based on these criteria, the LL initiated some cross breeding activities in 2024 and started to multiply seed for on-farm trials that will start in season 3.
The detailed results of the cultivar tests at research stations and agricultural schools will be reported in Deliverable - D4.2.

Figure 7. Field visit and on-field participatory evaluation of the einkorn cultivars (photo: BIOCIVAM11).

2.4 LL Leg-ItSwitz – White lupin for protein-rich plant-based food of domestic origin in Italy and Switzerland

Introduction and background

The activities in the Swiss portion of the LL are facilitated by the Research Institute of Organic Agriculture FiBL and are situated in the German and French speaking part of Switzerland. In Italy the activities take place in two geographically distinct yet thematically connected areas. In Northern Italy, due to the greater engagement of the CREA-ZA research centre, the focus is on breeding and processing, while activities in Central Italy, facilitated by FIRAB, hinge around the construction of a range of lupin value chains spearheaded by a number of interested farmers who use a mix of landraces and improved lupin varieties (including a new variety registered by CREA-ZA). The link between the four subgroups (French and German-speaking Switzerland, North and

Central Italian) is ensured by the common aim of developing knowledge and practices around white lupin breeding, cultivation and use.

In Switzerland, farm scale trials were carried out in season 2 on two organic farms (one in the in the German and one in the French-speaking region of Switzerland) (**Table 5**). The first trial was dedicated to the introduction of lupins in the crop rotation of a farm that had no experience with this NUC yet. The second experiment took place in a farm that already cultivates lupins for several years and aimed to test spelt-lupin relay intercropping agroecological practice. These farms can be classified as diversified arable or mixed farm and innovative pioneer farm (according to DIVINFOOD D3.1, 2023).

In Italy, FIRAB, together with CREA and LL stakeholders, planned the launch of on-farm activities in season 1 and as part of a preparatory trial, CREA has successfully propagated the genotypes and populations in order to make a sufficient quantity of seed available for the on-farm trials, planned mainly in Central Italy from season 2.
Therefore, the on-farm evaluation of the white lupin in Italy has also started in season 2.

NUC varieties tested:
In Italy, three different white lupin cultivars, one registered DUS variety, Arsenio (1), one local landrace, *'Dolce di Maremma'* (2) originated from regional gene bank and an old Chilean variety (3) derived from own multiplication of the farmer were tested.

In Switzerland, important cultivation practices include the use of healthy (certified) seeds and the choice of resistant varieties to reduce the impact of the fungal disease anthracnose. The commercial variety Frida was selected for on-farm trials because of its increased resistance to anthracnose.

Farmers motivation to join the on-farm trials

Lupin growers involved in the DIVINFOOD LL in Italy tend to value the potential and urgency of cultivated biodiversity and often grow other NUCs in rotation or in parallel. In some cases, they belong to territorial networks where lupins go hand in hand with local traditions (Central Italy). In Northern Italy interest is also growing among farmers to introduce proteaginous crops for their relevance at both agronomic and nutritional level.

Farmers in Switzerland are interested in the sustainability and agro-environmental benefits of lupin, such as its nitrogen fixation and pollen-provider services. However, in Switzerland, white lupin cultivation is challenging due to anthracnose disease pressure than can determine very strong to complete yield loss and the variability in alkaloid content in the harvested grain that makes it difficult to build value chains for food use. Despite these challenges, the marketing potential for lupin is significant: not only does it have better reputation and several agronomic advantages compared to soybean, but also it responds to current vegan, vegetarian, sustainable, regional and high-protein food consumption trends (Cropdiva, 2022).

Overview of the on-farm trials

In Italy, two trials were located in Grosseto and one in Rome municipality, while the Swiss trials located in Payerne and Regensberg (**Figure 8**) and the main characteristics of the trials are summarised in **Table 5**.

Figure 8. Location of the on-farm trials in Leg-ItSwitz: Payerne, Switzerland (1), Regensberg, Switzerland (2), two farms at Grosseto, Italy (3), Rome, Italy (4)

Table 5. Overview of the trials carried out in Leg-ItSwitz in season1&2

No of farms	Location (season)	Farm type	NUC Crop	Experiment	AE system/practice applied	Annual precipitation, altitude and soil fertility*	Aim of the trial	Learnings at farm level
1	Payerne, Switzerland (season 2)	Innovative pioneer farm	White lupin variety Frida	farm-scale	• relay intercropping • organic farming	- 8-900mm - 677 m - medium	Test spelt-lupin relay intercropping	Weeds can become an issue in this system. Combine harvest is a challenge if spelt does not grow tall enough. Low anthracnose but too high alkaloid content.
2	Regensberg, Switzerland (season 2)	Diversified arable or mixed farm	White lupin variety Frida	farm-scale	• diverse crop rotation • organic farming	- 1000mm - 600m - medium	Introduce lupin as a new crop in the rotation	Good yield, low anthracnose (alkaloid content not evaluated yet).
3	Grosseto, Italy (season 2)	Diversified mixed or arable farm	White lupin variety Arsenio	farm-scale	• organic farming • diverse crop rotation	- 624mm - 0-100m - fairly low	Test lupin production on small-scale	Good yield and medium-low alkaloid content.
4	Grosseto, Italy (season 2)	Custodian growers	White lupin-"Dolce di Maremma" landrace	farm-scale	• heritage variety • mechanical weeding	- 650mm - 0-100m - low	Test "Dolce di Maremma" landrace	Good yield, no lodging but this variety has very high alkaloid content.
5	Rome, Italy (season 2)	Diversified mixed or arable farm	White lupin-old Chilean variety	farm-scale	• organic farming • diverse crop rotation	- 799mm - 0-100m - low-medium	Test old lupin variety	Medium yield and moderate alkaloid content but this variety tends to lodge.

Trial design and management

In Payerne, the **spelt – white lupin relay intercropping trial (Figure 9)** took place on an area of 15 x 260 m and it was fully managed with farm scale machinery.

The trial design included:

- 1.5 m x 260 m sole crop lupin stripe
- 12 m (which is 4 times for the 3 m width of the sowing machine) of spelt – lupin intercropping (including alternation of 3 rows and 4 rows lupin stripes) x 260 m
- 1.5 m x 260 m sole crop spelt stripe.

The spelt was sown on 23 November 2023 and the white lupin (variety Frieda) on 7 April 2024.

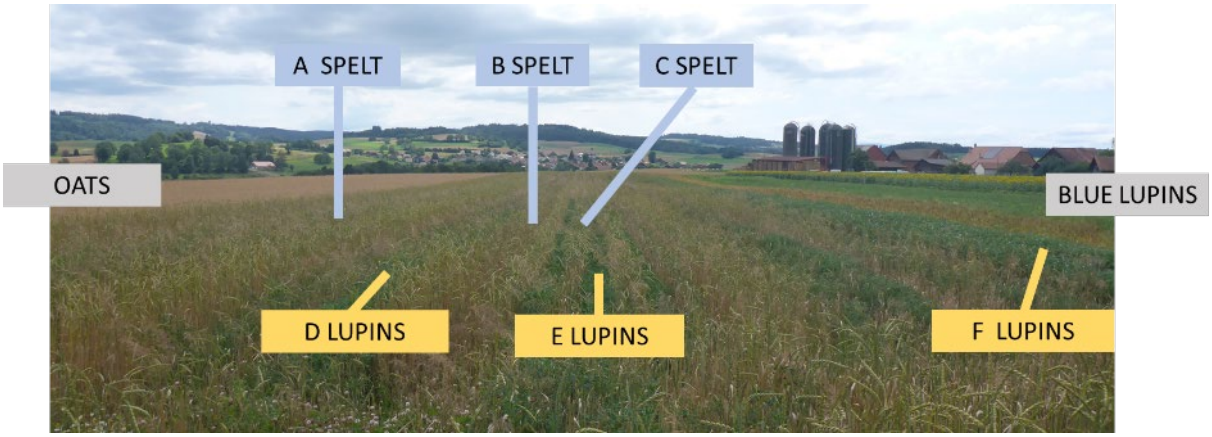

Figure 9. Overview of the spelt – white lupin relay intercropping trial on 2024/07/16 (photo: Mariateresa Lazzaro, FiBL).

On **Figure 9** the two neighbouring fields (oats on one side and blue lupins on the other) and one example of each experimental unit that was sampled for the yield quantification are marked (A – spelt as sole crop, B - wider stripe of spelt between lupins, C-narrow stripe of spelt between two stripes of lupins, D - 4 rows lupin stripe, E - 3 rows lupin stripe and F – lupin sole crop).

The variety Frida was selected due to its increased anthracnose resistance. Mechanical weeding was applied 3 times, once at lupin sowing, with weeding device attached to the sowing machine and then on 30 April and on 9 May with a weeding harrow.

Harvesting of the two crops happened separately for the two crops (**Figure 10**). On 29 July 2024 the spelt was collected, keeping the cutting bar of the combine harvester high to collect the spelt ears but avoid lupins. The lupins were combine harvested later on 28 August 2024.

Figure 10. Spelt harvest (left) and lupin harvest (right) in the 2024 relay intercropping trial (photo: FiBL).

In Regensberg, the same cultivar, Frieda was sown on an area of 12 m x 82 m on 30 April 2024 as sole crop. The experiment aimed at the introduction of lupins as new crop in the rotation of the farm and it was managed with farm scale machinery as well (**Figure 11**).
Sowing was made with 12,5 cm interrow spacing. Mechanical weeding was applied once with tine weeder on the 2 weeks old seedlings. Three samples from a 1 m^2 area were hand harvested for grain yield measurement as the rest of the field was harvested for biomass to be mixed with maize for silage (being the farm a mixed farm with livestock).
Rhizobia seed inoculation was used in both trials.

Figure 11. White lupin trial in Regensberg: overview of the field (left) and close-up of a lupin root with active nodule (right) on 11. 07. 2024 (photo: Mariateresa Lazzaro, FiBL).

In Italy, three different white lupin cultivars were tested in the on-farm trials (one in each trial). One registered DUS variety Arsenio, one local landrace, the sweet lupin of Maremma originated from regional gene bank and an old Chilean variety derived from own multiplication of the farmer

(original seed from a variety from Chile). The aim of the trials was to test lupin production on small-scale and compare the alkaloid content of the three varieties.

The lupin was sown around mid-November at all three locations. Sowing was carried out in narrow rows (12-18 cm) with a cereal seeder in one farm or broadcasted with a manure spreader in two other farms. The recommended sowing density is 150 kg/ha and this rate was applied by the two farms located in Grosseto but farmer of the sweet lupin Maremma decided to sow with lower rate, with 80kg/ha sowing density.

'Dolce di Maremma' lupin landrace was sown on 2000 m^2 in Grosseto; the Chilean variety on 2 ha in Rome, while on the third farm 6 kg of the new commercial variety Arsenio seed was sown by broadcast sowing on a total area of ca. 400 m^2. The lupin was mainly combine harvested at end of July on all three locations but the landrace was partially hand harvested to avoid grain fractures. Weed control was only made mechanically in the heritage variety field (row cultivation) but neither mechanical weeding nor fertilizer or input material was applied on other fields in Italy. Rhizobia seed inoculation was applied on the variety Arsenio.

List of traits assessed

- Yield
- Alkaloid content in the grain
- Weeds (in Switzerland)
- Plant lodging
- Pollinators presence (in Switzerland)
- Anthracnose disease (in Switzerland)

Main results

Italy

In Italy, the "Dolce di Maremma" landrace yielded 2.8 t/ha and no lodging was observed despite sparse sowing. However, the alkaloid content of this traditional landrace is high, so debittering is necessary. Based on alkaloid content analysis Arsenio variety had 570 ppm while 'Dolce di Maremma' heritage variety had 34.000 ppm (the suggested threshold is 200 ppm for human and 400 ppm for animal consumption). The yield of the old lupin variety multiplied by the farmers was 1.5 t/ha with a medium alkaloid content, which can be used for food production after debittering. However, lodging occurred before harvest due to heavy rains in late spring, exacerbate by wild boars wandering in the field. The broadcast seeded lupin variety Arsenio also produced a good yield, but the main aim of this experiment was to explore lupin production on a small scale with limited seed, as this was the first year that farmers had grown lupin, with a seed to crop ratio 1:20.

Switzerland

The lupin yield was 3.4 t/ha at Regensberg, providing a very satisfactory result of this first year of cultivation in this farm.

The average lupin yield was 2.5 t/ha at farm level in Payerne (the farmer cultivated also another lupin field in addition to the experimental field). The yield in the experimental trial was 1.6 t/ha

of lupins and 2 t/ha of spelt in the spelt-lupin intercrop stripe, 3 t/ha of lupins and 2.5 t/ha of spelt in the sole crop stripes of the experimental trial.
For the Payerne trial, we analysed the alkaloid content of the seed source (1 sample), the lupin grain harvested in the intercrop strip (6 samples) and in the sole crop strip (3 samples). Unfortunately, the initial level in the seeds was very high, 3090 mg/kg, whereas the recommended level for direct human consumption is 200 mg/kg. We detected a difference between the alkaloid level in the grain harvested in the intercrop (2190 mg/kg) and the sole crop (4322 mg/kg). Even if we cannot draw a clear conclusion about the effect of the intercrop treatment, a hypothesis to be further investigated for the higher content in the grain harvested from the sole crop is the continuation of flowering for a longer period and because of this the presence of more green pods at harvest. Nevertheless, the main reason for the very high alkaloid content is the seed source. Frida is a sweet commercial variety based on the well-known sweetness mutation *pauper*, which alkaloid value should be low. Further investigation is needed to determine the reason for the high value in the seed used in the trial.
No lodging occurred in Payerne, while a moderate level of lodging (due mostly to the high pods productivity, which did not hamper the harvest) occurred in Regensberg.
In both farms, weeds were relatively difficult to manage and mechanical weeding was necessary. The result of the relay intercropping trial showed that weeds can become an issue in this system as late weeds grew in the stripes left uncovered after the harvest of the spelt until the harvest of lupins.

Main limitation or problem during the season

In Payerne, the wet winter caused soil compaction and waterlogging, which hampered spelt development. As a result, the spelt did not develop well during the season and the plant height was lower than expected. As a result, the concept of harvesting spelt with a higher cutter bar was only partially successful and spelt could not be perfectly separated from lupin at harvest. As mentioned in the section above, late weeds were difficult to manage in this trial.

In Italy, on one farm, deer munched lupin flowers, and in the case of Maremma lupin, farmers had difficulties in determining the proper sowing time.

Combine harvesters are mainly used by the farms belonging to the Italian part of the LL, but in the future, they need more precise and correct instructions on how to set up the harvester in order to avoid broken grains. In addition, the ideal time for harvesting must be chosen, taking into account the asynchronous ripening of the pods and their possible dehiscence.

Take-home message and next steps
Italy
A review of the literature on Italian cultivation suggests yields of 3.5-5.0 t/ha in southern Italy (with autumn sowing) and 2.0-4.0 in northern Italy (with spring sowing), which is roughly in line with the yield measured in the season 2 of Italian on-farm trials. No particular diseases or pests are indicated in real conditions and they are not recorded as major barriers in Italy.
Based on the result of the on-farm trials and farmer-experience in Italy, we recommend tillage with a plough (important for weed management) and sowing in autumn as lower yield can be expected in the case of late sowing of the lupin.

The two main actions planned for the next seasons are the further multiplication of low alkaloid varieties (1) either for seed distribution within the community or to start processing a low alkaloid variety with no or limited debittering, and the adaptation of the combine harvester for mechanical harvesting (2) to ensure the prevention of any breakage for lupins to be processed as lupin snacks. As the main bottlenecks are the alkaloid content and the processing into attractive food products, this will be of greatest interest to the Living Lab farmers. This will be promoted by paying special attention to dialogue with processing companies, as lupin valorisation needs to be further explored, with its agro-ecological benefits and potential being the most promising features

Switzerland

Since the introduction of the two varieties Frieda and Celina with increased anthracnose resistance, a major step has been taken towards yield security for white lupins in Switzerland. However, the two varieties do not have a stable low alkaloid content. Both on-farm trials in 2024 used the cultivar Frieda and in both locations the anthracnose pressure was very low but the alkaloid content too high (data for alkaloids from Payerne trial only).

Given the 2024 experience, in 2025 the two farms will continue the cultivation of this variety as no alternative is available yet with the same level of anthracnose resistance and stable low alkaloid level. Special attention will be given to the seed source used. In Regensberg the experimentation will continue with the test of the undersowing practice as the crop resulted generally suitable for cultivation in this test year. In Payerne an emmer – lupin contemporary intercropping will be tested to try to overcome the difficulties at harvest and the problem with the late weeds encountered in the relay intercropping setting.

2.5 LL GPea-Port – Innovative grass pea food product in Portugal

Introduction and background

The grass pea is a traditional grain legume that has been revived by local authorities, especially in the Alvaiázere region where LL GPea-Port is located. Thanks to the efforts made to promote this grain legume, grass pea cultivation has been given new impulses and there is growing interest in its production. As consumer demand has also been increased, grass pea could become a profitable crop.

NUC varieties tested:

In the LL GPea-Port, 2023 was the first year of on-farm trials and the main aim was to compare and evaluate the performance of 3 grass pea traditional varieties (landraces).

Two of the three grass pea varieties were local landraces commonly grown by the farmers and used by the processors for pastry and bakery. These two varieties differ from each other mainly in seed size (one has a large seed size, while the other has a small seed size), but both have a light seed colour.

The third variety is an exotic one (with small seed size and dark colour), but with interesting characteristics such as precocity and a higher number of seeds per plant, which are important traits for the Mediterranean climate conditions.

Farmers motivation to join the on-farm trials

Grass pea is a very low-input crop and does not require a lot of labour which motivates many farmers to grow it.

On the other hand, the traditional NUC varieties are well adapted to the farmers' land, so the investment to produce them is not very high. Farmers have a good knowledge of cultural practices needed to achieve reasonable NUC yields. In some cases, there has been a shift from the main crop (vines) to NUC, especially grass pea.

Overview of the on-farm trials

In season 1, on-farm trials were established in four different farms (**Figure 13)** with the two traditional light seeded Portuguese grass pea varieties intercropped with three wheat species (einkorn, rivet and spelt) at three farms and with an additional exotic grass pea variety at one farm.

The LL activity in season 2 continued with the evaluation of a single grass pea landrace (with light, smaller seeds) and focused mainly on the testing of different management approaches suitable for grass pea cultivation as a sole crop instead of different intercropping systems. Season 2 also focused on testing different interrow distances for weed control with and without herbicide treatment. Similar to season 1, season 2 trials were set up in Alvaiázere (**Figure 13)**.

In both season the same farms participated in the on-farm trials and out of the four, three are conventional farms (one with integrated protection system with Global GAP certification) and one farm is applying some organic practices.

Figure 13. Location of the on-farm trials in seasons 1&2 in the Alvaiázere (Portugal)

Table 6. Overview of the trials carried out in GPea-Port in seasons 1&2

No of farms	Location (season)	Farm type	NUC Crop	Experiment	AE/system practice applied	Annual precipitation, altitude and soil fertility*	Aim of the trials	Learnings at farm level
1 (C)	Alvaiázere, Portugal (season 1&2)	Traditional farms	2 traditional and one exotic, dark seeded grass pea landraces	farm-scale	**season 1:** grass-pea-minor cereal intercropping **season 2:** innovative weed management	- 5-600mm - 0-200m - low	**season 1**: Test grass pea-minor cereal intercropping **season 2:** Test grass pea performance as a sole crop	• No yield in season 1 due to weed problem. Weed management needs to be reviewed • Reduced interrow spacing with herbicide treatment is promising
2 (M)	Alvaiázere, Portugal (season 1&2)	Innovative grass pea farms	2 traditional grass pea landraces	farm-scale		- 5-600mm - 3-400m - m		• No yield in season 2 due to wild pigs. Protection needs to be reviewed
3 (N)	Alvaiázere, Portugal (season 1&2)	Innovative grass pea farms with food product	2 traditional grass pea landraces	farm-scale		- 5-600mm - 3-400m - low		• Low amount of yield in season 1 due to weed problem. Weed management needs to be reviewed • Reduced interrow spacing with herbicide treatment is promising
4 (P)	Alvaiázere, Portugal (season 1&2)	Innovative grass pea farms with food product	2 traditional grass pea landraces	farm-scale		- 5-600mm - 4-500m - low		• Reduced interrow spacing is promising

Trial design and management

In season 1, on-farm trials at four location were carried out to collect data on the agronomic performance of grass pea in the GPea-Port LL. Three different grass pea varieties (two traditional white-seeded varieties, differing in seed size (one large and one small), and one exotic black seed variety) were selected and tested comparing sole cropping to different innovative intercropping systems with different minor cereals (spelt and einkorn) using two schemes (alternated lines or mixed lines) in incomplete block design (**Figure 15**).

Figure 15. Intercropping trial in Alvaiázere in season 1 (visited during Annual Meeting in 2023)

Sowing with 25 cm interrow distance took place at three farms on 27 January and due to extreme meteorological conditions the fourth farm could only sow on 6 of April 2023. Sowing rate was 260 kg/ha for big seeded grass pea and 195 kg/ha for small seeded grass pea landrace. Yield could be harvested on two farms on 16 June and 5 July, the latter is the one with late sowing, and due to weed problem no yield has been harvested on the other two locations. Several indicators were measured, such as plant height, resistance to diseases and pests, vegetative biomass, yield and grain quality related traits.

In season 2, field trials were established at the same four farms but the main purpose of the trials had changed from testing different intercropping systems to testing grass pea performance as a sole crop. Therefore, different management systems with different interrow distance and herbicide versus herbicide free treatment were tested.

The white seeded small grain grass pea landrace was machinery sown on all four farms between 18 and 24 of April 2024 with a seed amount of 195 kg/ha at 30cm row spacing and 106 kg/ha at

70 cm row spacing. No mechanical weeding was applied at the farms but plots with and without herbicide treatment was carried out. Harvest took place on 27 July and 19 August 2024 on three farms and no yield were harvested at one farm where wild pigs munched the crop significantly. Plot size varied from 24 to 92,5 m^2 depending on the farm, and the herbicide when applied was pendimethalin in pre-emergence.

List of traits accessed

- plant biomass
- yield

Main Results

In season 1, on the Farm 1 (C) where normal sowing time was applied, light colour small seeded grass pea yielded 98 g/m^2 while big seeded yielded 46 g/m^2. Interestingly on the farm where late sowing was applied Farm 4 (P), the grass pea performed better and yielded: 144 g/m^2 and 127 g/m^2 for small and big seeded varieties, respectively. Overall, there was no significant difference between the two grass pea varieties neither between the spelt and einkorn nor between the two intercropping schemes, due to high variance among the farms tested (**Table 13**).

In season 2, yield and total biomass of the grass pea cultivated as sole crop were successfully assessed at three farms However, the herbicide treatment did not provide clear effects especially in the bigger interrow distances (**Table 14**). Nevertheless, the 30 cm interrow distance, applied with the herbicide treatment, provided the most consistent results.

Table 13. Result of the intercropping trial in LL GPea-Port in Season 1 For the comparison of the different intercropping schemes we used the Land Equivalent Ratio, as defined by Tavoletti & Merlotti (2020) where on each mixed crop combination, the LER of each crop and total LER were calculated as follows: LER for cereal = cereal yield as a mixed crop/cereal yield as a pure crop, LER grass pea = grass pea yield as a mixed crop/grass pea yield as a pure crop, Total LER = LERcereal + LERgrass pea

		Total LER			
Intercropping Scheme		Alternate lines		Mixed lines	
Ancient wheat		Spelt	Einkorn	Spelt	Einkorn
Farm 2.	big seed	5.46	2.43	1.70	1.41
Farm 2.	small seed	0.20	1.80	0.44	2.31
Farm 3.	big seed	0.05	6.88	1.71	1.56
Farm 3.	small seed	1.13	1.00	0.27	0.38
Farm 4.	big seed	1.02	0.76	0.66	0.75
Farm 4.	small seed	1.15	0.80	0.84	0.81

Table 14. Agronomic traits of the grass pea assessed in LL GPea-Port in Season 2

	Yield (g/m^2)	
Interrow distance	70 cm	30 cm

Herbicide treatment	No	Yes	No	Yes
Farm 1.	3	22	13	135
Farm 2.	101	131	93	211
Farm 3.	96	56	14	28

Total biomass (g/m²)

Interrow distance	70 cm		30 cm	
Herbicide treatment	No	Yes	No	Yes
Farm 1	535	158	155	289
Farm 2.	215	325	195	505
Farm 3.	257	180	62	97

Some grain quality parameters have also been analysed in lab but results are not yet available therefore they will be introduced in the report on season3&4.

Main limitation or problem during the season

In season 1, the exotic grass pea was grown only in one location and due to extreme climatic events, that occurred in the field where this trial located, it was not possible to evaluate the performance of this variety.

Based on the experience of the two seasons, the biggest challenges in general were protecting the crop from wild pigs, coping with extreme weather conditions, especially drought, and the weed control.

Take-home message and next steps

The results of the grass pea – spelt/einkorn intercropping trials suggest that among the cereal species tested the spelt was the one which performed the best, but harvesting the intercropped plants and sorting the seeds after harvest are not in line with the resources (including human and physical resources) available to the farmer in the LL region. In addition, the average farm size of the grass pea producer is less than 10 ha and the farmers consider their area too small for arable cereal production.
Therefore, grass pea cultivation has more perspective in single-crop system in LL GPea-Port.

Based on the outcome of LL meeting where the results of season 1 were discussed with different actors it was concluded that due to the better seed availability of the landrace with light and smaller seeds (farmers' information) and a change in the main processing approach (processors' information) the production of big seeded grass pea variety is not a priority anymore for pastry production, which the LL GPea-Port is focusing on.

Among the farming practices tested so far, narrow row spacing with 30 cm interrow distance with pre-emergence herbicide application seem the most promising approach, but great variance among the 3 different farms requests a repetition of this trail in the next season. As mechanical

weed control is not possible in the case of narrow interrow spacing due to lack of adequate machinery, green manure and cover crop in rotation will be also tested with *Lupinus luteus* in the next season to reduce or avoid herbicide application in pre-emergence and to improve soil conditions.

2.6 LL Faba-Nord and LL Leg-Nord – Adapted varieties for minimal processed plant-based food

Introduction and background

The information below concerns two distinct LLs: one is larger, focused on faba bean, and works with larger, industrial actors (LL Faba-Nord), while the other is smaller, considers a wider diversity of legumes and works on direct sales/short food chains (LL Leg-Nord). Although these LLs are distinct, we are however presenting their data together as there is a very close tie and several overlaps between the activities of the two. For example, both are emerging and work across borders, deal with legumes and in some cases, farmers grow more NUCs belonging to both LLs.

NUC species of LL Leg-Nord namely heritage grey pea varieties, lentils and narrow-leaved lupins for human consumption are niche crops that only occupy some hundreds of ha in Sweden. Faba bean, the NUC species of LL Faba-Nord grown on larger areas, is around 20,000 ha, but most of these crops are used for animal feed (especially for faba beans). Like in Sweden, the production area of faba bean is around 20,000 ha in Denmark (18,400 ha in 2024), but the main use is as animal feed. Farmers in the LL are therefore mainly familiar with growing faba beans, but introducing them as a food product is a new aspect.

The outcome of the joint kick-off meeting of the LLs in January 2023 revealed significant differences in the status of the three NUC species of Leg-Nord, namely lentil, grey pea and narrow-leaved lupin. The most common interest is for lentil varieties, given that lentil is a relatively new crop in the Nordic region, both in terms of cultivation and integration into the local cuisine. In Sweden, the traditional lentil landrace 'Gotlandslins' is available only in limited quantities. Nevertheless, there is a general interest in testing varieties for cultivation and quality in the LL Leg-Nord. It was therefore beneficial to carry out on-farm trials involving different varieties and to collect data on the agronomic characteristics of the lentil.
The discussion on the faba bean (NUC of LL Faba-Nord) during the LLs kick-off meeting was structured around the value chain from breeding to kitchen. Rather quick in the discussion, it was clear that the focus in the season 1&2 should be more on the quality and processing than testing different faba-bean varieties through on- farm trials.

NUC varieties tested
On-farm trials with lentils including six varieties (Anicia, Samos, Beluga, Laird, Red Flash, and Gotlandslins) were conducted on two locations in Denmark in both seasons. The trials included varieties of interest for both Danish and Swedish farmers, and for varieties with small seeds.

Five heritage grey pea varieties (Bjurholms småärt, Rustica, Maglaby, Pelusk från Dalarna and Solberga) intended for local, alternative and short food chains were also tested in Sweden using grey pea-faba bean intercropping system.

Farmers motivation to join the on-farm trials

Organic farmers, who are the main partners in these two LLs, are generally more innovative than conventional farmers in their choice of crops. The need for rotations opens the way for new crops and many of the farmers have an interest in producing plant products for food rather than feed production.

Overview of the on-farm trials

In Sweden 5 on-farm trials were conducted in season 2, two in Halland county (both in Varberg) and three in Skåne county (in Kristianstad, Lund and Kvidinge). In Denmark, on-farm trials were located in Hesselballe (Djursland) and Rønne (located on Bornholm Island) in season 1 and in Rødekro and Rønde in season 2 (**Figure 16)**.

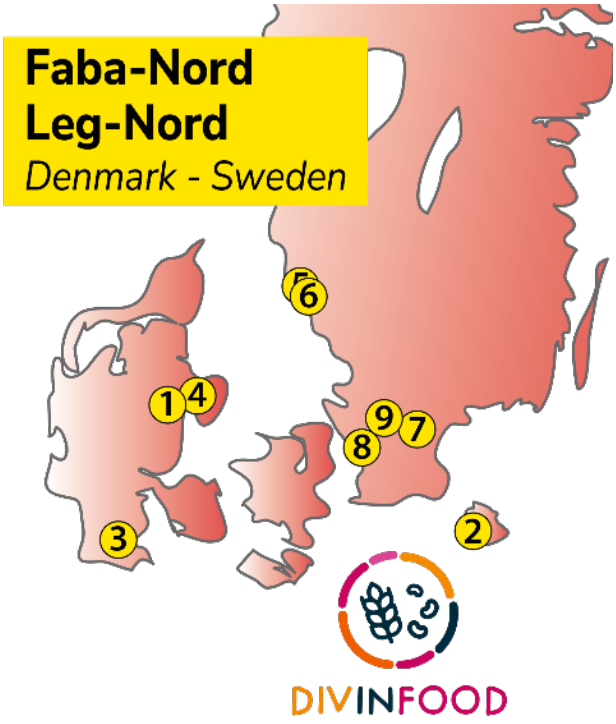

Figure 16. Location of the on-farm trials in Faba-Nord and Leg-Nord: Hesselballe , Denmark (1), Rønne, Bornholm Island, Denmark (2), Rødekro, Denmark (3), Rønde, Denmark (4), Varberg, Sweden (5-6), Kristianstad, Sweden (7), Lund, Sweden (8) Kvidinge Sweden (9)

Table 15 Overview of the trials carried out in LL Faba-Nord and LL Leg-Nord in season1&2

No of farms	Location (season)	Farm type	NUC Crop	Experiment	AE system/ practice applied	Annual precipitation, altitude and soil fertility*	Aim of the trials	Learnings at farm level
1	Hesselballe, Denmark (season 1)	Diversified organic farms cultivating modern legume cultivars	6 lentil varieties	small-plot	• organic farming • diverse crop rotation • mechanical weeding	- 358 mm** - 0-100m - high	Test 6 lentil varieties and weed management with different plant density	• No yield due to drought and weed problem
2	Rønne,Denmark (season)1	Diversified organic farms cultivating modern legume cultivars	6 lentil varieties	small-plot	• organic farming • diverse crop rotation • mechanical weeding	- 260 mm mm** - 0-100m - high	Test 6lentil varieties and weed management with different plant density	No yield due to drought and weed problem
3	Rødekro, Denmark (season 2)	Diversified organic farms cultivating modern legume cultivars	7 lentil variety	small-plot	• organic farming • diverse crop rotation • mechanical weeding	- 435 mm mm** - 0-200 m - high	Test 7 lentil varieties and weed management with different plant density	• txt

4	Rønde, Denmark (season 2)	Diversified organic farms cultivating modern legume cultivars	7 lentil variety	small-plot	• organic farming • diverse crop rotation	- 523 mm mm - 0-200m - high	Test 7 lentil varieties and weed management with different plant density	• No prior experience with lentils and mechanical weeding techniques was not applied and lentils were overgrown by weeds at an early stage
5	Varberg 1, Sweden (season 2)	Innovative organic farms with direct sales	heritage grey pea (Pelusk från Dalarna),	farm-scale	• pea-spelt intercropping • heritage variety • organic farming •	- 650-800mm - 0-200m - medium	Test intercropping and heritage pea variety	• Spelt not grown due to water logging, but pea managed to grow decently but had less support from spelt
6	Varberg 2, Sweden (season 2)	Innovative organic farms with direct sales	heritage grey pea (Solberga) faba bean (Fanfare)	farm-scale	• pea-faba bean intercropping • heritage variety • organic farming	- 650-800mm - 0-200m - medium	Test intercropping and heritage pea variety	• The pea and faba bean intercropping was heavily lodged resulting complete yield loss
7	Kristianstad, Sweden (season 2)	Innovative organic farms with direct sales	heritage grey pea (Bjurholms småärt)	farm-scale	• pea-oat intercropping • heritage variety • organic farming	- 650-800mm - 0-200m medium	Test intercropping and heritage pea variety	• The farmer was pleased with the performance and wants to continue with the variety Bjurholms småärt

8	Lund, Sweden (season 2)	Organic farms contracted to intermediaries	heritage grey pea (Rustica), faba bean	farm-scale	• pea-spelt intercropping • heritage variety • organic farming	- 650-800mm - 0-200 medium	Test intercropping and heritage pea variety	• The pea plants were suffering heavily from pigeon damages but managed to recover. The farmer was positively surprised (yield not sampled)
9	Kvidinge Sweden (season 2)	Organic farms contracted to intermediaries	heritage grey pea (Maglaby), faba bean	farm-scale	• pea-oat intercropping • heritage variety • organic farming	- 650-800mm - 0-200 medium	Test intercropping and heritage pea variety	• Less than a week before the harvest deer ate everything, no yield harvested

*, ** The precipitation between April and August

Trial design and management

In season 1 the two on-farm trials with lentils in Denmark included six varieties: Anicia, Samos, Beluga, Laird, Red Flash, and Gotlandslins. The trials were sown on 20 and 27 April 2023 in Hesselballe and Rønne, respectively on area of 432 m^2 in randomized complete block design with four replicates, plot size 18 m^2. The seed of the six varieties were sown by plot sowing machine with 12,5 interrow spacing. The same seed density (130 seed/m^2) was applied for all six varieties Mechanical weeding was applied 3 times (8 May 2023: harrowing, 16 May 2023 and 25 May: harrowing in Hesselballe and 4 May 2023: harrowing, 12 May 2023 and 27 May: harrowing in Rønne).

In season 2, the lentil trial with the same experimental design was replicated in Rødekro (**Figure 17**) and Rønde (Denmark). One more variety Klaus was included. The same seed density (130 seed/m^2) was applied for all seven varieties but three varieties (Anicia, Beluga and Gotlandslins) were sown with high seed density (200 seed/m^2) as well. Mechanical weeding was applied 3 times and the total size of the trial was 648 m^2. Certified conventional seeds (untreated) were sown on 23 April 2024 (in Rødekro) and on 02 May 2024 (in Rønde). In Rødekro mechanical weeding using weed harrow was applied once on 16 May 2024 and the trial was harvested on 29 August 2024. The farmer in Roøde had no prior experience with lentils and did not apply mechanical weeding techniques. As a result, the lentils were overgrown by weeds at an early stage, and data on agronomic performance could not be recorded at Rønde.

Figure 17. Lentil trial in Rødekro (photo: Inger Bertelsen, ICOEL)

In season 2 on-farm trials at 5 locations were performed on organic arable farms in the far south of Sweden. The farming method tested was grey peas in intercropping – either with cereals (at 4 farms) or faba beans (at 1 farm). The tested grey peas are heritage varieties and require a supportive crop for rational production on arable scale. The varieties used in the on-farm trials were selected together with the farmers, based on variety information acquired in WP4. The farmers made their final choice based on the availability of seeds also taking into consideration the agroecological conditions of their farm, as well as product potentiality for their established market channels (alternative niche markets in all cases). The short summary of the five on-farm trials is the following:

Farm Kristianstad: Trial field of 500 m², pea variety 'Bjurholms småärt' intercropped with a modern oat variety (grey pea -oat ratio: 70:30)

Farm Lund: Trial field of 160 m², pea variety 'Rustica intercropped with spelt wheat. Seeding proportions were not precise as the farmer did it not have the capacity to measure them precisely.

Farm Kvidinge: Trial field of 1000 m², grey pea variety 'Maglaby' intercropped with a modern oat variety (grey pea-oat ratio: 70:30)

Farm Varberg (1): Trial field of 500 m², pea variety 'Solberga' intercropped with faba bean variety 'Fanfare' (grey pea-faba bean ratio: 75:25)

Farm Varberg (2): Trial field of 100 m², pea variety 'Pelusk från Dalarna' intercropped with heritage spelt wheat "Hallands vårvete" (grey pea -spelt ratio: 70:30)

List of traits accessed

- Yield
- TGW
- Weed coverage
- Protein content (in progress)

Main Results

In season 2 in Denmark, no differences were found between varieties in weed cover during the formation of side shoots (BBCH scale: 29), while at harvest weed cover ranged from 12% to 26% in Rødekro. In contrast to the other lentil varieties, Gotlandslins showed the same weed cover at the two plant densities. All the other varieties tested at low plant density had lower weed cover at high plant density. Regarding the yield, the two big seeded variety Klaus and Laird performed moderate and their yield ranged from 0,87 to 1,04 while Beluga performed the best resulting yield of 1,66 t/ha (at low plant density) and 1,98 t/ha (at high plant density) (**Table 16**). In Anicia a higher plant density gave less weed and a significantly higher yield.

In Sweden, the farmer in Kristianstand was pleased with the performance of the grey pea variety and wants to continue the cultivation. At the other four sites, heavy lodging, waterlogging, deer or pigeons damaged the trials and caused total or significant yield losses (**Table 17**).

Table 16. Agronomic performance of the lentil varieties tested in Rødekro (2024)

	Low plant density			High plant density		
	Yield (t/ha)	TGW (g)	Weed coverage at harvest (%)	Yield (t/ha)	TGW (g)	Weed coverage at harvest (%)
Anicia	0.84	27	26	1.34	28	19
Beluga	1.66	20	14	1.98	20	10
Gotlandslins	1.16	22	12	1.48	23	23
Klaus	1.04	46	n/a			
Samos	0.32	24	21			
Laird	0.87	55	19			
Red Flash	1.31	30	19			

Table 17. Agronomic performance of the grey pea varieties tested in intercropping trials in Sweden

Farm	Intercropping combination	Gray pea variety	Yield
Kristianstad	grey pea-oat (70:30)	Bjurholms småärt'	0,832 kg/m^2
Varberg (1)	grey pea-faba bean (75:25)	Solberga	no yield
Varberg (2)	grey pea-spelt (70:30)	Pelusk från Dalarna'	0,11 kg/m^2
Kvidinge	grey pea-oat (70:30)	Maglaby	no yield
Lund	grey pea-spelt (~70:30)	Rustica	no yield

Main limitation or problem during the season

In season 1 in Denmark, due to a very dry period in May the plants did not recover the mechanical weed control resulting in a too low plant density and too much weed. Unfortunately, both trials were discarded before harvest and no data on agronomic performance could be evaluated. This is similar to the trial in Ronde in season 2.
Two trials in Sweden were not sampled as one suffered from almost complete loss of grain yield due to heavy lodging (Varberg 2) and the other was completely eaten by deer (Kvidinge) in the last week before harvest time.

Take-home message and next steps
At the Living Lab meeting held at Nordic seed 5 December 2024 the outcome for the trials was discussed. The farmers had the same impression of the two growing seasons as in the trials, 2023 was a disaster due to the bad weather and 2024 was more normal growing season. The most grown variety Anicia is the most difficult to grow, due to weak weed competition and low harvest height. They will focus on improving the weed control and see if other varieties with better agronomic traits can be introduced together with Anicia. The variety Gotlandslins could be an alternative, but is only available for Swedish farmers growing for Nordisk Råvara.

On Sweden it can be assumed that three out of the five farmers will continue the on-farm trials in 2025. Out of the two that probably will not continue, one wants to continue with grey pea, but does not have a spot for it in his crop rotation in the next year; and the other has concluded that his farm is better suited for lentil cultivation due to reoccurring problems with pigeons. For the upcoming year, we need to re-assess some of the methods to avoid crop failure – which mainly includes using protective nets, or scare tactics, where there is significant threat of animals eating the crop; as well as adjusting some seeding ratios to avoid significant lodging.

2.7 LL Leg-Hung - Grain legumes in Hungary

Introduction and background

NUC varieties tested
In LL Leg-Hung, all grain legumes for human consumption can be considered as NUCs in a broad sense due to their low production (and consumption) level across the whole Hungary. However, chickpea, cowpea, faba bean, yardlong bean (*Vigna unguiculata* ssp. *sesquipedal*) and sugar snap pea (*Pisum sativum*) were the subject of the on-farm trials carried out in season 1&2**.**

The selection of the main species and varieties to be included in the trials was based on the experience gained in a previous project (TRUE - No. 727973) and in the first year of DIVINFOOD project (season 0), through pilot on-farm trials, online consultation and subsequent discussions with the participating farmers (participatory evaluation, see Chapter 2.1). The main aspects considered in the selection were as follows:

- Varieties that have stable yields based on previous projects' and growers' own experience
- Varieties available commercially in larger quantities
- Engagement to conduct small plot experiments with accessions provided by National Centre for Biodiversity and Gene Conservation, Hungary with the possibility of seed multiplication
- The need to produce quantities suitable for kitchen testing

Farmers motivation to join the on-farm trials

Several farmers joined the on-farm trials because they realised that there is a market need or customer demand for these products. They mention that a certain niche of consumers searches for legumes because they believe that they are tasty, healthy and a good protein alternative. We can say that generally, these farmers' motivations for cultivating any plants are the same: they choose different varieties of vegetables when they believe that the customers will like them and thus it makes sense to cultivate them financially.

Some of the farmers' motivation for participating in on-farm trials was personal curiosity or interest. Most of these farmers come from an academic/research background who moved to the countryside/started farming because they wanted to gain practical experience in the field as well. They grow legumes because they want to experiment with different varieties in different settings and are interested in the science behind as well.

Most farmers mentioned the different practical benefits of cultivating legumes (such as nitrogen fixation, them being good cover crops, etc.) but for several farmers, these were the primary motivations in starting NUC cultivation and join on-farm trials.

Location of the on-farm trials

In Season 1, altogether 23 varieties of 6 legume species were tested at 10 sites. In season 2, on-farm trials continued at 8 sites, 6 of which were the same as in season 1 while two new sites joint to the trial network (**Figure 18**, **Table 18**).

Figure 18. Location of the on-farm trials in Leg-Hung: Zsámbok (1), Vértessőlős (2), Nagynyárád (3), Páty (4), Siófok-Töreki (5), Hódmezővásárhely (6), Kisjakabfalva (7), Borjád (8) Somogyvámos (9) Bugacpuszta (10), Hedrehely (11), Sződ (12)

Table 18. Overview of the trials carried out in LL Leg-Hung in season1&2

No of farms	Location (season)	Farm type	NUC Crop	Experiment	AE system/ practice applied	Annual precipitation, altitude and soil fertility*	Aim of the trials	Learnings at farm level
1	Zsámbok (season 1&2)	Small-scale vegetable gardens in advanced agroecology	cowpea, sugar snap pea, yardlong bean	• garden-scale	• organic farming	- 350-700 mm - 0-100m - medium	Test different legumes species for small-scale cultivation	• Not harvested in season 1
2	Vértesszőlős (season)1	Small-scale vegetable gardens in advanced agroecology	2 cowpea varieties	• garden-scale	• organic farming	- 750 mm mm - 600m - medium	Test cowpea for small-scale cultivation	• Not harvested
3	Nagynyárád (season 1)	Small-scale vegetable gardens in advanced agroecology	5 cowpea varieties, two mungbean variety	• garden-scale	• mechanical weeding	- 750 mm mm - 0-200 m - medium	Test different legumes species for small-scale cultivation and raw material production	• Not harvested in season 1
4	Páty (season 1&2)	Small-scale arable farms	2 chickpea varieties	garden-scale	• organic farming	- 800 mm mm - 2-400m - medium	Test chickpea for small-scale cultivation	• Moderate yield for chickpea in LL Leg-Hung (0.5-1,5 t/ha
5	Siófok-Törek (season 1)	Small-scale arable farms	French bean	garden-scale	• organic farming	- 850mm - 600m - medium	Test different French bean for cultivation	• Not harvested in season 1
6	Hómezővásárhely (season 1&2)	Small-scale arable farms	yellow pea, cowpea	farm-scale	• organic farming	- 600mm - 0-200m - medium	Trial cultivation of yellow pea as an arable crop	• Best yield for chickpea in LL Leg-Hung (1,6 t/ha)

7	Kisjakabfalva (season 1&2)	Medium-sized arable or mixed farms in advanced agroecology	chickpea variety Donia	farm-scale	• mechanical weeding • organic fertilizer • no-till	- 790 mm - 5-600m medium	Trial cultivation of chickpea as an arable crop	• Moderate yield for chickpea in LL Leg-Hung (1,0 t/ha)
8	Borjád (season 1&2)	Medium-sized arable or mixed farms in advanced agroecology	chickpea variety Donia	farm-scale	• mechanical weeding • no-till	- 790 mm - 5-600 medium	Trial cultivation of chickpea as an arable crop	• Moderate yield for chickpea in LL Leg-Hung (1,0 t/ha)
9	Bugacpuszta (season 1)	Medium-sized arable or mixed farms in advanced agroecology	chickpea variety Donia	farm-scale	• organic farming	- 350 mm - 0-200 medium	Trial cultivation of chickpea as an arable crop	• Not harvested in season 1
10	Somogyvámos (season 1&2)	Medium-sized arable or mixed farms in advanced agroecology	faba bean, yardlong bean,	garden-scale	• organic farming • landraces	- 850 mm - 4-600 - medium	Test different legumes species for small-scale cultivation	• Probably because of the late spring sowing, faba bean was not strong enough to resist the pests, it has to be sown in autumn or February. • Yardlong bean was very susceptible to lice.
11	Hedrehely (season 2)	Mixed farms in advanced agroecology	chick pea variety Pascia	farm-scale	• no-till	- 380 mm - 4-600 - medium		• Cotton bollworm (*Helicoverpa armigera*) caused serious problems and low amount of yield harveseted
12	Sződ (season 2)	Small-scale vegetable	sugar snap pea,	garden-scale	• organic farming	- 600 mm - 100		• Faba bean: Very few flowers were produced

	gardens in advanced agroecology	yardlong bean, faba bean	- medium	and only a very small number of pods were formed • Yardlong bean: farmer had no capacity to harvest the pods continuously

Trial design and management

In season 1, in Kisjakabfalva (**Figure 19**) and Borjád the area dedicated to chickpea production was 1 and 2 hectares and a Hungarian-bred, one of the few commercially available variety Donia was sown on first week of April 2023 with 200 kg/ha sowing density. Both chemical (Leopard only at farm located in Borjád) and mechanical weeding (comp harrow, at both farm) was applied. Cow manure (at Kisjakabfalva) or mineral fertiliser (at Borjád) were used as input material. The annual precipitation was 790 mm in the region where the farms located and the seed came from own production or was an exchanged farm seed. The crop was combine harvested on 25 of August 2023 at both farms.

Figure 19. Chickpea (variety Donia) trial in Kisjakabfalva (photo: AgriKulti)

At Nagynyárád five cowpea cultivars Grey speckled papalye, Sinai5, Ex50, Ex52, Pilisi and two mung bean (*Vigna radiata)* cultivars MB1 and MB2 were sown on a total area of 50 m^2 on 20 May 2023. The primary purpose of this trial was raw material production and seed multiplication as the genebank was able to provide only few seeds from each cultivar. Mechanical weed management was applied by hand and the trial was not irrigated. The yield of the different cultivars was harvested by hand from August to September due to the different ripening times of the different varieties.

At Páty two chickpea variety Olasz and Fekete and a cowpea variety Fagiolino nano were machinery sown on a total of 2000 m^2 (1500 m^2 chickpea and 500 m^2 cowpea) in an organic vegetable garden on 11 May 2023 with seed distance 50 cm x 5 cm. During the vegetation period plant protection treatments with Dipel, Kondisol and Polyverzum were applied. These products are all authorised for use in certified organic production. Weeding was done by hand (took 80 hours of work) and no irrigation was applied.

Harvesting was a lengthy process for both crops. Green chickpeas for fresh use were harvested between 28 June and 10 August while dried pods of the cultivar Fekete between 16-30 August.

Cowpea for fresh use was harvested on 28 June while dry cowpea on 5 September 2023. Unfortunately, the harvesting of cowpea as dry beans was not successful. After harvesting the green pod crop, the newly bound pods were attacked by green stink bug (Nezara viridula) that caused significant yield loss.

The other sites of the season 1 have not been harvested so details of the experimental layout are not presented.

In Season 2 the number of on-farm experimental sites and size continued to increase, both for horticultural and arable trials. A single variety of chickpea (Dania or Pascia) was sown on an area ranging from 1 to 1.4 ha on four farms (Hedrehely, Borjád, Kisjakabfalva and Hódmezővásárhely), while more legume species and cultivars were sown on an area ranging from 40 to 3000 m^2 at four farms (Páty, Somogyvámos, Sződ, Zsámbok).

In Borjád, Kisjakabfalva and Hódmezővásárhely, chickpea variety Donia was sown, while in Hedrehely certified untreated seed of chickpea variety Pascia was sown using direct seeding methods on 5 May 2024 with 250 kg/ha sowing density and 45 cm interrow spacing with seed drill. A pre-emergence herbicide for the control of annual grass weeds (Dual Gold 1.25 l/ha and Command 0.2 l/ha) was applied after sowing while mineral fertilizer 200kg/ha and Turkey manure 20t/ha were also applied. Mechanical weed control was carried out by hand using hoe. The trail was not irrigated and harvested on 25 August 2024. The annual precipitation in 2024 was only 380 mm which caused severe drought (in 2023 it was 1156 mm).

In Borjád, Kisjakabfalva and Hódmezővásárhely chickpea variety Donia was sown on 6 April and 20 April using 12 or 18,5 cm interrow spacing with sowing 250 kg-300 kg/ha sowing density. Soil active herbicide Dual Gold 1.5 l/ha and glyphosate were applied in Borjád and systemic herbicid Leopard (1 l/ha) in Kisjakabfalva. At Hódmesővásárhely (certified organic farm) no chemical weed treatment but weed comb (one time), chaining (two times in chickpea and one time in pea) and hand hoeing (7 people, two times) were applied. The trial in Hódmezővásárhely was irrigated and combine harvested on 20 July 2024. In Borjád the chickpea was harvested on 31 July 2024 while in Kisjakabfalva no harvest was carried out as chickpea was overgrown by weeds.

At Páty one cowpea variety Dolico d'oriccho and three chickpea cultivar Fekete, Donia, Pascià, were hand sown on a total of 3000 m^2 in an organic land on 23 May (cowpea) and 20 May 2024 (chickpeas). Cowpea was sown with plant density 70 cm x 40 cm, while chickpea Fekete in 3 cm x 10 cm and chickpea Donia and Pascià in 7cm x 10cm (multisown bush pea). During vegetation period plant protection treatments were applied with Mospilan (on 2 September) and Kondisol (tree times) on cowpea and Dipel (two times in July) on chickpea Fekete. Weeding was carried out by hand during the growing season, with occasional irrigation when severe drought threatened plant survival. Green cowpea (for fresh use) was harvested on 20 July, while dry cowpea from 10 August to 15 September in several stage. Chickpeas were harvested from 5 August to 30 August 2024.

At the other three organic vegetable farms specialized in market gardening (Sződ, Somogyvámos, Zsámbok) (**Figure 20**), different cultivars of chickpea, cowpea, faba bean, yardlong bean and sugar snap pea were cultivated in small quantities. The cropping area of the different NUC species at each farms ranged from 40 m2 to 290 nm. All plots were hand sown and hand harvested, drip irrigated and compost, compost mulch or green compost were applied as nutrient supply and for weed controlling. CoCana and BorOil were used on demand (one or two times maximum) based

on the farmer's individual choice. These products are all authorised for use in certified organic production.

Figure 20. Yardlong bean in Zsámbok (photo: AgriKulti)

List of traits accessed

- Yield
- Weed coverage (season 2)

Main Results
Based on the results of the trials carried out in arable cropping system in season 1, chickpea Donia was able to yield 1 t/ha in both Kisjakabfalva and Borjád, with plant height varying between 40-60 cm depending on the location. In the season 2, the best yields were obtained in the organic farm in Hódmezővásár, where Donia yielded 1.6 t/ha, while in Borjád the same variety yielded 1 t/ha. In Hedrehely, cotton bollworm (*Helicoverpa armigera*) caused serious problems and a yield of 200 kg/ha was harvested, roughly the same as sown. The results of the successful garden-scale trials are summarised in the **Table 19.**

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Table 19. Yield of NUC legumes in garden-scale trials in LL Leg-Hung

Location of the farm	Season	Name of the NUC	Yield (kg/m$^{2)}$
Páty	season 1	chickpea (Fekete)	0.40
		cowpea (Fagiolino nano)	0.22
	season 2	cowpea (Dolico d'oriccho)	0.6

		chickpea (Fekete)	1.5
Nagynyárád	season 1	cowpea (Grey speckled papalye)	0.2
	season 1	cowpea (EX050)	0.37
	season 1	cowpea (Pilisi)	0.05
	season 1	mung bean (MB1)	0.1
	season 1	mung bean (MB2)	0.1
Sződ	season 2	sugar snap pea (Sweet horizon)	2.6
	season 2	sugar snap pea (Norl)'	1.0
Somogyvámos	season 2	sugar snap pea (Sweet horizon)	0.95
Zsámbok	season 2	sugar snap pea (Norli)	0.02
	season 2	sugar snap pea (Bernhardsberge)	0.27
	season 2	yardlong bean (Aquadulcie)	0.08
	season 2	yardlong bean (Cannetti)	0.5

Main limitation or problem during the season

In the arable trials, the biggest difficulty was getting sufficient amount and quality of legume seed. Some farmers reseeded their own seed but they only receive subsidy for growing protein crops if they sow metal-locked (certified) seed but chickpeas are too expensive to obtain in Hungary. Small-scale and horticultural trials were affected by the severe drought during season 2.

Take-home message and next steps

Over the course of the first two seasons of the DIVINFOOD project, LL Leg-Hung has grown significantly. More farmers have become involved in the project, particularly larger arable farms. While arable farmers provide fewer opportunities to experiment with special varieties (as they prefer to use tried and tested commercial varieties), when they accept to do so, they present the opportunity to produce larger quantities for kitchen trials, consumer evaluation, and sale in restaurants and shops, which is a key objective of the LL Leg-Hung. An important step forward has been that of including farmers who have access to mills and processing facilities, as this allows to overcome the logistics blockage.

For the arable trials, we would like to involve a farmer who has a green pea combine and would like to grow chickpeas on certified organic land and could harvest them green.

We are also involving a regenerative farmer growing both cowpea and grass pea in the trial.

We have found a Hungarian seed dealer who supposedly has several varieties of certified chickpeas. We expect more detailed information from them in early January 2025.

Horticultural trials will continue with sugar pea, faba bean, edamame soybean, grasspea, cowpea and yardlong bean varieties and will include peanuts, autumn lentils (Rézi variety) and dry green peas (Aviron variety).

2.8 LL Cer-Hung - Emmer and Einkorn in Hungary

Introduction and background

The main cereals grown in Hungary are wheat, barley, rye, triticale and oats, but among the species belonging to the *Triticum* genus spelt has also significant area sown. The cultivation areas of emmer and einkorn, considered as underutilised cereals, are significantly smaller in magnitude compared to other cereal types but there is a strong need among farmers for a wider range of cereal varieties that are better adapted to climate change, especially the hot springs and summers and drought that is increasingly typical in Hungary. However, the diversity of the available varieties is rather limited, therefore, the main focus of the on-farm trials was to evaluate the agronomic performance and adaptability of the different landraces to local conditions or for small-scale processing.

NUC varieties tested
The NUCs of LL Cer-Hung, einkorn and emmer, are cereals that can be grown successfully on less favourable soils, even under extensive conditions, without the use of pesticides, and may also have higher nutritional values than modern bread wheat. In season 1&2, four einkorn varieties (3 landraces: Nödik alakor, GT-2139, Bözödi, 1 cultivar: Mv Alkor) and four emmer landraces (Roter, Grauer, Weisser, GT-381) were tested in farm-scale on-farm trials.

Farmers motivation to join the on-farm trials

The majority of farms participating in the on-farm trials are organic or certified organic farms. On average, they have more than ten years' experience of cereal production. They are willing to participate in experiments to try new crops and new varieties that can be successfully grown on their farm and integrated into their crop rotation. Growing and finding marketing channels for NUC varieties can be an interesting challenge for them.

Overview of the on-farm trials

On-farm trials were carried out at 5 locations in season 1, while in season 2 experiments continued at Szár and Füzesgyarmat, while the farms at Jászszentandrás, Tiszaszentimre and Egyek joined the network. The on-farm trials are mainly located in eastern and central Hungary.

Figure 19. Location of the on-farm trials in Cer-Hung: Magyarhomorogd (1), Ballószög (2), Hómezővásárhely (3), Füzesgyarmat (4), Szár (5), Vác (6), Jásszentandrás (7), Tiszaszentimre (8) Egyek (9)

Table 20. Overview of the trials carried out in LL L Cer-Hung in season1&2

No of farms	Location (season)	Farm type	NUC Crop	Experiment	AE system/ practice applied	Annual precipitation, altitude and soil fertility*	Aim of the trials	Learnings at farm level
1	Ballószög (season 1)	Organic farms contracted to intermediary	3 einkorn varieties 2 emmer varieties	• farm-scale	• organic farming • no-till	- 150-300 mm - 0-100m - low-medium	• Test different einkorn and emmer varieties on sandy soil with no till	• Conversion for no-till management and severe drought caused total yield loss
2	Hómezővásárhely (season 1)	Diversified organic farms with occasional market outlets	emmer (Grauer)	• farm-scale	• organic farming	- 250-450 mm - 0-100m - high	• Test emmer cultivation	• Cultivation on high fertility soil caused moderate logding
3	Vác (season 1)	Diversified organic farms with occasional market outlets	emmer (GT-381) einkorn (Bözödi)	• farm-scale	• mechanical weeding	- 500 mm mm - 4-500 m - low	• Test emmer cultivation	• Bad soil condition and drought during spring caused weed problem
4	Szár (season 1&2)	Diversified organic farms connected to local food network	einkorn (Bözödi) emmer (Grauer)	• farm-scale	• organic farming	- 4-500mm - 2-400m - low	• Raw material production	• Bad soil condition and drought during early plant development caused yield loss
5	Füzesgyarmat (season 1&2)	Diversified organic farms with occasional market outlets	emmer (Roter, Weisser) einkorn (GT-2139)	• farm-scale	• organic farming	- 400 mm - 100m - medium	• Raw material production	• Good yield with high protein content
6	Magyarhomorog (season 1)	Organic farms contracted to intermediary	einkorn (Mv Alkor)	• farm-scale	• organic farming	- 400mm - 0-200m - medium	Raw material production	• Moderate yield with moderate protein content

7	Jásszentandrás (season 2)	Diversified organic farms connected to local food network	einkorn (GT-2139)	• farm-scale	• mechanical weeding • organic farming	- 400 mm - 5-600m low	Test einkorn cultivation on sandy soil	• Good yield with good protein content
8	Tiszaszentimre (season 2)	Conventional farmers aiming for conversion to organic practices	einkorn (GT-2139) emmer (Roter)	• farm-scale	• no-till	- 600 mm - 200m - medium	Test einkorn and emmer cultivation	• High yield with high protein content, no lodging
9	Egyek (season 2)	Conventional farmers aiming for conversion to organic practices	einkorn (Nödik alakor) emmer (Weisser)	• farm-scale	• no-till	- 350 mm - 0-200 medium	Test low-input einkorn and emmer cultivation	• Moderate yield with high protein content

List of traits accessed

- Plant height
- Lodging
- Yield
- Protein content

Trial design and management

In season 1, two NUC cultivars were tested at Szár (**Figure 20**). Grauer (emmer) was sown on 4.2 ha with a seed density of 165 kg/ha and einkorn Bözödi on 3.15 ha with a seed density of 180 kg/ha. Both crops were sown with 12 cm interrow spacing in November and harvested on 16th August. Weed harrow was applied twice during the season.

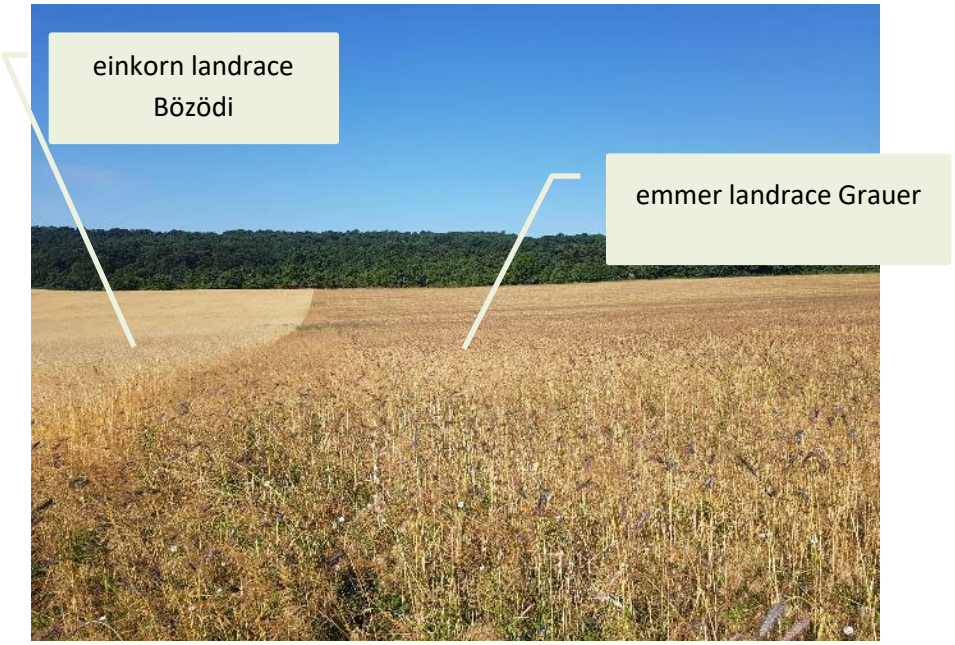

Figure 20. Einkorn and emmer trial in Szár in season 1 (photo: ÖMKi)

At Füzesgyarmat emmer "Roter" and "Weisser" were sawn on 24th of October with 12.5 cm interrow spacing and harvested on 20 July. At Magyarhomorog Mv Alkor einkorn was sown on 18 ha on 28 October and harvested on 14th of July. Weed management was performed with roller hacke. No irrigation and no plant protection were applied on any of these farms.

At Vác emmer GT381, at Ballószög emmer Grauer and GT 1402, einkorn Nödik alakor and GT2139, and at Hódmezővásárhely Grauer were sown on 0.5 ha in each. No detailed data on trial management could be collected but samples were taken at harvest for yield and quality measurements.

In Season 2, at Jászszentandrás einkorn "GT-2139" was sown on 25th of November with seed density of 140 kg/ha on 2.2 ha. The seeds are exchanged farm seed. At Tiszaszentimre einkorn "GT-2139" on and Roter emmer were tested. Einkorn was sawn with 184 kg/ha on 2.2 ha and emmer was sawn with seed density of 173 kg/ha on 0.4 ha. Both crops were sown on 18th of

October with 16.8 cm interrow spacing, the forecrop was barley. At Szár einkorn "Bözödi" was sawn on 5th of December to 5 ha with seed density of 129 kg/ha. "Grauer" emmer was sawn on 23rd of November with 168 kg/ha to 7.5 ha. Both variety were sawn with 18.5 cm interrow spacing and harvested on July 11. The forecrop was fodder pea. At Füzesgyarmat einkorn "GT-2139" was sown on 20th of November with 200 kg/ha to 0.5 ha. The forecrop was pea, the seeds derived from seed exchanges between farmers. "Weisser" emmer was broadcaste sawn on 1st of March with 250kg/ha seed density to 1 ha. The forecrops were flax and mustard, and the seeds derived from own production. Both varieties were sown with 12.5 cm interrow spacing. At Egyek Nödik einkorn was sown with 120 kg/ha, and "Weisser" emmer with 180 kg/ha. Each of them were sown to 0.5 ha on 8th of November and harvested on 20th of July. The forecrop was sorghum.

No irrigation and no plant protection were applied on any of these farms. Tillage was performed before sowing as soil management, except at Szár where soil loosening has been done in 27 cm depth. Farmers in this trial did not plough.

Main Results

In season 1, on-farm trials were carried out successfully at 3 locations with one landrace: at Hódmezővásárhely emmer "Grauer", at Vácduka emmer "GT-381" and at Magyarhomorog einkorn Mv Alkor were tested. More landraces were tested successfully at 3 locations: at Füzesgyarmat emmer "Roter" and "Weisser" and at Ballószög emmer "Grauer" and "GT-1402" and einkorn "Nödik alakor" and "Gt-2139" and at Szár Grauer and Bözödi alakor were evaluated. In season 2 field trials were carried out successfully at all the 5 locations.

Data on these NUC's agronomic performance have been collected on-site and samples were taken for quality traits analysis (NIR spectroscopy). Results of the first two seasons have been summarised in the **Table 21**.

Table 21. Yield and protein content of NUC cereal in LL Cer-Hung in season 1&2

Location	Seasons	Species	Varieties	Yield (t/ha)	Protein content (%)
Ballószög	season 1	einkorn	Nödik alakor	0.81	13.4
			GT-2139	0.73	12.2
			Mv Alkor	0.56	11.9
		emmer	Grauer	0.16*	n/a
			GT-1402	0.03*	n/a
Hódmezővásárhely	season 1	emmer	Grauer	1.12	15.9
Vác	season 1	emmer	GT-381	0.55	12.1
		einkorn	Bözödi	1.32	10.6
Szár	season 1	emmer	Grauer	0.70	10.4
		einkorn	Bözödi	0.90	10.6
	season 2	emmer	Grauer	1.3	12.0
		einkorn	Bözödi	1.4	10.8
Füzesgyarmat	season 1	emmer	Weisser	2.35	13.4
			Roter	1.6	12.7

	season 2	einkorn	GT-2139	n/a	18.1
Magyarhomorog	season 1	einkorn	Mv Alkor	2.0	10.7
Jászszentandrás	season 2	einkorn	GT-2139	2.5	12.1
Tiszaszentimre	season 2	emmer	Roter	3.4	14.2
		einkorn	GT-2139	3.1	10.2
Egyek	season 2	einkorn	Nödik alakor	1.95	14.5
			Weisser	1.84	15.3

* Varieties were not harvested by the farmer due to the low level of yield

Main limitation or problem during the season

In season 1, on-farm trials have partly failed due to severe drought (Ballószög) or sowing difficulty at 2 locations (at Szár and Hódmezővásárhely only one landrace was sown instead of more landraces)
From Füzesgyarmat bunt infection was reported and at Magyarhomorog common vole caused problems around harvest.
In season 2 at Szár the tested varieties were grown on very poor soil conditions and weed pressure became high. At Tiszaszentimre a certain degree of lodging of the tested crops have been observed, but fortunately no harvesting problem occurred.

Take-home message and next steps
In Hungary, especially in the east, hot, dry summers and droughts have caused severe problems for agriculture in recent years, reducing average annual yields across the country. Based on the results of the first two seasons, the yield capacity of einkorn and emmer ranged from 0.56 t/ha to 3.4 t/ha with protein content ranged from 10.02-18.1% but the trials will be replicated in season 3 and 4 to get a more comprehensive data set on different farm types.

3. Conclusion

This report is a first summary on the NUC agronomic performance collected through on-farm trials in the first two seasons of the DIVINFOOD project. Qualitative and quantitative data, especially on NUCs agronomic performances in specific environments, have been produced and will also feed the GxE database of the project.

According to the DoA all LLs will conduct on-farm trials in at least two consecutive seasons to evaluate the agronomic performance of LL-specific NUCs. Therefore, a more detailed summary and analysis of the on-farm trials will be possible in the later phase of the project when data from all 4 seasons and at least 2 seasons per LL will be available. These results as a follow up of the recent findings will be presented in the next deliverable (DIVINFOOD D3.3 due at M57).

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