Kmetijski inštitut Slovenije
Agricultural Institute of Slovenia

ECOBREED FARMERS PARTICIPATORY FIELD TRIALS 2023

ecobreed
IMPROVING CROPS

Funded by European Union
Horizon 2020
Grant agreement No 771367

ecobreed
IMPROVING CROPS

Funded by European Union
Horizon 2020
Grant agreement No 771367

Izdal / Published by
KMETIJSKI INŠTITUT SLOVENIJE
Ljubljana, Hacquetova ulica 17
Direktor/Director Prof Dr Andrej SIMONČIČ

Urednika / Edited by
Vladimir MEGLIČ, Andreja ŽIBRAT GAŠPARIČ

Avtorji / Authors
Werner VOGT-KAUTE, Miroslava APACSOVÁ-FUSKOVÁ, Caterina BĂDUȚ, Maria BERNHART, Paul BILSBORROW, Luca BONFIGLIOLI, Adam BREZÁNI, Rastislav BUŠO, Marion CHAMPAILLER, Peter DOLNIČAR, Vuk ĐORĐEVIĆ, Soňa GAVURNÍKOVÁ, Heinrich GRAUSGRUBER, Roman HAŠANA, Pavol HAUPTVOGEL, Katarína HRČKOVÁ, Katarina JANOVICKOVÁ, Dagmar JANOVSKÁ, Bojan JOCKOVIĆ, Aleš KOLMANIČ, Gheorghe LĂMUREANU, Ľubica MALOVCOVÁ, Ľubomír MENDEL, Peter MIKÓ, Simon OGRAJŠEK, Mario PAGNOTTA, Aurel PETRUȘ, Jarosław PLICH, Zsolt POLGÁR, Anna PEARCE, Ionuț STAN, Beata TATAROWSKA, Ion TONCEA, Ieva URBANAVIČIŪTĖ, Marjana VASILJEVIĆ

Fotografije / Photos
Vse fotografije so posneli avtorji / All photos were taken by the authors

Pregledala in lektorirala / Proofreading
Paul Bilsborrow, Andreja Žibrat Gašparič

Oblikovna zasnova naslovnice / Cover design
AV Studio d.o.o.

Elektronska verzija je dostopna na spletni strani Kmetijskega inštituta Slovenije (www.kis.si) / Electronic version is available on the Agricultural institute of Slovenia webpage (www.kis.si)

Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani
COBISS.SI-ID **185566979**
ISBN 978-961-6998-75-8 (PDF)

ecobreed
IMPROVING CROPS

Funded by European Union
Horizon 2020
Grant agreement No 771367

ECOBREED
Farmer Participatory Field Trials 2023

Ljubljana, 2024

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table of contents

Funded by European Union
Horizon 2020
Grant agreement No 771367

List of tables

Funded by European Union
Horizon 2020
Grant agreement No 771367

Funded by European Union
Horizon 2020
Grant agreement No 771367

List of figures

Funded by European Union
Horizon 2020
Grant agreement No 771367

Funded by European Union
Horizon 2020
Grant agreement No 771367

1 Introduction

The project ECOBREED (*Increasing the efficiency and competitiveness of organic crop breeding*) is funded by the European Union Horizon 2020 funding scheme and brings together 24 partners from 14 different countries. ECOBREED aims to increase the availability of seeds and varieties for the organic and low-input sectors, to identify traits and combinations of traits suited to organic and low-input production environment including high nutrient use efficiency and weed competitiveness and to increase breeding activities for organic and low-input crop production. ECOBREED Work package 6, aims to establish an efficient system for farmer-participatory-selection of new varieties in selected countries, representing different pedoclimatic zones and/or regions that can later be adopted throughout Europe and beyond. This will be achieved via:

- Identification of region-specific traits/trait combinations desired by organic farmers.
- Development and use of a data-recording system for Farmer Participatory Trials.
- Undertaking farmer-participatory breeding in contrasting pedo-climatic zones.
- Allowing farmers/breeders to select lines from evaluation of CCP that are particularly suited to their own environment.

The above-mentioned Farmer Participatory Field Trials, which are performed under Task 6.2, aim to establish on-farm variety evaluation trials in Northern, Central and Southern European organic production systems/rotation backgrounds. In each country, which is included as a partner in the project, 4-6 farmers are included, and each participating farmer established a non-replicated trial to compare the performance of 8-12 genotypes of each species (identified from phenotyping in WP 2-5, focusing on wheat, potatoes, soybean, and buckwheat). For each country, a standard agronomic and field assessment protocol was developed and used and each farmer was able to include additional parameters/protocols in the trials performed on his/her farm.

The responsible partner for this work package is Naturland Association for Organic Agriculture (NATUR) from Germany with task leader Werner Vogt-Kaute. The partners involved in this task are the University of Newcastle (UNEW) and LC Smales & Son Limited (SMA) from the UK, Agricultural Institute of Slovenia (KIS), Slovenia, University of Natural Resources and Life Sciences (BOKU) and Saatzucht Gleisdorf from Austria, Poslovni system Global Seed (GS) and Institute of Field and Vegetable Crops (IFVCNS) from Serbia, Crop Research Institute (CRI) and PROBIO sro from the Czech Republic, University of Tuscia (UNITUS) from Italy, Hungarian Academy of Sciences, Centre for Agricultural Research (ATK) and the Hungarian University of Agriculture and Life Sciences (MATE) from Hungary, National Research Institute – Plant Breeding and Acclimatization Institute (IHAR) from Poland, National Agricultural and Food Center (NPPC) and BIOMILA spol. sro from Slovakia, and National Agricultural Research and Development Institute (NARDI) from Romania.

Funded by European Union
Horizon 2020
Grant agreement No 771367

2 Wheat

2.1 Wheat farmer participatory trials in the UK

All wheat FPT trials were drilled in the autumn of 2022 at the same locations as in the previous year but with the addition of Nafferton Farm which resulted in five trials in total. For the respective trials; Newlands was drilled on 12 October, Thornton Farm was drilled on 10th of October, Nisbet Hill on 29 September, Gilchester's on 14 October and Nafferton Farm on 17 October 2022. The Newlands trial was ploughed after beans, Nafferton was ploughed after grass clover, Thornton Farm ploughed after red clover. The seed rate used at Thornton Farm, Gilchester's and Nafferton was 220 kg/ha whilst at Nisbet Hill it was 230 kg/ha. At Newlands the field where the trial was located had been under organic management for many years but on 1 January 2023 was taken out of organic production to kill some perinacious weeds, but the trial was managed organically without the input of mineral fertilisers and synthetic pesticides.

A number of wheat varieties were evaluated across the sites in addition to two seed treatments Newton (sourced from Interagro) and AminoA Start (biological seed treatment that contains a complex of 18 L-isomer amino-acids which improves rooting and early growth) while the biostimulant Fixio (sourced from ITAKA, Italy) was applied at a rate of 2kg/ha to part of the respective trials at Thornton Farm and Nisbet Hill in the spring of 2023 (Thornton Farm at GS30 on 13 April and at Nisbet Hill on 22 April 2023) . Fixio was applied at GS30 as recommended by ITAKA which was much earlier than when used in 2022 at Thornton Farm, Nisbet Hill and Gilchester's. All biostimulants used are approved (Organic Farmers and Growers) for use in organic production. A number of varietal mixtures were also evaluated, e.g. Group 3 soft mixture (KWS Brium, KWS Guium, LG Astronomer) at Nisbet Hill and Thornton Farm, Group 4 soft mix (RGT Stokes, RGT Bairstow, Revelation) at Nafferton Farm and Newlands and Group 4 hard mix (KWS Dawsum, Theodore, Oxford) at Nafferton Farm. In addition, a Pot Luck mix (mixture of 10 varieties harvested from the FPT trial at Thornton Farm in August 2022 i.e. Theodore, KWS Extase, Alessio, Roderik, Viki, Wakelyn's population, Royal, Wendelin, Barranco and Purino. This Pot luck varietal mixture thereby providing much greater genetic variation especially in height than the other mixtures evaluated. The sulphur-based fungicide Thiopron was used across part of the trial area at Nafferton Farm with applications on 19 May and 9 June (at T1 and T2 respectively) at a rate of 9.7 l/ha on each occasion.

The first disease assessment was carried out at Gilchester's and Nafferton Farm on 17 May and at Newlands, Thornton Farm and Nisbet Hill on 19th May. However, at all sites this turned out to be a little early as only Leaf 2 was fully emerged at all sites. Yellow rust was evident but only at Gilchester's and Nafferton Farm. Further disease assessments were carried out in late June and mid-July. Disease data for each site are presented in Tables 5-10. For disease assessments 10 replicate readings were taken from each plot/treatment. *Septoria tritici* was recorded as % leaf coverage on each of leaves 1-3 while for Yellow rust the data is based on a whole plant assessment scale 1-9 (where 1 is no disease present).

All trials were combined with a Deutsch plot combine (Nafferton Farm and Gilchester's on 23 August, Newlands 25 August, Thornton Farm 29 August and Nisbet Hill 30 August)

Funded by European Union
Horizon 2020
Grant agreement No 771367

and all grain yields (Table 1) are presented at 15% moisture content. Samples were retained for grain quality analysis and sent to Coastal Grains Ltd with all data presented in Tables 11-13.

Fig 1 Wheat FPT at Thornton Farm on 28 June 2023.

Fig 2 Wheat FPT at Newlands on 13 July 2023 showing early senescence and relatively low crop biomass.

Funded by European Union
Horizon 2020
Grant agreement No 771367

2.1.1 Grain yield

Table 1 Grain yield t/ha from all FPT sites presented @15% moisture content in the UK in 2022-23.

	Thornton Farm	Newlands	Nisbet Hill	Gilchester's	Nafferton Farm
Wendelin	3.79	3.71	3.94	5.76	4.62
Alessio	-	-	3.87	-	-
KWS Extase	7.09	5.24	5.89	6.81	4.85
KWS Extase (NST)	7.52	5.30	7.05	7.55	5.19
KWS Extase (AA)	8.23	7.25*	6.90	7.16	4.48
Wakelyn's pop	5.22	3.63	3.95	2.11	3.20
Pot luck mix	5.49	4.90	4.01	6.65	4.48
KWS Brium	7.11	-	5.12		-
KWS Guium	5.65	-	5.46		-
Theodore	5.30	-	-	8.11	6.84
KWS Dawsum	6.22	-	-	7.79	7.60
KWS Dawsum (NST)	5.75				
Oxford	6.28	-	-	7.63	7.38
Group 4 Hard mix	4.90	-	-	7.70	11.16
RGT Stokes	6.09	5.50	-	-	5.19
RGT Stokes (AA)	6.12	-	-	-	-
RGT Bairstow	5.45	5.05	-	-	4.26
Revelation	6.22	3.17	-	-	4.20
Group 4 Soft mix	5.85	4.48	-	-	4.74
LG Astronomer	6.22	-	4.15	-	5.04
Group 3 soft mix	5.85	-	5.13	-	-
1109	-	-	-	2.88	-
Elix	-	-	-	2.42	-

*Looked like ammonium nitrate had been applied to the edge of this plot when fertilising the surrounding conventional farm crop.

Grain yields were highest at Thornton Farm and Gilchester's with Nafferton Farm, Nisbet Hill and Newlands being at a lower level (Table 1). At Newlands the crop had a relatively low biomass throughout the season and was showing early signs of senescence on 13 July (Fig 2). KWS Extase was the highest yielding variety at Thornton Farm and Nisbet Hill but at Newlands it was RGT Stokes, at Gilchester's it was the variety Theodore and at Nafferton Farm it was KWS Dawsum. Wakelyn's population had a relatively low yield but suffered from a high level of lodging at Thornton Farm, Newlands, Nisbet Hill and Gilchesters it was only at Newlands where no lodging was observed. The popular German organic variety Wendelin showed a very disappointing grain yield at all sites but particularly at Thornton Farm, Newlands and Nisbet Hill. The seed treatments Newton (NST) and AminoA Staart (AA) were evaluated at all sites on the variety KWS Extase but in addition NST was used on KWS Dawsum and AA on RGT Stokes at Thornton Farm. For the varieties RGT Stokes and KWS Dawsum there was no benefit of seed treatment on grain yield (Table 1). However, for the variety KWS Extase results were more promising with yield benefit of 0.43 t/ha at Thornton Farm, 1.16 t/ha at Nisbet Hill, 0.74 t/ha at Gilchester's and 0.34 t/ha at Nafferton Farm following the use of the Newton seed treatment (NST). For the AminoA Staart seed treatment there were yield gains of 1.14 t/ha at Thornton Farm, 1.01 at Nisbet Hill and 0.35 t/ha at Gilchester's with a yield reduction observed at Nafferton Farm on the variety KWS Extase.

Funded by European Union
Horizon 2020
Grant agreement No 771367

With respect to the seed mixtures used there was no clear evidence of any uplift in grain yield. The exception being the Group 4 hard mix grown at Nafferton Farm where a grain yield of 11.16 t/ha was recorded but this seems abnormally and probably erroneously high compared to the rest of the data (maybe due to the combine not completely emptying when cutting the previous plot in the trial) and especially when compared with the plus Thiopron treatment (Table 4).

Table 2 Grain yield (t/ha) at15% moisture content from Thornton Farm with and without Fixio in the 2022-23 season.

	Control	With Fixio
Wendelin	3.79	5.85
KWS Extase	7.09	2.22*
KWS Extase (NST)	7.52	9.07
KWS Extase (AA)	8.23	8.74
Wakelyn's pop	5.22	5.13
Pot luck mix	5.49	9.01
KWS Brium	7.11	8.34
KWS Guium	5.65	9.43
Theodore	5.30	8.06
KWS Dawsum	6.22	9.40
KWS Dawsum (NST)	5.75	9.92
Oxford	6.28	9.53
Group 4 Hard mix	4.90	8.81
RGT Stokes	6.09	9.43
RGT Stokes (AA)	6.12	8.98
RGT Bairstow	5.45	9.14
Revelation	6.22	10.39
Group 4 Soft mix	5.85	9.36
LG Astronomer	6.22	9.53
Mean	**5.98**	**8.71**

*Error with the balance on the plot combine such that this data not included in the average yield calculation. Combine yields at Thornton Farm were based on 9 m harvested plot length (18 m^2 area) for the control and 9.7 m cut length (19.4 m^2 area) for the Fixio treatment.

The standout observation from all the trials was the increased grain yield observed at both Thornton Farm and Nisbet Hill (Table 3) following the application of Fixio at just prior to the start of stem extension. At Thornton Farm the increase in average grain yield following the application of Fixio was 2.73 t/ha (Table 2) while at Nisbet Hill it was 1.47 t/ha. At Thornton farm the increased grain yield resulting from the application of Fixio was consistent across all varieties with the exception of Wakelyn's population possibly due to the high degree of lodging in this variety. At Nisbett Hil again the yield response to Fixio was consistent across all varieties although relatively smaller where the NST and AA seed treatments had been used on KWS Extase.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 3 Grain yields (t/ha) at 15% moisture content from Nisbet Hill in response to Fixio application in the 2022-23 season.

	Control	Fixio
WB/ KWS Extase	5.15	-
Pot luck mix	4.01	5.96
Alessio	3.87	4.99
Wendelin	3.94	6.07
Group 3 soft mix	5.13	6.72
KWS Guium	5.46	7.17
KWS Brium	5.12	6.13
LG Astronomer	4.15	6.95
Wakelyn's pop	3.95	5.54
KWS Extase	5.89	7.59
KWS Extase (AA)	6.90	7.29
KWS Extase (NST)	7.05	7.24
Mean	**5.04**	**6.51**

*Grain yields at Nesbitt Hill were based on 25 m cut length (50 m^2 area) for both the control and Fixio treatments

Following the application of Thiopron at both T1 and T2 at Nafferton Farm (Table 4) an increase in grain yield of 0.47 t/ha was observed although the response was not consistent across all varieties. There was a greater response in KWS Extase (AA), Wakelyn's population, Pot luck mix, Theodore, Oxford and RGT Bairstow which was not related to disease susceptibility as KWS Extase, Theodore and Oxford showed good resistance to *S. tritici* in the trial.

Table 4 Grain yields (t/ha) @15% moisture content from Nafferton Farm in response to Thiopron application in the 2022-23 season.

	Control	With Thiopron
Wendelin	4.62	5.37
KWS Extase	4.85	5.26
KWS Extase (NST)	5.19	3.75
KWS Extase (AA)	4.48	5.65
Wakelyn's pop	3.20	4.24
Pot luck mix	4.48	5.65
Theodore	6.84	8.06
KWS Dawsum	7.60	7.90
Oxford	7.38	8.99
Group 4 Hard mix	11.16	8.30
RGT Stokes	5.19	5.78
RGT Bairstow	4.26	6.14
Revelation	4.20	5.02
Group 4 Soft mix	4.74	4.83
LG Astronomer	5.04	5.40
Mean	**5.55**	**6.02**

Funded by European Union
Horizon 2020
Grant agreement No 771367

2.1.2 Disease results

Table 5 Septoria leaf blotch and yellow rust disease levels from Nisbet Hill Farm in the 2022-23 season.

	19 May		28 June		13 July	
	*S. tritici**	Yellow rust**	*S. tritici*	Yellow rust	*S. tritici*	Yellow rust
WB/KWS Extase	-	1	-	1	-	1
Pot luck mix	-	1	0, 25,96	1	5, 79, 96	1
Alessio	-	1	0, 20,97	1	37, 92, 100	1
Wendelin	-	1	0, 6, 47	1	0, 34, 81	1
Group 3 soft mix	-	1	0, 1, 60	1	3, 44, 99	1
KWS Guium	-	1	0, 0, 31	1	1, 24, 87	1
KWS Brium	-	1	0, 6, 80	1	1, 55, 100	1
LG Astronomer	-	1	0, 6, 63	1	3, 58, 95	1
Wakelyn's pop	-	1	0, 24, 84	1	6, 49, 100	1
KWS Extase	-	1	0, 15, 89	1	14, 72, 100	1
KWS Extase (AA)	-	1	0, 16, 73	1	6, 38, 94	1
KWS Extase (NST)	-	1	2, 15, 98	1	8, 74, 100	1

**Septoria tritici* % disease recorded on L1, L2 and L3 respectively
***Yellow rust 1-9 scale where 1 = no disease present

At Nisbet Hill on 19 May there was no evidence of yellow rust on any of the varieties and also in the most advanced varieties only leaf 2 was fully emerged such that assessment for *S. tritici* was not carried out at this time. At later sampling dates on 28 June and 13 July again there were no signs of any yellow rust symptoms, but leaf blotch was clearly evident. The Group 3 soft wheat variety KWS Guium had the lowest levels of *S tritici* with surprisingly KWS Extase showing high levels despite good resistance to the disease (AHDB 2023). On 13 July only the variety Wendelin exhibited a clean flag leaf but with low levels also on KWS Guium, KWS Brium, LG Astronomer and the Group 3 soft mix while Alessio, KWS Brium, Wakelyn's population, KWS Extase and KWS Extase (AA) had 100% coverage of leaf 3. The Group 3 soft mix showed no real benefit over the three individual varieties i.e. KWS Guium, KWS Brium and LG Astronomer in terms of *S. tritici* levels.

At Newlands Farm on 19 May the flag leaf just emerging on the most advanced variety KWS Extase while Revelation was only at the start of stem extension. There was at this time no evidence of yellow rust and with only 2 leaves emerged on most varieties no evidence of leaf blotch being present on these leaves. At the following disease assessments on 28 June and 13 July 2023 (Table 6) there were no signs of yellow rust in any variety. On 28 June patches of the trial were starting to senesce and were looking quite poor although disease levels were low.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 6 Septoria leaf blotch and yellow rust disease levels from Newlands Farm on the on 28 June and 13 July in the 2022-23 season.

	28 June		13 July	
	*S. tritici**	Yellow rust**	*S. tritici*	Yellow rust
KWS Extase (AA)	0, 9, 59	1	3, 24,93	1
KWS Extase	0, 0, 37	1	0, 18, 100	1
KWS Extase (NST)	0, 0, 38	1	0, 17, 90	1
Group 4 soft mix	0, 0, 34	1	1, 13, 90	1
Wendelin	0, 0, 54	1	1, 22, 57	1
Wakelyn's pop	0, 4, 52	1	12, 29, 94	1
Revelation	0, 0, 14	1	0, 11, 62	1
RGT Stokes	0, 0, 20	1	1, 7, 68	1
RGT Bairstow	0, 0, 21	1	0, 8, 66	1
Pot luck mix	0, 21, 67	1	14, 37, 86	1

**Septoria tritici* % disease recorded on L1, L2 and L3 respectively
***Yellow rust 1-9 scale where 1 = no disease present

At Thornton Farm on 19 May the flag leaf was just starting to emerge through to 50% emergence. As only Leaf 3 and 2 had fully emerged there was no sign of leaf blotch or yellow rust on these leaves. At this time high levels of Charlock (*Sinapis alba*) were present across both the FPT and the commercial crop of RGT Bairstow. On 28 June there were no symptoms of yellow rust and by 13 July the disease was only evident on KWS Extase and KWS Extase (NST) but at low levels. The variety Wendelin showed good resistance to *S. tritici* in addition to the hard wheat varieties Theodore and Oxford. Very high levels of *S. tritici* were observed on the Pot luck mix at both 28 June and 13 July together with Wakelyn's population at the latter date. The Group 3 soft and Group 4 hard varietal mixtures showed no clear benefit in disease resistance compared with the individual varieties in each mixture.

Table 7 Septoria leaf blotch and yellow rust disease levels recorded from Thornton Farm on 20 June and 5 July in the 2022-23 season.

	28 June		13 July	
	*S. tritici**	Yellow rust**	*S. tritici*	Yellow rust
Wendelin	0, 2, 50	1	3, 19, 75	1
KWS Extase	0, 4, 33	1	3, 15, 82	1.6
KWS Extase (NST)	0, 4, 19	1	3, 15, 55	1.9
KWS Extase (AA)	0, 11, 36	1	10, 46, 82	1
Wakelyn's pop	0, 4, 45	1	18, 39, 96	1
Pot luck mix	0, 21, 64	1	15, 29, 92	1
KWS Brium	0, 10, 76	1	5, 29, 89	1
KWS Guium	0, 1, 27	1	6, 24, 90	1
Theodore	0, 1, 59	1	0, 19, 86	1
KWS Dawsum	0, 8, 61	1	6, 37, 92	1
Oxford	0, 0, 40	1	8, 29, 88	1
Group 4 hard mix	0, 4, 45	1	1, 21, 91	1
RGT Stokes	0, 0, 31	1	-	1
RGT Stokes (AA)	0, 2, 32	1	6, 31, 96	1
RGT Bairstow	0, 2, 35	1	5, 26, 90	1
Revelation	0, 4, 46	1	5, 42, 98	1
Group 3 soft mix	0, 2, 62	1	3, 25, 98	1
LG Astronomer	0, 3, 38	1	4, 30, 84	1

**Septoria tritici* % disease recorded on L1, L2 and L3 respectively ; **Yellow rust 1-9 scale where 1 = no disease present

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 8 Septoria leaf blotch and yellow rust disease levels from Gilchester's on 17 May, 27 June and 14 July in the 2022-23 season.

	17 May		27 June		14 July	
	*S. tritici**	Yellow rust**	*S. tritici*	Yellow rust	*S. tritici*	Yellow rust
Wakelyn's pop	0, 0, 1	1	4, 9.5, 54	1.7	11, 59, 100	1
Wendelin	0, 0, 0	1.1	0, 3.5, 36	1	0, 36, 100	1
KWS Extase	0, 0, 0	1.2	3, 13, 58	1.2	14, 79, 100	1
KWS Extase (NST)	0, 0, 0	1.5	3, 14, 59	1.5	11, 71, 100	1
KWS Extase (AA)	0, 0, 0	1.3	5, 14, 58	1	12, 47, 98	1
Pot luck mix	0, 0, 3	1.8	12, 25, 53	2.7	19, 50, 95	1
Theodore	0, 0, 2	1.2	0, 1, 22	1	0, 51, 96	1
KWS Dawsum	0, 0	1	1, 3, 32	1	5, 42, 100	1
Oxford	0, 0	1	0, 2, 35	1	3, 27, 90	1
Group 4 Hard mix	0, 0	1	0, 1, 31	1	2, 42, 91	1
1109	0, 0	1	12, 33, 81	3.5	28, 66, 94	1
Elix	0, 6	2.2	10, 26, 81	4.1	60, 94, 100	1

**Septoria tritici* % disease recorded on L1, L2 and L3 respectively
***Yellow rust 1-9 scale where 1 = no disease present

On 17 May at Gilchester's only 2 leaves had fully emerged on KWS Dawsum, Oxford, Group 4 Hard mix, 1109 and Elix while for all other varieties leaf 3 was about 50% emerged. For the variety Elix there were high levels of leaf blotch in the base of the canopy. At the disease assessment on 14 July (Table 8) there was a high level of lodging in the Wakelyn's population (Table 8). Yellow rust was evident on 17 May and 27 June but not later in the season on the 14th of July where the highest disease levels were found on the Pot luck mix. With respect to leaf blotch lowest disease levels on 27 June were found on the varieties: Wendelin, Theodore, KWS Dawsum, Oxford and the Group 4 hard mix with high levels recorded on Elix, 1109 and the Pot luck mix. By 14 July Wendelin and Theodore both had zero levels of disease on the flag leaf but with high levels again on Elix, 1109 and the Pot luck mix (Table 8).

At Nafferton Farm on 17 May the crop growth stage varied between leaf 2 only just emerging to fully emerged, therefore only yellow rust data was collected at this time. Symptoms of yellow rust were only observed on KWS Extase, RGT Stokes and LG Astronomer at this time (Table 9). On 27 June low levels of *S tritici* were found in Wendelin, Theodore, KWS Dawsum and Oxford with the highest disease levels in the Pot luck mix, RGT Stokes and RGT Bairstow. By 14 July all varieties with the exception of KWS Dawsum had 100% *S tritici* coverage on leaf 3 with the Polt luck mix also having almost half of the flag leaf senesced due to the disease. The NST and AA seed treatments showed no effect on foliar disease levels and the Group 4 hard mix showed no difference in disease levels when compared to the individual varieties.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 9 Septoria leaf blotch and yellow rust disease levels from the control treatment at Nafferton Farm in the 2022-23 season.

	17 May		27 June		14 July	
	*S. tritici**	Yellow rust**	*S. tritici*	Yellow rust	*S. tritici*	Yellow rust
Wendelin	-	1	0, 16, 68	1	0, 23,100	1
KWS Extase	-	1	4, 24, 77	1	4, 66, 100	1
KWS Extase (NST)	-	1.7	7, 19, 85	1	14,73,100	1
KWS Extase (AA)	-	1.1	3, 18, 69	1	10,81,100	1
Wakelyn's pop	-	1	4, 34, 79	1	4, 59,100	1
Pot luck mix	-	1	14, 48, 85	1	45,83,100	1
Theodore	-	1	0, 7, 47	1	2, 68, 100	1
KWS Dawsum	-	1	0, 0, 35	1	10, 27, 85	1
Oxford	-	1	0, 0, 21	1	2, 73, 100	1
Group 4 Hard mix	-	1	0, 6, 45	1	4, 33, 100	1
RGT Stokes	-	1.4	5, 18, 51	1	15,49, 100	1
RGT Bairstow	-	1	6, 19, 52	1	8,53,100	1
Revelation	-	1	2, 12, 39	1	0, 30, 100	1
Group 4 Soft mix	-	1	9, 14, 56	1	8, 35, 100	1
LG Astronomer	-	1.1	1, 23, 74	1	8, 77,100	1

**Septoria tritici* % disease recorded on L1, L2 and L3 respectively
***Yellow rust 1-9 scale where 1 = no disease present

Table 10 Septoria leaf blotch and yellow rust disease levels following Thiopron treatment at Nafferton Farm in the 2022-23 season.

	17 May		27 June		14 July	
	*S tritici**	Yellow rust**	*S tritici*	Yellow rust	*S tritici*	Yellow rust
Wendelin	-	-	0, 5, 32	1	4, 19, 94	1
KWS Extase	-	-	4, 14, 39	1.1	5, 47, 96	1
KWS Extase (NST)	-	-	4, 12, 72	1	4, 46, 99	1
KWS Extase (AA)	-	-	3, 13, 32	1	7, 47, 100	1
Wakelyn's pop	-	-	6, 20, 53	1.6	15, 53, 98	1
Pot luck mix	-	-	21, 35, 75	1	39, 83, 100	1
Theodore	-	-	0, 0, 54	1	0, 25, 94	1
KWS Dawsum	-	-	0, 4, 53	1	1, 10, 94	1
Oxford	-	-	0, 2, 34	1	0, 21, 100	1
Group 4 Hard mix	-	-	0, 1, 39	1	0, 34, 93	1
RGT Stokes	-	-	14, 24, 46	1	6, 28, 100	1
RGT Bairstow	-	-	17, 27, 51	1	10, 44, 94	1
Revelation	-	-	7, 16, 41	1	2, 26, 100	1
Group 4 Soft mix	-	-	6, 23, 36	1	4, 35, 100	1
LG Astronomer	-	-	6, 20, 63	1	5, 49, 94	1

**Septoria tritici* % disease recorded on L1, L2 and L3 respectively
***Yellow rust 1-9 scale where 1 = no disease present

The use of the sulphur-based fungicide Thiopron had no observable effect on foliar disease levels (Table 10) although a yield increase of 0.47 t/ha was observed at Nafferton Farm when averaged across all varieties (Table 4).

Funded by European Union
Horizon 2020
Grant agreement No 771367

2.1.3 Grain Quality

Table 11 Grain protein (%) from the FPT sites presented @15% moisture content in the 2022-23 season.

	Thornton Farm	Newlands	Nisbet Hill	Gilchester's	Nafferton Farm
Wendelin	12.9	10.0	13.7	16.0	14.7
Alessio	-	-	12.9	-	-
KWS Extase	11.5	9.1	10.3	13.5	13.6
KWS Extase (NST)	11.6	8.2	10.4	12.4	12.7
KWS Extase (AA)	11.2	9.2	10.7	12.8	11.7
Wakelyn's pop	12.9	9.1	12.8	14.9	14.6
Pot luck mix	12.0	9.7	10.7	13.1	13.8
KWS Brium	11.2	-	10.5	-	-
KWS Guium	9.7	-	10.6	-	-
Theodore	10.1	-	-	11.0	12.0
KWS Dawsum	9.5	-	-	10.2	12.0
KWS Dawsum (NST)	9.8	-	-	-	
Oxford	10.1	-	-	10.1	11.8
Group 4 Hard mix	10.0	-	-	10.5	11.8
RGT Stokes	-	8.7	-	-	12.2
RGT Stokes (AA)	10.5	-	-	-	-
RGT Bairstow	9.0	8.3	-	-	12.2
Revelation	10.9	8.2	-	-	12.5
Group 4 Soft mix	11.4	7.8	-	-	11.3
LG Astronomer	9.8	-	11.4	-	12.2
Group 3 soft mix	9.9	-	10.8	-	-
1109	-	-	-	13.6	-
Elix	-	-	-	17.7	-

Grain protein content was much higher at Gilchester's and Nafferton Farm than other sites and was lowest at Newlands in the 2022-23 season (Table 11). At all sites the popular German organic variety Wendelin had the highest grain protein content at all sites with the exception of Gilchester's where the variety Helix had a very high 17.7%. The most popular wheat variety in conventional production in 2024 KWS Extase had very low grain protein content at Newlands, Thornton Farm and Nisbet Hill but was much closer to the 13% milling specification at Gilchester's and Nafferton Farm. The Wakelyn's population had an overall high grain protein content especially at Thornton Farm where it was at the same level as Wendelin but especially at Gilchester's and Nafferton Farm with levels greater than 14%. This is surprising as the parents for this CCP comprise bread making and feed wheat varieties but can also possibly be explained by the high level of lodging and relatively low yield when compared to other varieties and the previous 2 seasons when this CCP was evaluated.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 12 Grain Hagberg Falling Number (s) from the five FPT sites in the 2022-23 season.

	Thornton Farm	Newlands	Nisbet Hill	Gilchester's	Nafferton Farm
Wendelin	253	226	189	248	200
Alessio	-	-	215	-	-
KWS Extase	173	285	212	308	176
KWS Extase (NST)	258	293	211	288	289
KWS Extase (AA)	280	296	248	290	256
Wakelyn's pop	147	250	122	168	207
Pot luck mix	286	278	265	332	290
KWS Brium	208	-	184	-	-
KWS Guium	233	-	240	-	-
Theodore	232	-	-	375	274
KWS Dawsum	346	-	-	301	277
KWS Dawsum (NST)	304	-		-	
Oxford	218	-	-	186	177
Group 4 Hard mix	252	-	-	200	299
RGT Stokes	229	229	-	-	258
RGT Stokes (AA)	202	-	-	-	-
RGT Bairstow	211	176	-	-	290
Revelation	258	267	-	-	250
Group 4 Soft mix	308	-	-	-	249
LG Astronomer	213	-	186	-	248
Group 3 soft mix	214	-	169	-	-
1109	-	-	-	208	-
Elix	-	-	-	255	-

Grain HFN values were much lower than in 2022 mostly due to the wet weather experienced in the UK from the beginning of July through to final harvest. This was the case when compared with much higher HFN values in 2022 largely attributable to the much drier conditions during grain maturation and harvest. Wakelyn's population had very low HFN at Thornton Farm, Nisbet Hill and Gilchester's largely due to the high degree of lodging at all these sites but at Newlands where the crop did not lodge it recorded a HFN of 250s (Table 12). The variety KWS Dawsum grown at Thornton Farm, Nafferton Farm and Gilchester's recorded consistent and high HFN levels >250s. The popular conventional variety KWS Extase recorded high variability in HFN across sites with values of 173 and 176 s at Thornton and Nafferton Farm respectively but with values of 285 s at Newlands and 305 s at Gilchester's.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 13 Grain specific weight (kg/hl) from the five FPT sites in the 2022-23 season.

	Thornton Farm	Newlands	Nisbet Hill	Gilchester's	Nafferton Farm
Wendelin	78.0	75.9	77.8	77.9	78.5
Alessio	-	-	79.0	-	-
KWS Extase	73.7	72.5	73.9	73.5	70.7
KWS Extase (NST)	73.5	71.1	74.1	72.3	71.5
KWS Extase (AA)	74	72.7	73.9	72.9	69.0
Wakelyn's pop	74.4	73.2	75.0	74.5	75.8
Pot luck mix	75.7	72.6	75.1	73.2	71.0
KWS Brium	73.5	-	72.8	-	-
KWS Guium	74.3	-	74.8	-	-
Theodore	71.0	-	-	70.2	65.9
KWS Dawsum	75.3	-	-	73.0	72.5
KWS Dawsum (NST)	75.8	-		-	
Oxford	72.2	-	-	72.0	69.6
Group 4 Hard mix	72.5	-	-	71.0	70.3
RGT Stokes	71.5	71.5	-	-	68.6
RGT Stokes (AA)	72.2	-	-	-	-
RGT Bairstow	71.2	70.8	-	-	68.1
Revelation	73.7	71.9	-	-	70.6
Group 4 Soft mix	72.7	71.3	-	-	69.7
LG Astronomer	73.0	-	74.1	-	70.3
Group 3 soft mix	73.9	-	73.8	-	-
1109	-	-	-	73.7	-
Elix	-	-	-	74.1	-

The organic milling variety Wendelin produced consistently high grain specific weight and it was only at Newlands where this dropped below the 76 kg/hl threshold (Table 13). Alessio also produced a very high specific weight of 79 kg/hl but was only grown at Nesbitt Hill in the 2022-23 season. The hard feed wheat variety Theodore together with the Group 4 soft wheat varieties RGT Stokes and RGT Bairstow had low specific weights <72 kg/hl.

Grain specific weights and HFN were much lower than observed in the previous season which confirms UK grain quality data where the specific weight of Group 1 varieties was 5 kg/hl lower than in 2022 with the HFN of the same group being 62 s below the 2022 level. (AHDB Cereal Quality Survey 2023 available at Cereal Quality Survey | AHDB. The grain protein levels were similar in 2023 to those recorded in 2022. The abundant sunshine particularly during grain filling and lack of rainfall prior to and during crop maturity in 2022 were the main reasons for the higher HFN and specific weight in the 2022 when compared with the 2023 season.

Funded by European Union
Horizon 2020
Grant agreement No 771367

2.2 Wheat farmer participatory trials in Austria

(1) Ing. Andreas Patschka, Zeile 85, 2020 Aspersdorf

GPS: 48.593586, 16.089751 – Parz. 902, KG Schöngrabern

Varieties: ARISTARO, AXARO, MV ELIT CCP, LIOCHARLS POPULATION

Sowing date: 19 October 2022

Sowing density: 320 seeds per m²

Harvest date: 14 July 2023 (3 x 1 m² samples per genotype)

Table 14 Results of the FPT in Aspersdorf 2023.

GEN	PH[1]	LO	GYLD	HLW	TKW	GE2.5	PROT
Aristaro	135	6	5685	85.0	42.2	92.8	11.0
Axaro	115	1	10061	84.9	49.5	96.4	9.2
Liocharls	145	6	6573	85.0	43.4	95.7	11.3
Mv Elit CCP	100	1	6045	83.6	41.2	90.1	12.7

[1] PH, plant height (cm); LO, lodging score (1-9); GYLD, grain yield (kg/ha); HLW, hectolitrer weight (kg/hL); TKW, thousand kernel weight (g); GE2.5, seed plumpness >2.5 mm (%); PROT, protein content (%)

Due to heavy rainfall before harvest about 50% of the plots of Aristaro and Liocharls were severely lodged (score 7-9); in total the plots were, therefore, scored with a 6. With respect to test weight (HLW) all genotypes met the Austrian requirements for quality wheat (78 kg/hL), however, only Mv Elit CCP reached a protein content >12% which is required for "quality wheat"; Aristaro and Liocharls reached >11% and would therefore be marketed as "milling wheat", whereas Axaro could be marketed only as "feed wheat" due to the very low protein content.

(2) Petra Borchert, Hauptstraße 18, 7151 Wallern im Burgenland

GPS:

Varieties: ADAMUS, ARMINIUS, AURELIUS, AXARO, CAPO, CHRISTOPH, EDELMANN, EHOGOLD, ENERGO, MANDARIN, MV ELIT CCP, TILLSANO, TOBIAS

Sowing date: 21 October 2022

Sowing density: 325 seeds per m²

Harvest date: 9 July 2023

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 15 Results of the FPT in Wallern im Burgenland 2023.

GEN	GYLD[1]	HLW	TKW	GE2.5	PROT
Adamus	4060	85.2	43.3	97.0	9.6
Arminius	2970	84.2	42.9	95.5	8.6
Aurelius	3060	83.6	43.3	96.2	8.0
Axaro	3082	81.3	41.4	93.4	6.9
Capo	3160	84.1	38.7	92.8	8.0
Christoph	3078	81.7	39.2	95.0	7.7
Edelmann	3071	83.2	36.9	92.6	8.0
Ehogold	2616	84.2	39.4	93.0	8.4
Energo	4060	82.7	39.9	93.4	7.1
Mandarin	2794	81.9	41.3	92.0	7.1
Mv Elit CCP	2100	81.5	39.3	92.1	8.0
Tillsano	2981	80.8	45.2	95.7	7.2
Tobias	2526	83.7	38.5	94.7	8.4

[1] GYLD, grain yield (kg/ha); HLW, hectolitre weight (kg/hL); TKW, thousand kernel weight (g); GE2.5, seed plumpness >2.5 mm (%); PROT, protein content (%)

All genotypes reached the basic requirement for "quality wheat" with respect to test weight, however, due to the very low protein content (<11%) all genotypes would have been marketed only as "feed wheat".

(3) Experimental Station of the University of Natural Resources and Life Sciences, Vienna

GPS: 48.232179, 16.590429 - KG Poysdorf

Varieties: ARMINIUS, ARNOLD, AURELIUS, CAPO, EDELMANN, LIOCHARLS POPULATION, MV ELIT CCP, MV KAREJ, MV KOLOMPOS, MV MENROT, +9 BOKU OHMs

Sowing date: 17 October 2023

Sowing density: 350 seeds per m²

Harvest date: 17 July 2023

The basic requirement for test weight was not reached by Mv Kolompos, Mv Menrot and 4 of the BOKU OHMs; Mv Menrot and B-594-605-6 did not even reach the minimum requirement of 75 kg/hL and would, therefore, be marketed only as "feed wheat". With respect to protein content, only Arnold achieved the requirement for "premium wheat" (>13%) and only Liocharls for "quality wheat" (>12%). Capo, Edelmann, Mv Karej, Mv Kolompos and Mv Menrot, together with 6 BOKU OHMs did not reach 11% and therefore failed to meet the requirement for "milling wheat".

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 16 Results of the FPT in Raasdorf 2023.

GEN	YR[1]	CB	PH	GYLD	HLW	TKW	GE2.5	PROT
Arminius	4.8	+	123	7298	82.8	41.2	92.6	11.8
Arnold	6.3	-	115	6559	83.4	40.7	93.4	14.0
Aurelius	3.0	-	100	8123	82.2	40.0	91.6	11.4
A-1-13-B-584-632	4.5	-	118	6575	80.1	40.7	83.7	11.9
A-8-9-11-12	1.8	-	110	6308	80.6	40.5	83.8	10.8
B-578-95-6	5.3	-	105	5337	78.7	38.5	75.4	10.3
B-579-86-8	4.0	-	123	6169	76.0	37.4	84.8	10.1
B-580-1-2-90	5.0	-	120	6718	80.1	42.0	89.1	11.4
B-586-609	4.5	-	110	5411	76.8	35.4	84.2	11.1
B-591-2-3-8-9	3.3	-	115	7218	77.6	44.6	81.7	9.6
B-594-605-6	4.8	-	123	5872	74.3	38.4	76.2	9.0
B-607-8	4.8	-	115	7151	79.6	41.5	90.2	10.8
Capo	3.5	+	123	7443	83.7	38.1	87.4	10.9
Edelmann	2.8	-	115	6884	81.4	34.2	86.3	9.8
Liocharls	4.8	-	135	6901	80.5	39.0	89.7	12.1
Mv Elit CCP	5.8	-	95	5226	79.7	38.7	75.6	11.2
Mv Karej	4.8	-	93	5581	79.9	40.0	74.5	10.9
Mv Kolompos	2.8	-	98	6454	75.0	42.0	89.0	10.7
Mv Menrot	3.5	-	100	5616	64.7	38.7	79.4	10.8

[1] YR, yellow rust score (1-9); CB, common bunt natural soilborne infection (+/-); PH, plant height (cm); LO, lodging score (1-9); GYLD, grain yield (kg/ha); HLW, hectolitre weight (kg/hL); TKW, thousand kernel weight (g); GE2.5, seed plumpness >2.5 mm (%); PROT, protein content (%)

(4) Experimental Station of the University of Natural Resources and Life Sciences, Vienna

GPS: 48.232961, 16.590818 - KG Poysdorf

Varieties: ARISTARO, CAPO

Treatments: Control (untreated), RhizoVital® 42 F (*Bacillus velezensis* FZB42), T-Gro Easy-Flow® (*Trichoderma asperellum*)

Sowing date: 18 October 2023

Sowing density: 350 seeds per m²

Harvest date: 20 July 2023

Analysis of the biostimulants experiment revealed only a significant effect of genotype but no significant effect of treatment. Except for test weight, Aristaro was significantly superior to Capo in all other traits. Regarding grain yield the significant difference can be explained with a significantly higher infection of Capo with yellow rust. While Aristaro had a variability of yellow rust scores between 1 and 2.5, Capo had scores up to 4.5.

Although it seemed that the treated plots had a faster and better emergence after sowing, no significant effect was obvious for either of the two treatments at harvest.

With respect to quality requirements, it must be noted that the protein content of Capo was <11% which would mean that it would be marketed only as “feed wheat”, whereas Aristaro reached 12% and, therefore, even achieved the requirement for “quality wheat”.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 17 Analysis of variance and mean comparisons for the biostimulant experiment, Raasdorf 2023. ANOVA table indicates the probability of significance, mean comparisons are based on Tukey-Kramer adjustments with different letters indicating significant differences.

Source	GYLD[1]	HLW	TKW	GE2.5	PROT
GEN	0.0232	<.0001	<.0001	0.0060	0.0172
TREAT	0.7907	0.3632	0.9538	0.9133	0.9517
G*T	0.1063	0.8314	0.4980	0.5697	0.3041
Aristaro	6754 a	82.3 b	41.6 a	90.4 a	12.0 a
Capo	6048 b	83.8 a	37.9 b	86.1 b	10.9 b
Control	6456 a	82.7 a	39.7 a	88.4 a	11.4 a
Bacillus	6491 a	83.0 a	39.7 a	87.8 a	11.5 a
Trichoderma	6255 a	83.3 a	39.9 a	88.6 a	11.4 a

[1] GYLD, grain yield (kg/ha); HLW, hectoliter weight (kg/hL); TKW, thousand kernel weight (g); GE2.5, seed plumpness >2.5 mm (%); PROT, protein content (%)

2.3 Wheat farmer participatory trials in the Slovak Republic

The participatory field trials were performed on four organic farms and Borovce Research station located in Slovakia.

Table 18 List of organic farms with participatory field trials in Slovakia.

Name of farm	Farm address	GPS latitude	GPS longitude	MSL (m)	Area of farm site
BIOMILA SK, s. r. o.	Rudník 428	48.760822	17.638586	325	135.07 ha
Vladimír Zeman SHR	Polianka 115	48.721571	17.595196	416	179.87 ha
Martin Kolárik SHR	Horná Polianka 203	48.72704	17.58127	416	64.84 ha
SEMA HŠ s.r.o.	Nový Dvor 1862	48.214648	17.597916	121	1313 ha
Borovce Research station	Borovce 60, 922 09	48.581427	17.730292	167	102,7
Note: GPS - global positioning system; MSL - mean sea level					

Funded by European Union
Horizon 2020
Grant agreement No 771367

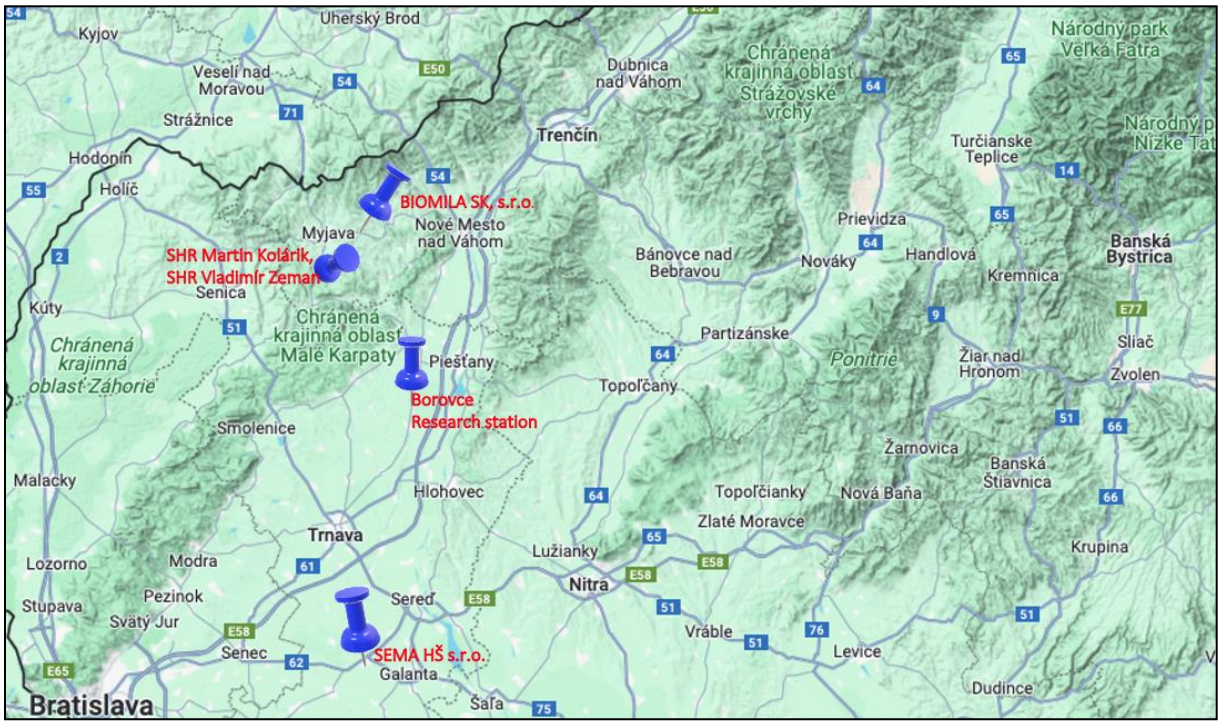


Fig 3 Location map of the four farms in Slovakia.

A total of eight wheat varieties (both domestic and international) for organic cultivation and low-input conditions were sown in autumn 2022 in plots with a minimum plot size of 300 m^2 (Table 19). Plus, in Borovce, 22 populations were sown on the same date (Table 19). The sowing dates were as follows: 08 October 2022 in SEMA HŠ s.r.o. Sládkovičovo, 04 November 2022 in Rudník, and 13 October 2022 in Borovce. The sowing density was 450 seeds per m^2 for all varieties and locations. The weed control was done by using the stale seedbed technique before sowing, and by inter-row cultivation three times during the growing season. The weed infestation was low in all trials, and no significant differences were observed among varieties.

Table 19 The list of varieties with their 1000 grain weight (TGW).

Variety name	TGW (g)	Seeding rate (g/m^2)
Alessio	43.3	22.50
Arnold	41.6	18.00
Aurelius	37.3	18.00
Ehogold	39.3	18.00
IS Laudis	39.8	20.25
Capo	37.2	18.00
Viki	36.1	20.25
PS Dobromila	47.9	20.25

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 20 The list of populations with their 1000 grain weight (TGW).

NO.	Variety name	TGW (g)
1.	6409 BTX501-WT	40.45
2.	6408 BTX501-GpcB1	40.91
3.	7806 BTX501-F5	40.36
4.	6310 BTX502-WT	46.14
5.	6308 BTX502-GpcB1	43.75
6.	7410 BTX502-F5	44.5
7.	6110 BTX609	48.32
8.	6206 EBLK579-86-88	45.35
9.	6208 EBLK586-609	43.64
10.	6209 EBLK580-1-2-90	47.01
11.	7509 BTX503	44.98
12.	7804 BTX540	45.31
13.	7805 BTX551	43.39
14.	8007 BTX543	44.91
15.	6710 06IFAFS3	40.7
16.	7306 06IFAFS2	37.41
17.	7010 06IFAFS223	38.92
18	7208 06IFAFS227	31.52
19.	7110 06IFAFS36	39.15
20.	7106 06IFAFS37	36.55
21.	6810 06IFAFS44	36.47
22.	6808 06IFAFS45	40.77

Cultivars were evaluated during the vegetation period on all farms: winter response, growth habit, ground cover, flag leaf emergence, date of heading, number of wheat heads, plant height (cm), canopy, lodging, identification and scoring of diseases, and pests using a 1-9 scale (1 meaning low prevalence), grain yield (kg/ha), test weight (kg/hl).

The weather conditions during the vegetation period were generally good for the vegetation and development of wheat. In locality Rudník, the sowing was delayed to 04/11/2022 because of intense rainfall that affected the area.

The trial in SEMA HŠ s.r.o. at the end of the season looked very promising. The trial showed good results, with low weed and disease infestation across all varieties (Table 21). The most infected varieties were Viki and Arnold, but they still had acceptable levels of damage. The other varieties had very few or no signs of infection. The harvest was done on 10 July 2023, and the yield data was collected and analysed. The best yield was achieved by Capo and Viki, with 6.8 and 6.5 t/ha respectively. The lowest yield was recorded by Arnold and Ehogold, with 4.9 kg/ha, respectively.

All the varieties looked promising at the Borovce research station. Weed infestation was low. However, the varieties were more susceptible to disease. (Table 22). Most of them were affected by Septoria and Yellow rust, varieties Viki, Ehogold, and Arnold – had a score of 4. The harvest was done on 15 July 2023, and the yield data were collected and analysed. The best yield was achieved by Capo and Alessio, with 12.85 and 13.1 kilograms per plot respectively. The lowest yield was recorded for PS Dobromila and Arnold, with 11.1 and 9.93 kilograms per plot, respectively. Field trials in Biomila SK, s. r. o., SHR Martin Kolárik and SHR Vladimír Zeman: The weed infestation (*Tripleurospermum*

Funded by European Union
Horizon 2020
Grant agreement No 771367

inodorum, *Cirsium vulgare*, *Galium aparine*, *Equisetum arvense*, *Lamium purpureum*) reached up to 100% in some plots, and completely overtook the plants. Growth and development were severely hampered by the weed competition for light, water, and nutrients, and plants were stunted, thin, and pale, and had very low or no grain production. Due to this situation, it was impossible to conduct any evaluations of the trial's performance during July - September 2023. The weed biomass was too high to allow any measurements or observations. After discussing with the farmers, we agreed that the trials were impossible to harvest. The yield data would be unreliable and meaningless, as the plants were almost non-existent. The weed infestation also posed a risk of contamination and damage to the harvester.

Table 21 Disease evaluation *Tilletia caries*, *Tilletia controversa*, *Septoria tritici* and agronomic characters of plant height, lodging, and grain yield levels in the 2022-2023 season from farm SEMA HŠ s.r.o. in Sládkovičovo.

Variety name	*Tilletia caries*	*Tilletia controversa*	*Septoria tritici*	Plant height (cm)	Lodging	Grain yield (t/ha)
Alessio	1	1	1	130.4	1	6.03
Arnold	1	1	3	110.6	1	4.90
Aurelius	1	1	1	128.2	1	6.00
Ehogold	1	1	1	132	1	4.90
IS Laudis	1	1	1	125.8	1	5.20
Capo	1	1	1	123.2	1	6.80
Viki	1	1	3	101.2	1	6.50
PS Dobromila	1	1	1	124.60	1	6.20

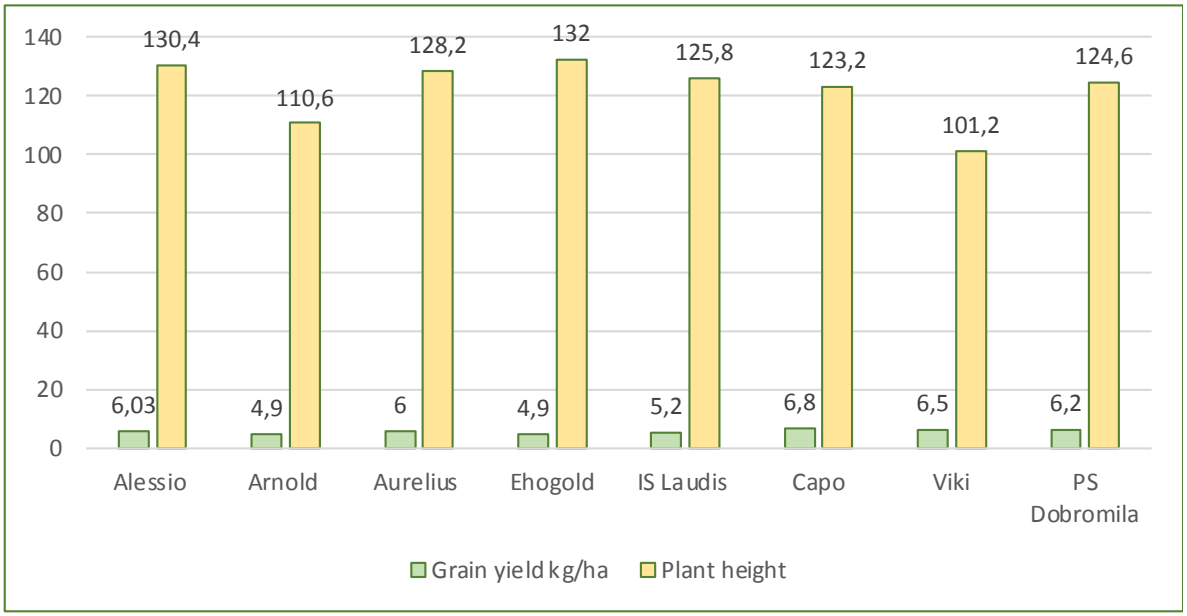


Fig 4 Plant height and grain yield of varieties in the season 2022-23 from the farm SEMA HŠ s.r.o. in Sládkovičovo.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 22 Disease evaluation *Tilletia caries*, *Tilletia controversa, Septoria tritici* and agronomic characters of plant height, lodging, and grain yield levels in the 2022-2023 season from Research station in Borovce.

Variety name	*Tilletia caries*	*Tilletia controversa*	*Septoria tritici*	Plant height (cm)	Lodging	Grain yield (kg/plot)
Alessio	1	1	3	119.2	1	13.1
Arnold	1	1	4	101.6	1	9.93
Aurelius	1	1	3	110	1	12.81
Ehogold	1	1	4	123	1	12.13
IS Laudis	1	1	3	107.6	1	11.32
Capo	1	1	3	114	1	12.85
Viki	1	1	3	87.4	1	11.51
PS Dobromila	1	1	3	111.4	1	11.1

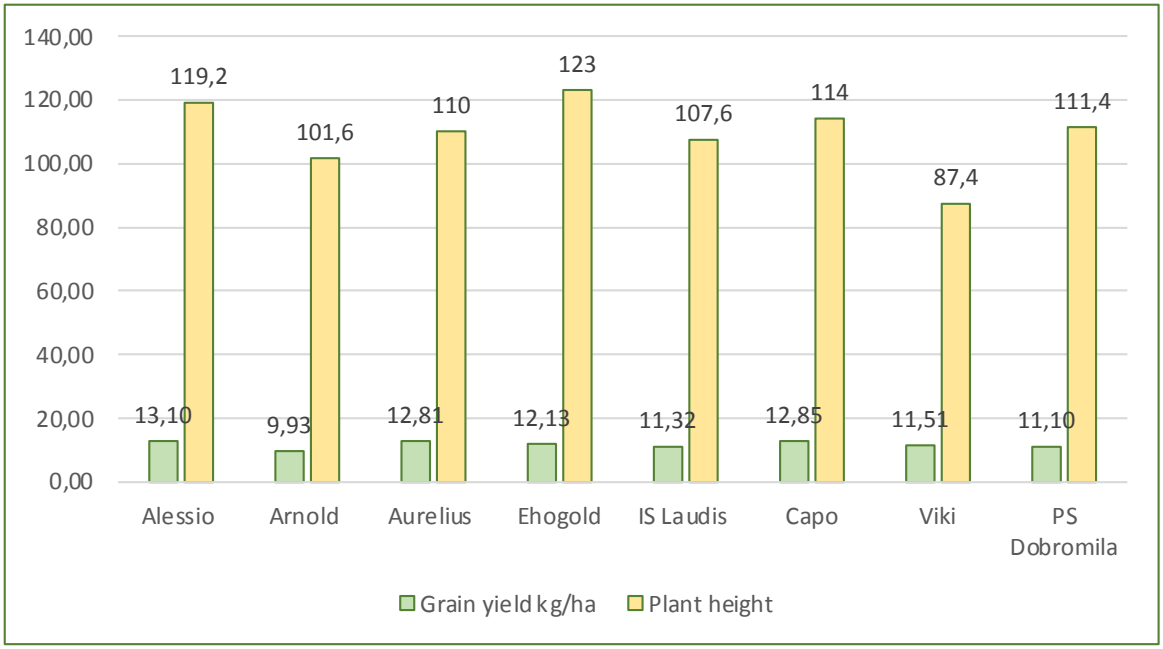


Fig 5 Plant height and grain yield of varieties in the season 2022-23 from Research station in Borovce.

Approximately 1kg of representative grain sample was used for moisture determination, and quality analyses (protein, moisture, starch, volume weight, sedimentation index, falling number, dry matter and nitrogen). Results of the analysis for starch, wet gluten, sedimentation index, volume weight, and protein are shown in Table 23 and Table 24.

The highest protein content was produced by variety Viki (13.0) at SEMA HŠ s.r.o. and the lowest by Aurelius (9.6) at the Research station in Borovce. The mean highest protein content was achieved at SEMA HŠ s.r.o. 12.1 % and the mean lowest at Research station in Borovce 10.3% (Table 23 and Table 24). The sedimentation value also showed the differences between the mean values of all trials. Values ranged from 45 ml (IS Laudis and Ehogold) at SEMA HŠ s.r.o. to 30 ml (Aurelius) at Research station in Borovce. The highest mean value was 41.75 ml at SEMA HŠ s.r.o. and the lowest at Research station in Borovce 35 ml (Table 23 and Table 24).

Funded by European Union
Horizon 2020
Grant agreement No 771367

The percentage of wet gluten was the highest at SEMA HŠ s.r.o. 26.5% (PS Dobromila) and the lowest at Research station in Borovce 18.5% (Aurelius), (Table 6 and Table 7).

The highest starch values were achieved at the Research station in Borovce (Ehogold) 63.7% and the lowest at SEMA HŠ s.r.o. (Capo) 60.7%. The variety with the highest test weight produced was PS Dobromila 83.8 kg/hl at Sema HŠ s.r.o. and the lowest Viki 78.0 kg/hl at Sema HŠ s.r.o.

Table 23 Values of indicators of quality characteristics of selected varieties in organic trials at the farm SEMA HŠ s.r.o. Sládkovičovo in growing season 2022/2023.

Variety name	Starch (%)	Wet gluten (%)	Sedimentation index	Test weight (kg/hl)	Protein (%)
Alessio	61.4	24.0	39	80.6	11.9
Arnold	61.6	22.9	39	79.5	11.2
Aurelius	62.1	23.2	40	82.6	11.1
Ehogold	61.3	25.5	45	83.3	12.2
IS Laudis	60.9	26.1	45	81.8	12.7
Capo	60.7	25.2	40	83.0	12.1
Viki	60.9	25.6	42	78.0	13.0
PS Dobromila	60.8	26.5	44	83.8	12.6

Note: Starch [%] calibrated by IS0 10520; Wet gluten [%] calibrated by ICC 155; Sedimentation index, calibrated by ISO 5529:2007; Volume weight (kg/hl) – bulk density ISO 7971-3: 2009; Falling number (s) ISO 3093: 2009; Protein (N% x 5.7) in dry matter (%), Dumas method

Table 24 Values of indicators of quality characteristics of selected varieties in organic trials at the Research station in Borovce in growing season 2022/2023.

Variety name	Starch (%)	Wet gluten (%)	Sedimentation index	Test weight (kg/hl)	Protein (%)
Alessio	62.6	19.6	32	80.8	10.4
Arnold	62.5	19.7	36	80.1	10.2
Aurelius	63.2	18.5	30	82.4	9.6
Ehogold	63.7	19.2	35	83.6	9.9
IS Laudis	62.9	19.4	35	82.2	10.1
Capo	62	21.2	34	83.6	10.9
Viki	60.1	19.2	36	78.6	10.6
PS Dobromila	62.5	22.7	42	82.7	11.3

Note: Starch [%] calibrated by IS0 10520; Wet gluten [%] calibrated by ICC 155; Sedimentation index, calibrated by ISO 5529:2007; Volume weight (kg/hl) – bulk density ISO 7971-3: 2009; Falling number (s) ISO 3093: 2009; Protein (N% x 5.7) in dry matter (%), Dumas method

Funded by European Union
Horizon 2020
Grant agreement No 771367

Fig 6 Participatory field trials in Slovakia.

Funded by European Union
Horizon 2020
Grant agreement No 771367

2.4 Wheat farmer participatory trials in Serbia

NS OBI-CCP was sown on Ignjat Jurišić's farm (45.05'33.4'' N, 19.41'04.7'' E), located in the village Šuljam (RS). Trial was consisted of 1 plot (plot=20x1 m), 10 rows. Sowing date was 02.11.2022 and Sowing was done in optimal time (HEGE sowing machine) with optimal sowing density for this region (500 seeds/m^2). Pre-crop was soybean. Yellow rust occurred, as this year (2023) it was a big problem in Serbia. NS OBI was harvested on July 18th using Wintersteiger harvester. After harvest, all data were collected and analysis was performed – results are available in data sheet (disease screening, sedimentation, falling number, protein etc.).

In 2023, NS OBI grain yield at location Šuljam was 3375 kg/ha (14% moisture) with protein content of 12.4% (DM). Estimated falling number was 335, sedimentation 27.0 ml with 25.3 % (DM) of wet gluten.

Fig 7 NS OBI-CCP 2023.

Funded by European Union
Horizon 2020
Grant agreement No 771367

2.5 Wheat farmer participatory plant breeding in Hungary

The Hungarian on-farm organic wheat trials started in autumn 2020 (see ECOBREED bulletin on participatory trials in 2021 and 2022). Winter wheat varieties and two populations (Mv Elit CCP, Mv Bio2020 Pop) were sent to organic farmers with the aim to start participatory testing (PVS: participatory variety selection) and breeding (PPB: participatory plant breeding) on their farms. Trials were run on 3 farms in 2021 completed with 2 additional farms from the following years, thus, besides the two Hungarian and one Slovakian locations (Szár, Füzesgyarmat and Zselíz), two other Hungarian farms at Kömlő and Tornyiszentmiklós (Organic Valley) were involved in the experiment also in 2023 (Fig 8). All farms are part of the on-farm trial network of ÖMKi (Hungarian Research Institute of Organic Agriculture), a research partner of ATK (Centre for Agricultural Research).

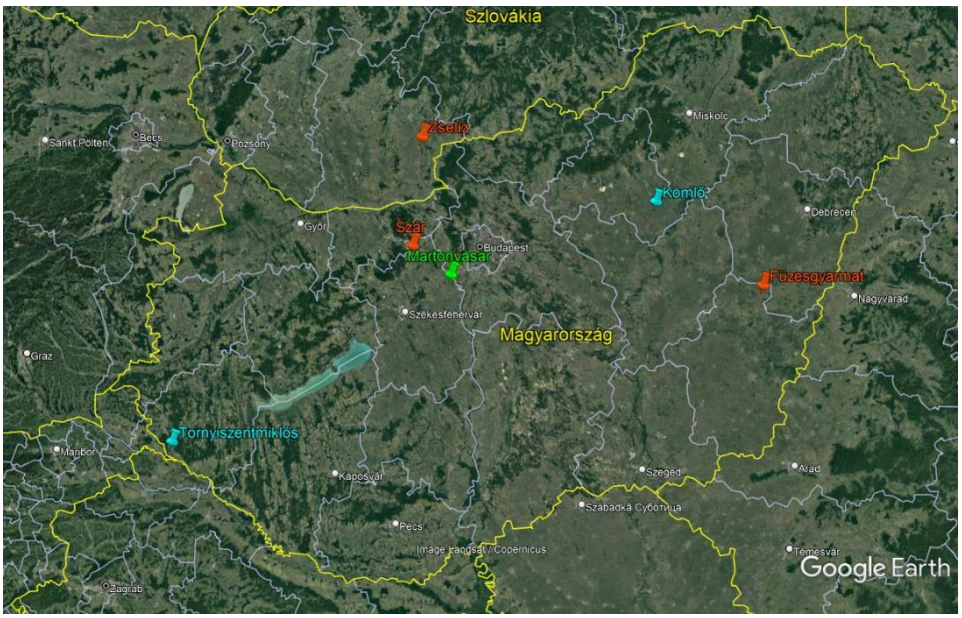


Fig 8 Locations of participatory plant breeding trials organised by ATK. Participating organic farms are in red (2021-2023) and blue (2022-2023), breeding station (ATK) in green.

Similar to previous years, cultivars were evaluated by farmers during the vegetation period in 2023. After farmer variety selection was carried out in 2022, further examination of 7 cultivars were finished and 3 new cultivars were put in the trial at Szár, while one cultivar less was examined on the other farms in 2023. Breeders from ATK visited the farms and they discussed the steps of observation, selection and harvest of trials with the farmers. Unlike during the year 2022, precipitation was not a limiting factor in 2023, but due to the mild winter and cool spring, fungal pathogens caused severe disease symptoms on plants. Especially, yellow rust was found to be the main factor in decreasing the green leaf area. All trials were harvested in time and near infrared (NIR) rapid quality measurement was performed on the harvested seed samples. Yield was determined from 5 random samples collected manually from 1m^2 areas of each medium sized plot on the farms. Trial on the farm near Szár had smaller plots and were harvested in total using a small plot combine harvester. Yield and quality

data for the 2023 on-farm trials are shown in Table 25 (medium sized plots) and Table 26/Fig 9 (small plots). Yield results of participatory trials are hard to be used for comparison, due to the different plot sizes and data types (estimated vs. actual yield), but they are useful to rank the tested cultivars within each farm.

In general, quality parameters were lower in the trials than in the previous drier year and only the site in Zselíz (SK) could produce milling quality wheat samples. On most farms, the variety Mv Pántlika has out-performed the trial average regarding all the measured parameters, except in Zselíz. This result is in line with that of the Hungarian post registration trial run for 3 years on 7 sites showing this variety to have outstanding yield and quality stability over the years. Based on the results of the on-farm non-replicated trials, the younger population, Mv Bio2020 Pop showed higher yielding ability than Mv Elit CCP, except on one of the farms, while its quality parameters were above the average for most of the farms (except in Zselíz). There were more cultivars under examination as part of ÖMKi's on-farm trial network, but the Mv cultivars performed near or even above the trial average of the given farm in 2023. Mv Elit CCP had the lowest grain yield with above average quality at Zselíz and Tornyiszentmiklós (Table 25).

Table 25 Agronomic results of Mv cultivars tested on 4 farms using medium sized plots (Hungary, 2023).

Site	Cultivar	Grain yield		Grain protein content		Gluten content		Test weight		Zeleny sedimentation	
		t/ha	% of trial avg.	%	% of trial avg.	%	% of trial avg.	kg/100 L	% of trial avg.	mL	% of trial avg.
Füzes-gyarmat	Mv Elit CCP	4.56	103	12.3	98	22.8	95	74	99	33	96
	Mv Bio2020 Pop	3.89	88	12.9	103	25.2	105	73	98	35	101
	Mv Tarsoly	4.44	100	11.9	95	22.8	95	73	98	31	90
	Mv Pántlika	5.55	126	13.2	105	25.4	106	75	100	37	107
	Mv Uncia	4.82	109	11.7	93	21.9	91	76	102	29	84
Zselíz	Mv Elit CCP	5.73	88	13.7	101	28.8	101	78	99	48	104
	Mv Bio2020 Pop	6.49	100	12.4	92	26.2	92	78	100	39	84
	Mv Tarsoly	6.28	96	14.9	110	32.1	112	76	97	55	117
	Mv Pántlika	6.27	96	13.5	100	28.4	99	78	100	46	99
Kömlő	Mv Elit CCP	3.38	88	10.8	96	19.9	92	80	98	30	91
	Mv Bio2020 Pop	3.99	104	11.4	102	22.0	102	80	98	32	98
Tornyi-szent-miklós	Mv Elit CCP	2.71	90	10.3	105	15.1	106	-	-	21	106
	Mv Bio2020 Pop	3.20	106	9.8	100	13.8	97	-	-	18	92

The small-plot PVS trial was harvested in Szár, and after the measurement of the harvested grains from the three replications, one-way ANOVA was carried out. In general, grain yield was almost half of that of the previous year, showing an average of 3.74 t/ha. A significant difference was not found between cultivars, because the standard deviation was too high. The two populations were below the trial average, showing similar yielding ability (Fig. 9).

Funded by European Union
Horizon 2020
Grant agreement No 771367

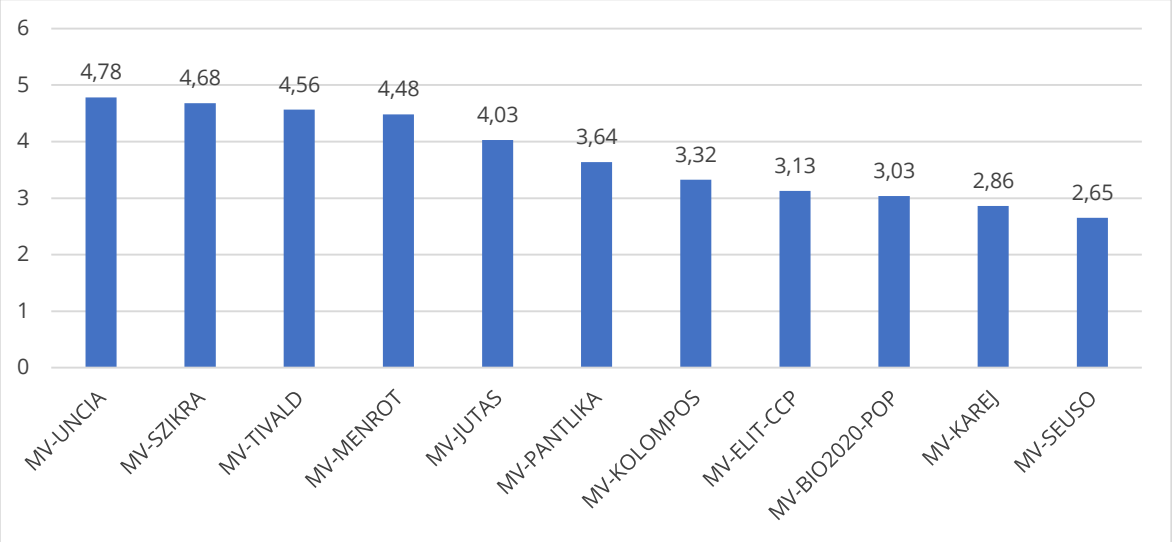


Fig 9 Grain yield (t/ha) of 11 Mv cultivars grown on organic replicated small plots (Szár, 2023).

Quality of cultivars tested at Szár was measured with a rapid (NIR) grain quality analyser. Quality parameters of the two populations harvested at Szár were not measured. Similar to the results of the medium plot trials, the variety, Mv Pántlika had the highest protein and gluten contents, so as Zeleny sedimentation volume, while its test weight was below the trial average. Most of the varieties with higher compositional quality had the lowest test weight, except for the variety Mv Ménrót, which was the third in the quality rank (having a slightly lower thousand grain weight). The second best quality Mv variety was Mv Kolompos, which was superior in most of the traits, except test weight (Table 9).

Table 26 Rapid (NIR) grain quality measurement data of winter wheat cultivars tested on replicated small plots at the organic field near Szár (Hungary, 2023).

Cultivar	Grain protein content (%)	Gluten content (%)	Zeleny sedimentation (mL)	Test weight (kg/100L)	Thousand grain weight (g)
MV-PANTLIKA	11.80	27.20	27.40	73.20	46.5
MV-KOLOMPOS	11.40	26.50	25.40	75.20	47.60
MV-MENROT	11.40	26.40	26.20	78	39.5
MV-UNCIA	11.30	25.30	23.70	77.40	42.1
MV-JUTAS	11.20	25.90	25.40	64.30	29.33
MV-SZIKRA	10.20	22	21	74.20	38.51
MV-KAREJ	10.10	22.90	19.50	79.50	41.34
MV-TIVALD	9.70	20.70	15.50	79.70	45.65
MV-SEUSO	9.30	20.20	14.10	73	37.46
Trial mean	10.7	24.1	22.0	74.9	40.9

Funded by European Union
Horizon 2020
Grant agreement No 771367

Our participatory plant breeding (PPB) program was started based on the two populations (Mv Elit CCP and Mv Bio2020 Pop) sown by farmers. Positive selection of spikes was performed on both populations by 3 farmers in 2021 (Fig. 10). Selected spikes were sent to ATK and threshed into 6 bulks resulting in 6 new sub-populations (based on the population and farm of origin).

Fig 10 Farmer is selecting his own spikes as a first step of participatory plant breeding (Szár, 2021).

The new sub-populations and the unselected ("original") populations were sown at two locations in October 2021 (on-station (Martonvásár, ATK) and on-farm (Szár, farmer)) in non-replicated, small-plot trials for multiplication and testing. After multiplication, replicated small plot trials were established for the growing season 2022/2023 in Martonvásár and Szár.

As yellow rust caused an epidemic in Hungary in 2023, all populations and their sub-populations were scored for their tolerance against this fungal disease at both locations. In general, the younger populations, Mv Bio2020 Pop (and its sub-populations) showed higher sensitivity to yellow rust than Mv Elit CCP and its sub-populations, except for the sub-population selected in Szár, which was infected similarly. Average heading date of the sub-populations was like their original populations, except for the sub-population of Mv Bio2020 Pop selected at the two Hungarian sites that showed slight improvement in earliness. In the case of plant height, similar trend could be detected as in the last year: the sub-populations selected in Zselíz were the tallest, followed by the sub-populations of Füzesgyarmat. At the same time, the farmer in Szár preferred more the shorter plants, thus the height of his sub-populations was similar to that of the mother populations (Table 27).

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 27 Assessment data and grain yield of PPB sub-populations developed by the participating farmers and grown in organic fields of ATK (on-station) and Szár (on-farm) (Hungary, 2023).

Subpopulation	Farm of origin	Yellow rust symptoms (1-9; 1=resistant)			Heading date (1=1st May)			Plant height (cm)			Grain yield (kg/6m^2)		Grain yield (t/ha)	
		on-station	on-farm	avrg.	on-station	on-farm	avrg.	on-station	on-farm	avrg.	on-station	on-farm	avrg.	Rank
MV-BIO2020-POP-FGY	Füzes-gyarmat	3	5	4	15	15	15	103	102	103	4.84	2.17	5.85	1
MV-BIO2020-POP-SZR	Szár	4	4	4	15	16	16	98	92	95	4.71	2.15	5.72	2
MV-BIO2020-POP-ZS	Zselíz	3	6	4.5	17	17	17	107	105	106	4.86	1.90	5.64	3
MV-BIO2020-POP	ATK	4	5	4.5	17	17	17	100	98	99	4.83	1.82	5.55	4
MV-ELIT-CCP	ATK	2	3	2.5	19	18	19	98	92	95	4.67	1.88	5.46	5
MV-ELIT-CCP-FGY	Füzes-gyarmat	4	2	3	19	19	19	100	99	100	4.46	1.79	5.21	6
MV-ELIT-CCP-SZR	Szár	7	2	4.5	19	19	19	97	96	97	4.44	1.74	5.15	7
MV-ELIT-CCP-ZS	Zselíz	2	4	3	19	18	19	110	107	109	3.05	0.65	3.08	8

Based on the average of the 2 sites, only the sub-populations of Mv Bio2020 Pop could yield more than the original population, while the original Mv Elit CCP had higher yield than its sub-populations. As one of the sites was also the place of farmer selection, farmer improvement could be also evaluated in the case of the sub-populations selected in Szár and examined in Szár. Based on this, it can be concluded that yielding ability of Mv Elit CCP has decreased by 7.5%, while this trait was improved by 18.1% in the case of the other, more diverse population (Table 27 and Table 28).

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 28 Analysis of variance of the grain yield of 2 winter wheat populations and their sub-populations developed by the participating farmers and grown in organic fields of ATK (on-station) and Szár (on-farm) (Hungary, 2023).

2-factor ANOVA, randomised block design

Year	Trial	Location	Genotypes	Repl.
2023	BIOFK	2	8	3

Trial mean: 5,21 t/ha

Cultivar	MV	Szár	Mean yield (t/ha)	Deviation from trial mean (%)	Rank	MV-rank	Szár-rank	CV%
MV-BIO2020-POP-FGY	8.07	3.62	5.85	112.3	1	2	1	42.9
MV-BIO2020-POP-SZR	7.85	3.59	5.72	109.8	2	4	2	43.9
MV-BIO2020-POP-ZS	8.11	3.17	5.64	108.3	3	1	3	47.5
MV-BIO2020-POP	8.06	3.03	5.55	106.5	4	3	5	46.8
MV-ELIT-CCP	7.79	3.13	5.46	104.8	5	5	4	47.8
MV-ELIT-CCP-FGY	7.44	2.99	5.21	100.1	6	6	6	43.8
MV-ELIT-CCP-SZR	7.40	2.90	5.15	98.8	7	7	7	46.1
MV-ELIT-CCP-ZS	5.09	1.08	3.08	59.2	8	8	8	47.8

Least significant difference between genotypes

LSD (P=5.0%)=	0.26	4.99%
LSD (P=1.0%)=	0.35	6.71%
LSD (P=0.1%)=	0.46	8.90%

Factor	SSQ	df	MSQ	F	
Total	287	47			
Replication	0	2			
Treatment	281	15	18.752	96.7	***
Genotype (A)	33	7	4.754	24.5	***
Location (B)	247	1	246.832	1273.0	***
AXB	1	7	0.167	0.9	
Error	6	30	0.194		

Least significant difference between any two combinations

LSD (P=5.0%) =	0.73	14.10%
LSD (P=1.0%) =	0.99	18.99%
LSD (P=0.1%) =	1.31	25.18%

STANDARD ERROR: 0.360

*/**/*** : P=5% / P=1% / P=0.1%

As the participatory trials on populations were re-sown for four years, severe bunt infection could be detected during the latest harvest, i.e. in 2023. Therefore, all harvested seed samples had to be destroyed to avoid contamination of the cereal

quality laboratory of Martonvásár and the trial fields of the next season, thus harvested seeds were not analysed for quality parameters.

Similarly to the previous years, our participatory trials, their results and ECOBREED project were presented at the Hungarian Organic Field Day in June 2023 at Szár (Fig. 11). The demonstration event was co-organised by ÖMKi and ATK.


Fig 11 Organic Field Day at Szár, 21 June 2023.

2.6 Wheat farmer participatory trials in Slovenia

2.6.1 Methods

The winter wheat (*Triticum aestivum* L.) farmer participatory field trial in Slovenia was established on an organic field at the testing station of the Agricultural Institute of Slovenia, in Jablje (46°08'37.3" N, 14°34'39.2" E; 320 m a.s.l., sub-alpine climate). The soil type in this trial was Umbrian planosol, characterised by a silt loam texture.

Like previous years, researchers and variety experts selected a total of 22 cultivars, encompassing both domestic and international varieties, for evaluation. The selection criteria for these cultivars were centred around their specific traits suitable for organic cultivation and their demonstrated performance in various organic and low-input trials. Slovenian experts opted for varieties such as Ingenio, Savinja, Tata mata, Reska, Primorka, Marinka, Illico, Izalco CS, Gorolka, Vulkan, and Nexera. Meanwhile, within the ECOBREED project, the chosen varieties included Liocharis population, Arnold, Capo, Aurelius, Albertus, IS Laudis, Purino, Viki, Wendelin, Edelman, and Ehogold.

The experimental plots underwent conventional tillage, involving 25 cm deep ploughing followed by seedbed preparation through cultivation. Crop rotation at the site involved a three-year cycle of maize, winter wheat or winter spelt and spring peas. Prior to seeding, weed control was implemented using the stale seedbed method. Two distinct trials were established based on the selection of cultivars (Slovenian or ECOBREED selections).

Cultivars were seeded on 26 October 2022 at a density of 400 viable seeds/m^2, using a Wintersteiger experimental plot seeder. Design of the experiments was a randomised block with four replications. Size of the plot was 7.5 m^2 (6 x 1.25 m). During the vegetation period a total of 63 kg N/ha was added, using the organic fertiliser Azocor 10.5% at the tillering and stem elongation phases. No mechanical weed control,

Funded by European Union
Horizon 2020
Grant agreement No 771367

fungicides or insecticides were applied during growth. Weeds were manually weeded two times during the spring.

Several traits were evaluated to evaluate the development and agronomic performance of the cultivars, including the date of heading, number of heads, plant height (cm), canopy, lodging susceptibility, identification and scoring of diseases and pests, grain yield (kg/ha), grain moisture at harvest (%), and test weight (kg/hl). Plant height was measured on ten randomly selected individual plants within each plot before harvesting. Ground cover (canopy), lodging susceptibility, diseases and pests were assessed using a 1–9 scale, where a score of 1 indicated low prevalence/susceptibility. Ground cover was estimated at the full flowering stage, whereas diseases and pests were evaluated both at the full flowering stage and late milk stages. At full maturity, the trials were harvested using a Wintersteiger Nursery Master plot harvester. Approximately 1 kg of representative grain samples underwent moisture determination and quality analyses. The Infratec Nova NIR analyser was used to analyse moisture, protein, starch, and wet gluten contents, while sedimentation values were determined using the Zeleny sedimentation test.

2.6.2 Results

The weather conditions during autumn and winter were favourable for the beginning of growth and development of winter wheat. However, drought in February and dry beginning and wet summer were not optimal conditions for the crop. Precipitations were 1122mm from October to July, +33mm compared to 2020/2021, +495mm 2021/2022. One third of precipitation was on the last two months in summer (Table 29 and Figure 12).

Table 29 Temperature and cumulative monthly precipitation from sowing to harvest in the 2022/23 growing season at Jablje.

Season 2022/23	Temperature min (°C)	Temperature max (°C)	Precipitation (mm)
October	7	19.7	62
November	2.7	10.3	85
December	-0.3	5.4	159
January	-1.9	5.4	153
February	-4.4	7.6	6
March	0.7	12.7	70
April	2.3	14.8	93
May	9	19.5	114
June	12.8	25.5	134
July	14.9	27.2	246
Average/Average/Sum	4.3	14.8	1122

Funded by European Union
Horizon 2020
Grant agreement No 771367

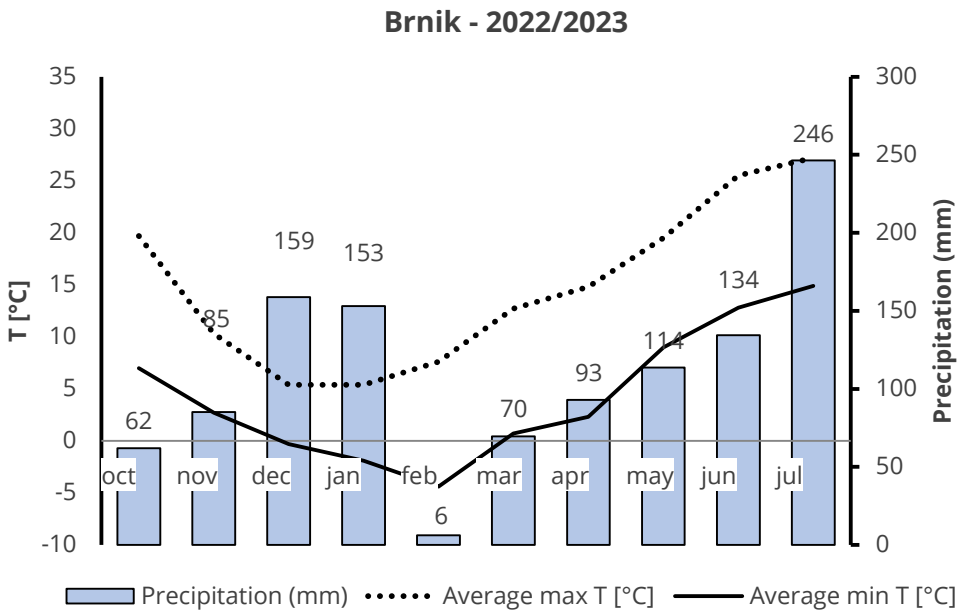


Fig 12 Weather conditions during the season 2022/23 data for Brnik (weather station at Airport Jože Pučnik, Slovenia).

The results of plant height are presented in Fig 13. Cultivars highlighted in green exhibited greater height compared to the average height within their respective trials. The average plant height in the initial trial measured 98 cm, while in the second trial, it reached 104.7 cm. In the first trial, plant height varied from 81 cm (Ingenio) to 117 cm (Marinka). In the second trial, plant height ranged from 92 cm (Viki) to 118 cm (Liocharls). Notably, the cultivars with the tallest plants were Liocharls, Capo, Illico, Wendelin, Ehogold in Aurelius.

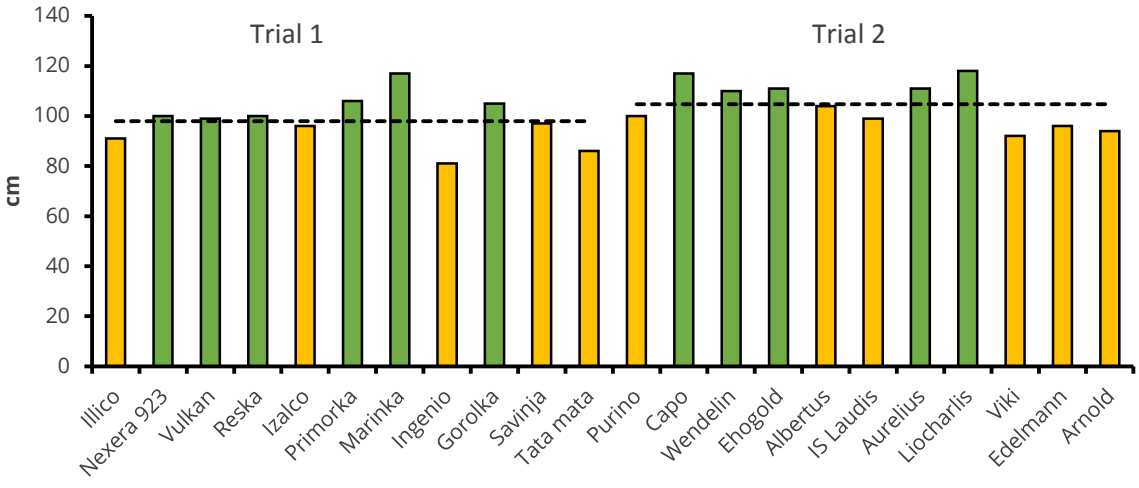


Fig 13 Plant height of the individual cultivars (columns) and trial average (dotted line) in organic trials at Jablje in growing season 2022/23.

Differences in ground cover between cultivars were evident, while no differences in lodging tolerance were observed (Fig 13 and Table 30). Assessments of ground cover, evaluated on a 1-9 scale (where 9 indicated the highest coverage), revealed an average

Funded by European Union
Horizon 2020
Grant agreement No 771367

cover 6.5 (respectively 6.3 for Trial 1 and 6.7 for Trial 2 The ground cover of different cultivars ranged from 6 (Illico, Nexera 923, Vulkan, Marinka, Ingenio, Gorolka, Savinja, Tata mata) to 7 (Reska, Izalco, Primorka) in Trial 1. In Trial 2, it also ranged from 6 (Capo, Ehogold, Albertus) to 7 (Purino, Wendelin, IS Laudis, Aurelius, Liocharls, Viki, Edelmann, Arnold). 50% of cultivars had ground cover equal to 7.

Table 30 Estimates of ground cover and lodging tolerance of selected cultivars in organic trials at Jablje in growing season 2022/23 using the 1-9 scale.

Cultivar	Ground cover	Lodging	Cultivar	Ground cover	Lodging
Illico	6	1	Purino	7	1
Nexera 923	6	1	Capo	6	1
Vulkan	6	1	Wendelin	7	1
Reska	7	1	Ehogold	6	1
Izalco	7	1	Albertus	6	1
Primorka	7	1	IS Laudis	7	1
Marinka	6	1	Aurelius	7	1
Ingenio	6	1	Liocharls	7	1
Gorolka	6	1	Viki	7	1
Savinja	6	1	Edelmann	7	1
Tata mata	6	1	Arnold	7	1
Average	**6.3**	**1**	**Average**	**6.7**	**1**

Septoria tritici was the most prevalent disease observed in the trials (Fig 14). No difference in the prevalence of the disease between the trials was observed (estimates of 4.1 in both trials), while individual cultivars had differences in tolerance. In Trial 1 estimates of *Septoria tritici* ranged from 2.0 (Vulkan) to 6.0 (Izalco and Ingenio) and in Trial 2 estimates ranged also from 2.0 (Edelmann) to 6.0 (Viki, Liocharls). Cultivars Vulkan and Edelmann appeared to have higher tolerance to *Septoria tritici*. *Septoria nodorum* was noticed in both trials, no difference for average, 2.1 for both trials. In Trial 1 estimates of *Septoria nodorum* ranged from 1.0 (Vulkan, Marinka, Ingenio, Savinja) to 5.0 (Izalco) and in Trial 2 estimates ranged also from 1.0 (Wendelin, Liocharls, Edelmann, Arnold) to 5.0 (Viki). Presence of steam and leaf rust were scored 1 in both trials for all cultivars. Fusarium was present in both trials, it scored from 1 to 3 (Izalco, Primorka in Trial 1; Viki and Albertus in Trial 2), average score was 1.7 for both trials. The cereal leaf beetle (*Oulema melanopus*) was not problematic. All selected cultivars had a score of 2.0 (except Tata mata which scored 1). Average was 1.9 for Trial 1 and Trial 2. Aphids were generally present on all cultivars, without variation between cultivars.

Funded by European Union
Horizon 2020
Grant agreement No 771367

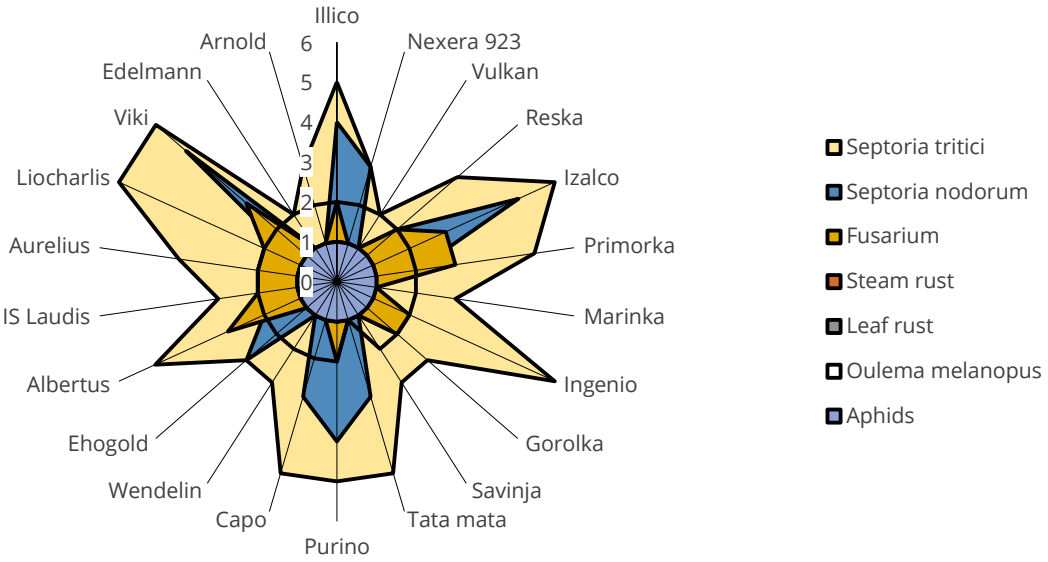


Fig 14 Scores for disease and pest prevalence for selected cultivars in organic trials at Jablje in growing season 2022/23.

Grain yields with 14% moisture are shown in Fig 15. Cultivars chosen within the ECOBREED initiative showed lower average yields. The average grain yield in Trial 1 reached 4907 kg/ha, while in Trial 2 it amounted to 4566 kg/ha. Notably, this marks the first time in testing, where the Slovenian-selected cultivars achieved a better average yield compared to the ECOBREED-selected cultivars, a departure from the trend observed in the previous two seasons (Table 31).

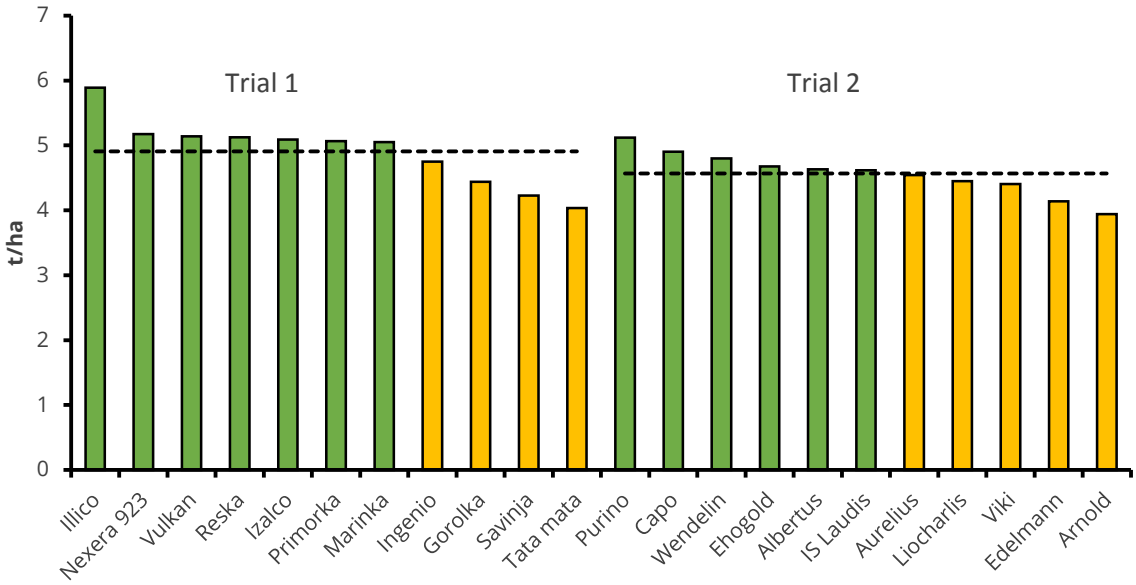


Fig 15 Grain yield of the individual cultivars (columns) and trial mean (dotted line) in organic trials at Jablje in growing season 2022/23. Yields of cultivars marked with green colour were higher compared to the average height of the specific trial.

Funded by European Union
Horizon 2020
Grant agreement No 771367

There was smaller variation among the cultivars in Trial 2 compared to cultivars in Trial 1. Comparing cultivars in Trial showed average grain yields ranging from 4033kg/ha (Tata mata) to 5891kg/ha (Illico), while in Trial 2 average grain yields ranged from 3942kg/ha (Arnold) to 5121kg/ha (Purino). The highest yielding cultivars were Illico (5890 kg/ha), Nexera 923 (5173 kg/ha), Savinja (5140kg/ha), Reska (5124kg/ha), Purino (5121kg/ha). The lowest were Arnold (3942kg/ha), Tata mata (4033kg/ha), Edelmann (4138kg/ha), Savinja (4226kg/ha).

Table 31 Average yield of winter wheat in Trial 1 and Trial 2 at Jablje for last 3 seasons 2020/21, 2021/22, 2022/23.

	Trial 1 (kg/ha)	Trial 2 (kg/ha)
2020/2021	4923	5781
2021/2022	5124	6231
2022/2023	4907	4565
Average	**4985**	**5398**

The results of the analysis for test weight, protein content, sedimentation value, gluten and starch are given in Table 32. Average test weight was higher in Trial 2 (78.9 kg/hl) and ranged from 74.0 kg/hl (Viki) to 82.0 kg/hl (Capo). In Trial 1, test weight ranged from 71.2 kg/hl (Ingenio) to 82.4 kg/hl (Gorolka). Cultivars with the highest test weight were Gorolka and Capo. Average protein content was higher in Trial 1 (11.4%) compared in Trial 2 (10.9%). In Trial 1 protein content ranged from 9.5% (Illico) to 13.2% (Savinja) while in Trial 2 ranged from 9.9% (Purino) to 12.2% (Albertus). The dilution effect of protein content with higher dry matter production can be noticed with the highest yielding cultivars showing the lowest protein content (Fig 6).

Sedimentation values showed difference between the average values 35 ml and 32 ml for Trial 1 and Trial 2 respectively. Values ranged from 26 ml (Illico) to 47 m (Savinja) in Trial 1 and from 26 ml (Purino) to 42 ml (Albertus) in Trial 2. Cultivars with the highest sedimentation value were Savinja, Izalco, Albertus and Tata Mata, while cultivars with higher grain yield were generally showing the smallest sedimentation value.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 32 Test weight, content of protein, sedimentation value, percentage of wet gluten, and percentage of starch in grains of selected cultivars in organic trials at Jablje in growing season 2022/23.

Cultivar	Test weight Kg/hl	Protein content %, DM	Sedimentation value ml	Wet gluten %	Starch %, DM
Illico	76.0	9.5	26	17.1	71.8
Nexera 923	78.9	10.0	29	20.4	72.3
Vulkan	77.6	11.1	31	21.6	71.3
Reska	78.3	11.6	35	23.6	70.9
Izalco	78.8	13.1	43	26.8	70.5
Primorka	76.5	10.8	30	20.9	70.4
Marinka	75.6	10.6	31	20.4	70.2
Ingenio	71.2	11.0	31	21.9	68.8
Gorolka	82.4	12.0	37	24.4	70.6
Savinja	76.3	13.2	47	27.0	68.3
Tata mata	79.3	12.9	41	26.7	69.7
Average	77.4	11.4	35	22.8	70.5
Purino	74.9	9.9	26	18.5	71.0
Capo	82.0	11.0	33	22.5	72.3
Wendelin	80.3	11.4	32	23.0	69.8
Ehogold	81.4	10.2	28	20.7	73.1
Albertus	80.5	12.2	42	25.3	70.9
IS Laudis	78.6	10.3	28	19.8	71.3
Aurelius	79.8	10.5	30	21.6	72.1
Liocharls	78.4	11.0	31	22.0	71.3
Viki	74.0	10.9	30	20.4	68.8
Edelmann	80.1	11.5	34	22.6	71.4
Arnold	77.6	11.4	34	22.1	69.0
Average	78.9	10.9	32	21.7	71.0

Percentage of wet gluten ranged from 17.1% (Illico) to 27% (Savinja) in Trial 1, and from 18.5% (Purino) to 25.3% (Albertus). Percentage of starch generally showed smaller variation than other quality traits and ranged from 68.3% (Savinja) to 72.3% (Nexera 923) in Trial 1, and from 68.8% (Edelmann) to 73.1% (Ehogold).

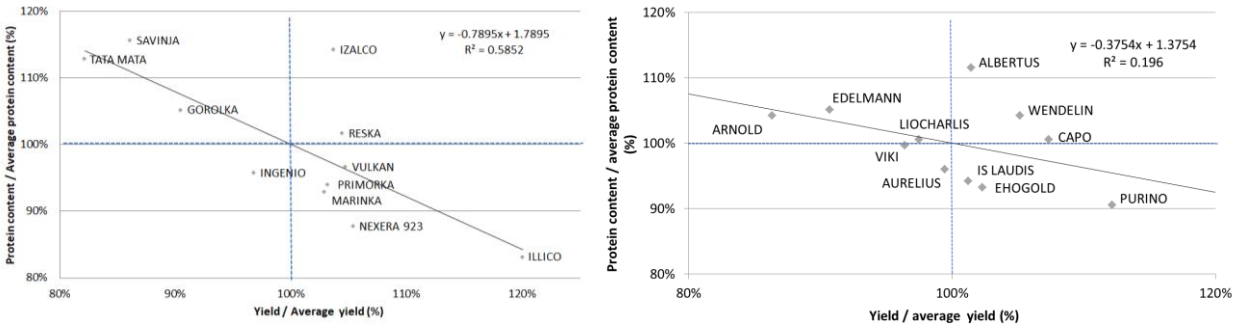


Fig 16 Comparison of selected cultivars by yield and protein content in Trial 1 (left) and Trial 2 (right) at Jablje in growing season 2022/23.

Funded by European Union
Horizon 2020
Grant agreement No 771367

2.7 Durum wheat farmer participatory trials in Italy

Seeds of ten accessions were distributed to Aquilani farmer in Montalto di Castro, and to Pagliaccia in Montefiascone.

The accessions were:

ID	Genotype
1	Sebatel
2	Pelsodur
3	IcaJin
4	HFN94n
5	S.Capelli
6	Azeghar
7	Vulci
8	Lunadur
9	MVTD15-19
10	mix pop

The farmer Pagliaccia in Montefiascone had some personal problems related to the weather conditions, so he was not able to sow the seeds until the end of March; the seeds given to him were returned as sowing so late would not give a useful result.

In the field located at Montalto di Castro 10 selected genotypes were sown at the end of December 2022. 3.5 kg of seed for each variety was sown in strip plots at the seed density normally used by each farmer. During the period from April to June, each plot was evaluated for traits such as growth-stage, lodging, and pathogen-resistance.

Table 33 Evaluation of 10 selected genotypes.

ID	Genotype	stage	longing	pathogens
1	Sebatel	55	No	No
2	Pelsodur	51	No	No
3	IcaJin	58	No	No
4	HFN94n	57	No	No
5	S.Capelli	37	No	No
6	Azeghar	59	No	No
7	Vulci	36	No	No
8	Lunadur	35	No	No
9	MVTD15-19	35	No	No
10	mix pop	51	No	No

Funded by European Union
Horizon 2020
Grant agreement No 771367

3 Potato

3.1 Potato farmer participatory trials in Hungary

3.1.1 Methods: Locations and conditions of trials

In 2023 the farmer participatory trial program WP 6.2 and WP.6.3 within the ECOBREED project was conducted on organic farms (Rábcakapi, Zalavár, Szakály) which are located in 3 different counties (Vas county, Zala county, Győr-Moson-Sopron county). Altitude of these farms (experimental locations) is between 115m and 200m above sea level (Fig 17).

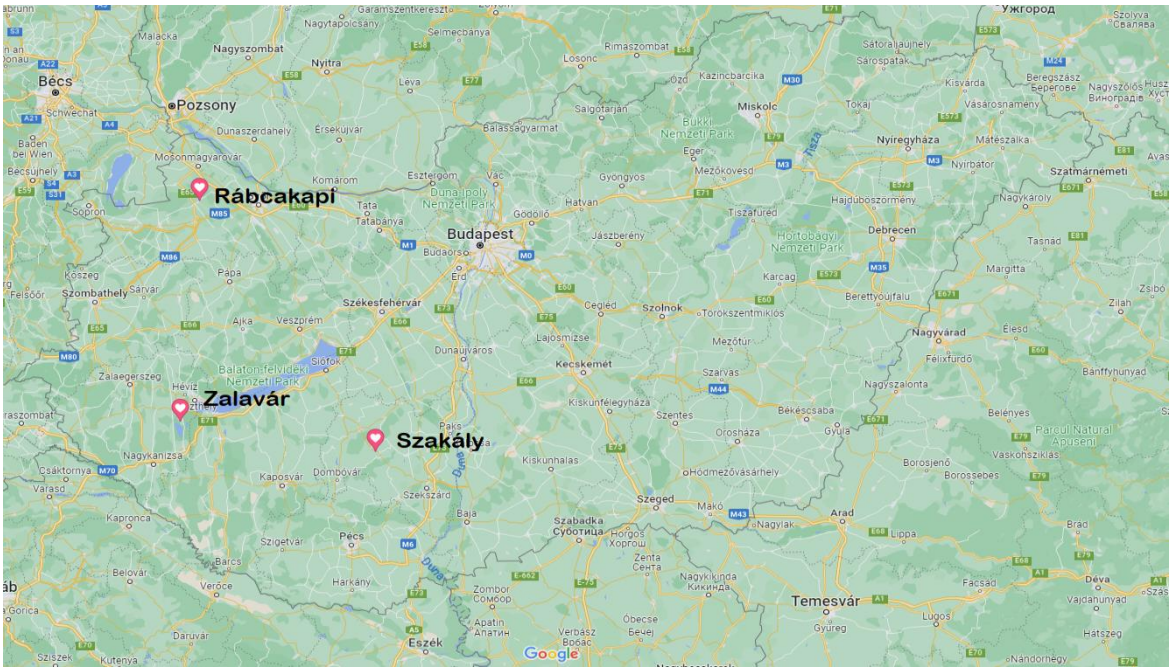


Fig 17 Locations of potato trials.

3.1.2 Participatory field trials:

Conditions of trial: Trials was set at location Rábcakapi. The selection of 6 varieties (Table 34) was done by researchers, farmers and consultants based on results of the previous years trials. The objective was to obtain a panel of varieties with different properties according to yieldpotential, earliness, resistance to late blight and PVY, end use, skin and flesh colour and other preferred characteristics.

Table 34 List of potato varieties in Hungary.

Variety	Maturity	Resistance to late blight
Alouette	intermediate	yes
Kis Kokra	intermediate	yes
Balatoni rózsa	early	no
Balatoni Sárga	intermediate	medium
Botond	early	medium
Basa	intermediate	medium

Funded by European Union
Horizon 2020
Grant agreement No 771367

A set of criteria has been developed by researchers and farmers/consultants to compare varieties on different sites with different management practices: planting date, planting density, date of emergence (BBCH 009), date of canopy closure (BBCH39), date of senescence (BBCH 91), plant height, late blight and early blight severity of symptoms, severity of black scurf (*Rhisoctonia*) symptoms, Silver scurf and Fusarium symptoms, Colorado potato beetle damage, yield, tuber size, dry matter, starch content, cooking type, taste discoloration of flesh after cooking, tuber disorders, regularity of tuber shape, depth of eyes. The planting was done on 6th of April by hand. Fertilisation, weed and pest management were done by farmers according to their organic farming protocol.

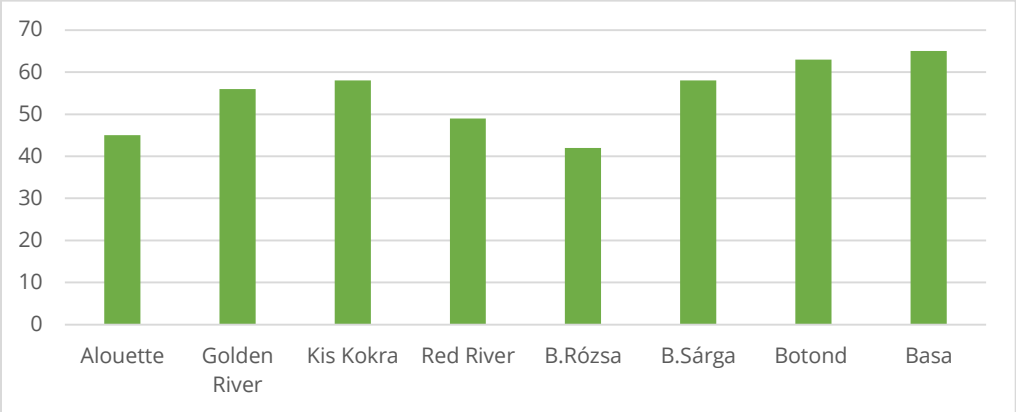
In Hungary, precipitation in 2020, 2021 and 2022 was lower than the long-term average. In 2023, this trend continued with about 40% less precipitation than the long-term average. From the beginning of the summer a high degree of drought was characteristic, which peaked in the second half of July. On several occasions, maximum daily temperatures reached 35 degrees Celsius or more. The location of Rábcakapi in terms of soil type and average precipitation is characterised as good conditions for organic production.

3.1.3 Results

The dry conditions of 2023 in general, like previous years were unfavourable for yield, tuber size and quality of potato. Colorado potato beetle was present but could be effectively managed by spraying twice with organic insecticide LASER PLUS. Weeds were present especially during the third decade of vegetation period but not noticed as a significant problem by the farmer. PVY infection was observed on all plants of the susceptible variety Alouette, but not on any other varieties. Different levels of early blight and late blight infections were observed on all 6 varieties.

3.1.3.1 Plant height

Varieties differed based on their bush type and plant height. Longest shoots were measured for the two varieties with erect type, Botond (early maturing) and Basa (mid late maturing). The early maturing variety Balatoni rózsa had the more compact bush type and shortest veins (Fig 18). Comparing the varieties based on their bush type, length of shoots and total yield we can state that there was no correlation among bush type, length of shoots and yield productivity.



Funded by European Union
Horizon 2020
Grant agreement No 771367

Fig 18 Average plant height (cm) of potato varieties.

3.1.3.2 Yield

Variety yields are shown in Figure 19. The highest yields were from early varieties (Balatoni rózsa, Botond and Red River, 42.2, 38.8 and 38.6 t/ha respectively). The lowest yield was from the variety Alouette (28.3 t/ha), most probably due to its virus susceptibility (Fig 19). The newest candidate variety from the Potato Research Station, MATE reached 35.2 t/ha yield. The average yield of the varieties was 35.1 t/ha – considering the difficult weather conditions of the season, the owner of the farm was satisfied with the yields he achieved.

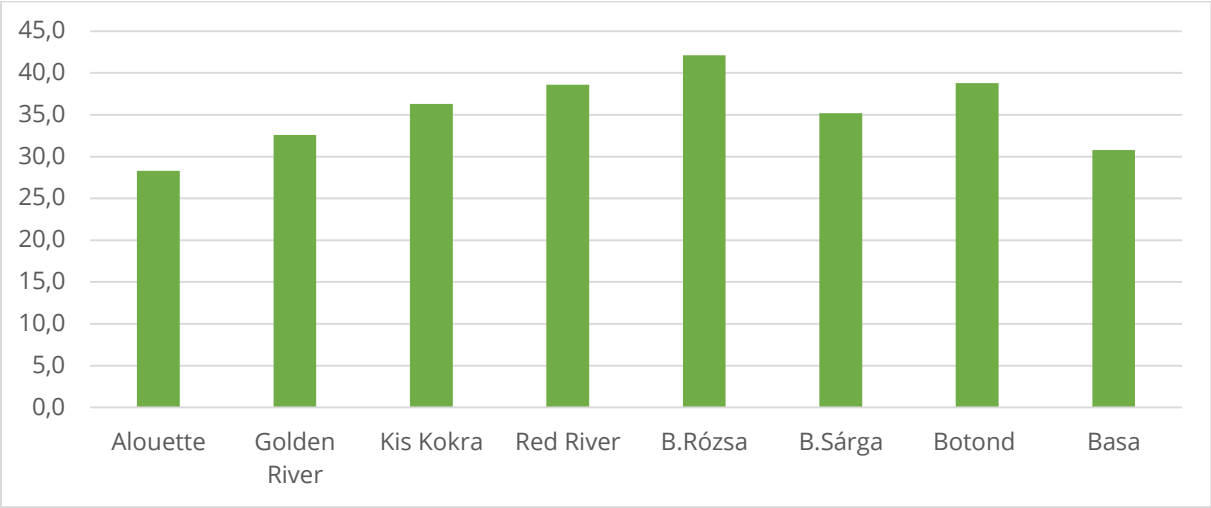


Fig 19 Yield of potato varieties (t/ha).

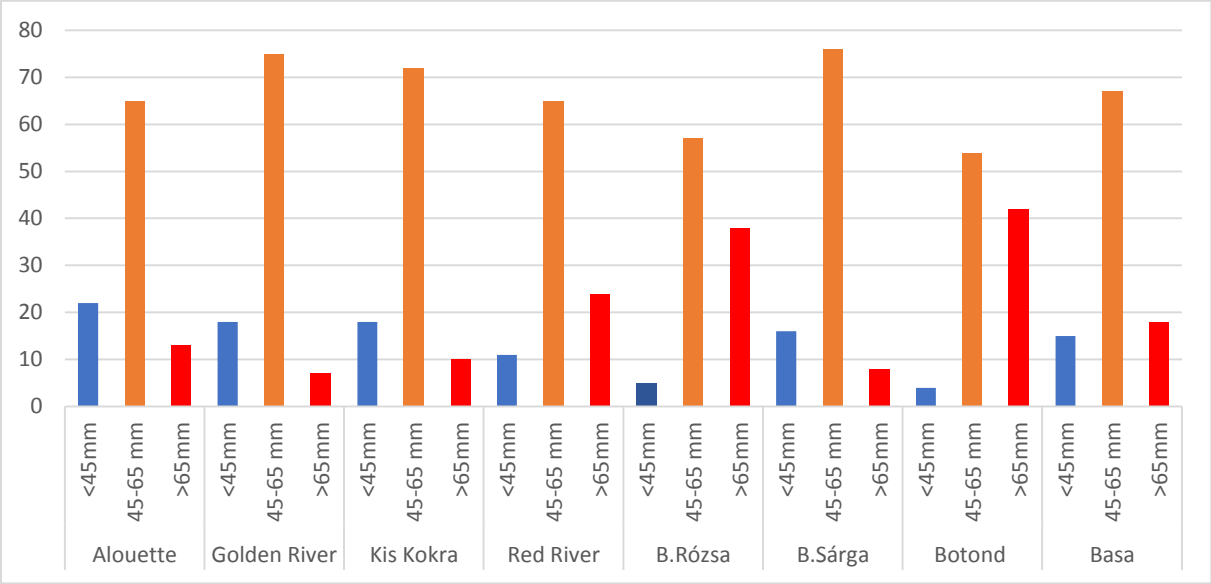


Fig 20 Summary of the distribution of tuber size of tested varieties.

The highest ratio of large size tubers was produced by the early maturing varieties Balatoni rózsa and Botond (38 and 42 %) fallowed by Red river (24 %). Golden River, Kis Kokra, Balatoni sárga and Basa produced the highest ratio of medium sized tubers, ideal for packaging.

Funded by European Union
Horizon 2020
Grant agreement No 771367

3.1.3.3 Tuber characteristics

Summary of different tuber traits are presented in Table 35.

Table 35 Data representing different tuber traits of tested varieties.

Rabcakapi	Tested varieties							
	Alouette	**Golden River**	**KIS Kokra**	**Red River**	**B.Rózsa**	**B.Sárga**	**Botond**	**Basa**
Stach content %	12.08	13.33	11.06	9.08	10.14	12.42	11.74	11.01
Cooking type	B/C	B/C	B	B	B	B/C	Botond	A
Taste	5	1	2	2	2	1	3	1
Regularity of tuber shape	6	8	6	8	7	7	7	8
Depth of eyes	7	9	7	8	7	8	7	9
Tuber size	6	5	6	7	8	5	6	5
Cooked discoloration	2	1	3	2	2	1	2	1
Raw discoloration	2	1	2	2	1	1	2	1

Starch content of varieties ranged between 9.08 % (Red river and) 12.42 % (Balatoni sárga). Most irregular shaped tubers were found in the yield of Alouette and Kis Kokra. The most stable tuber shape (8) was detected for Golden River, Red river and Basa. In terms of tuber eye depth all the varieties had great score 7-9. Best tuber size uniformity was found for Balatoni rózsa, while the worst for Alouette and Botond.

All the tested varieties had good or excellent tuber quality in terms of raw and after cooking discoloration. Scores ranged between 1 or 2 with one exemption, Kis Kokra showed somewhat higher cooked discoloration (score 3) then the other varieties.

Scoring of plants for the incidence of early blight and late blight infection took place one time during the season (mid-July for late blight and early August for late blight). Due to regular needs of irrigation and despite copper-based prevention both pathogens infected the varieties, but at different level and in different part of the season. Early blight infection became more serious closer to start of senescence. Results are showed in Figure 21.

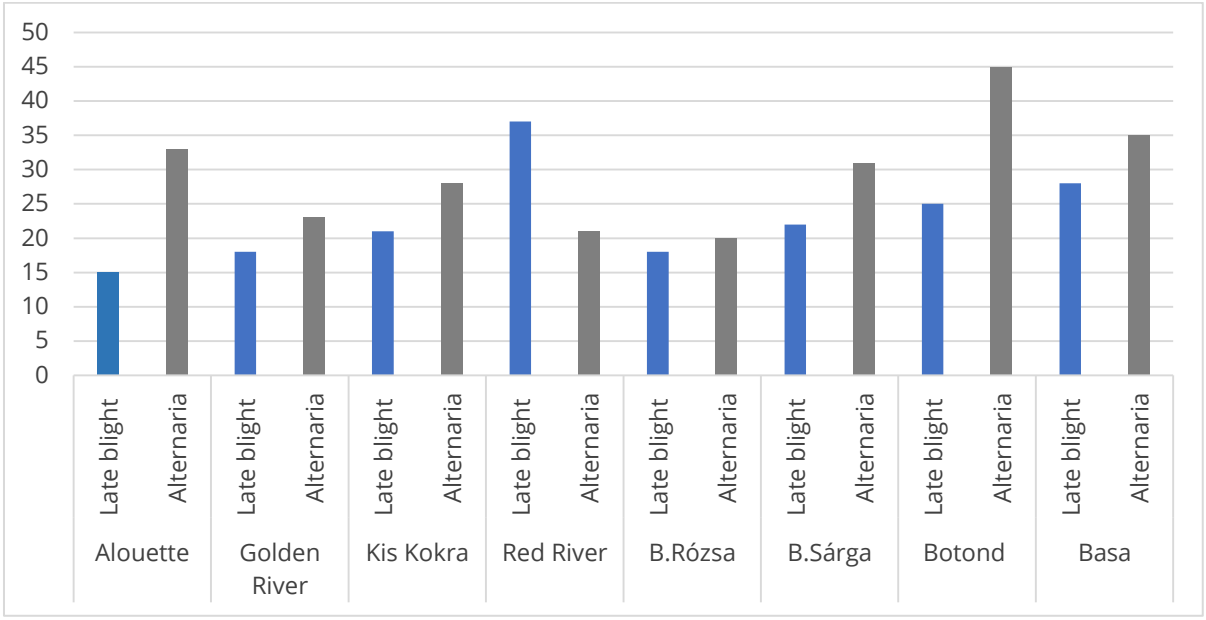


Fig 21 Percentage of leaf area affected by late and early blight.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Lowest level of late blight infection was recorded for the moderately resistant varieties (Alouette 15 % and Golden river 18 %), while the highest level had Red river, where about 37 % of total leaf area was affected by the pathogen. Alternaria attacked the plant almost a month later. Variety Botond and Alouette have got the highest infection (45 and 33 %).

3.1.4 Farmers participatory breeding

Participatory breeding trials were set up at three locations (Rábcakapi, Zalavár and Szakály). Five advanced breeding (Table 36) lines of the Potato Research Station, MATE was tested using the same methodology as for the Farmer Participatory Field Trials. Trials were planted between 6 and 14 of April.

Table 36 Main characters of tested breeding lines.

	Breeding lines				
	10.437	**14.21**	**18.146**	**18.159**	**13.361**
Maturity	late	middle	middle	middle	middle
Skin color	red	red	yellow	yellow	yellow
Flesh color	pale yellow	yellow	yellow	yellow	pale yellow
PVY resistance	9	9	9	9	9
Late blight resistance	5	6	7	6	6

3.1.5 Results

3.1.5.1 Yield

Location and production practices had the greatest influence on yield. From the three, two trials were irrigated, Rábcakapi and Szakály, but Zalavár was not. The dramatic effect of severe drought is obvious from the received results. Highest average yield was recorded at Szakály 36.2 t/ha. Yield at Rábcakapi was a bit lower than the average of tested lines, 34.8 t/ha (Figure 22). However, the average yield at Zalavar was just above 14 t/ha. Breeding line 10.437 reached the highest yield at both Rábcakapi and Szakály, however it had the lowest yield at Zalavár. This is directly correlated to this line late maturity and its higher sensitivity to drought stress.

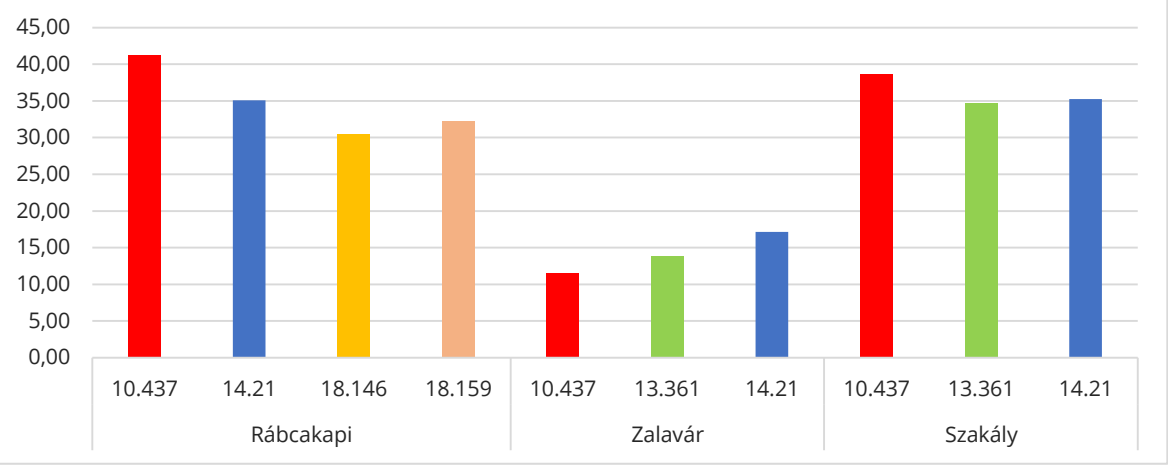


Fig 22 Yield (t/ha) of breeding lines.

Funded by European Union
Horizon 2020
Grant agreement No 771367

3.1.5.2 Tuber characteristics:

Starch content of the tested lines varied between 10.8 and 13.72 % (Table 37). The lowest dry matter was detected at Szakály for line 10.437, while the highest for line 18.146 at Rábcakapi. The highest average starch content was measured at Zalavár (12.01 %) which is in direct connection with lower average yield. Regularity of tuber shape and depth of eyes was found to be quite good (score 7-8). Only the line 10.437 and 13.361 have got score 6 at one of the locations. The biggest tubers were produced by the late maturing line 10.437, while the relatively smallest ones (score 5 and 6) by line 14.21. In terms of raw and after cooking discoloration there was no remarkable differences between the breeding lines. All of them performed well during the tests (score 2) and did show only limited discoloration.

Table 37 Data representing different tuber traits of tested breeding lines.

	Rabcakapi				Zalavar			Szakaly		
	10.437	**14.21**	**18.146**	**18.159**	**10.437**	**13.361**	**14.21**	**10.437**	**13.361**	**14.21**
Stach content %	11.4	11.5	13.72	10.82	11.50	13.61	10.92	10.80	13.31	11.22
Cooking type	B	B	B/C	A/B	B	B/C	A/B	A/B	B/C	B
Taste	3	4	2	3	3	2	3	3	2	3
Regularity of tuber shape	6	7	7	7	7	7	8	7	7	8
Depth of eyes	7	8	8	7	7	7	8	7	6	7
Tuber size	6	5	6	6	7	7	7	8	6	6
Cooked discoloration	2	2	1	2	2	2	2	2	2	2
Raw discoloration	3	2	2	2	2	2	2	2	2	2

3.1.5.3 Disease incidence observations

Scoring of plants for the incidence of early blight and late blight infection occurred once in the season at the same time as for the Participatory Field Trial (mid-July for late blight and early August for late blight). Recorded data are presented in Table 38 and Figure 23. Among the lines, 13.361 had the lowest average infection by late blight but the highest with early blight.

Table 38 Percentage of leaf area affected by late blight (LB) and early blight (EB) of tested breeding lines at the trial sites.

Rabcakapi							
10.437		**14.21**		**18.146**		**18.159**	
LB	EB	LB	EB	LB	EB	LB	EB
30	15	22	17	30	20	25	35
Szakály							
10.437		**13.361**		**14.21**			
LB	EB	LB	EB	LB	EB		
25	15	25	25	30	25		
Zalavár							
10.437		**13.361**		**14.21**			
LB	EB	LB	EB	LB	EB		
10	25	10	30	15	20		

Funded by European Union
Horizon 2020
Grant agreement No 771367

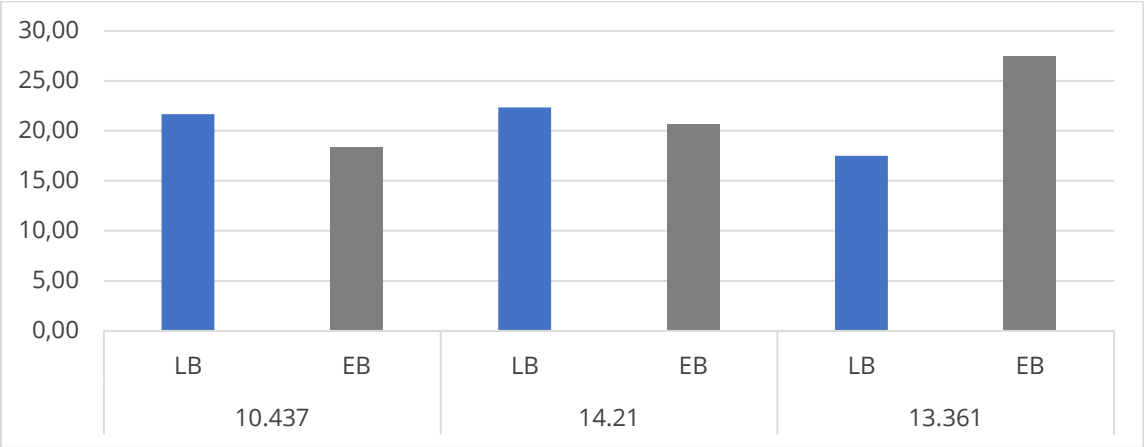


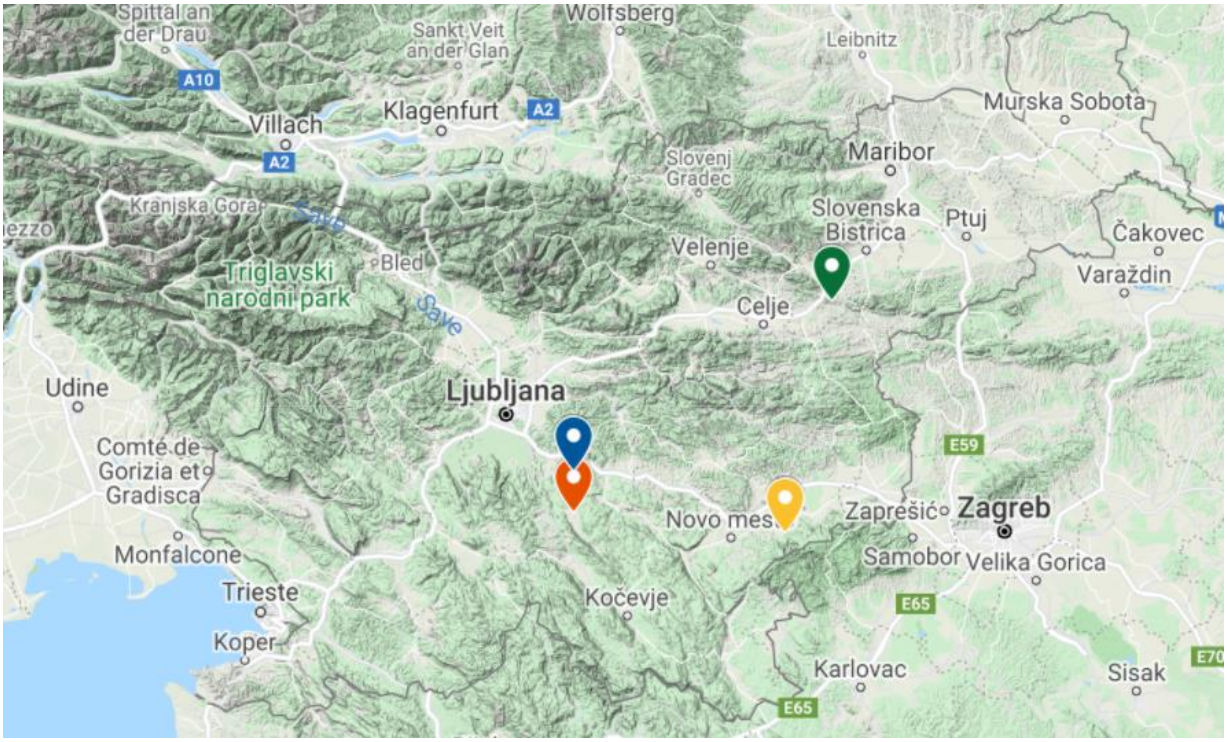
Fig 23 Leaf area (%) infected by late blight and early blight.

Funded by European Union
Horizon 2020
Grant agreement No 771367

3.2 Potato farmer participatory trials in Slovenia

3.2.1 Methods: Locations and conditions of trials

In 2023, the PPB trial program within the ECOBREED project started on four organic farms in the continental part of Slovenia in two different regions (Štajerska and Dolenjska region). The altitude of these farms (trial sites) is between 262 m and 520 m (Fig 24).



Name place	Farm elevation	Type of landscape	Pedo-climatic zones/regions	Farm size (ha)	Farm type	Organic since (years)
Grosuplje	335	Valley	Continental temperate climate	12	Mixed	+20
Šentjernej	262	Plain	Continental temperate climate	5,5	Mixed	+5
Videm Dobrepolje	441	Valley / "plateau"	Continental temperate climate	24	Mixed	+12
Ponikva	520	On the hills	Continental temperate climate	8,3	Mixed	+20

Fig 24 Locations of potato trials and main characteristics.

Trial conditions: In 2023, 13 selected potato clones from previous trials and 3 late blight resistant standard varieties were grown as part of PPB trials on 4 of the same organic farms. The aim was to obtain a panel of varieties and clones with different characteristics in terms of yield, late blight and PVY resistance, recovery, skin and flesh color and other traits (Table 39).

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 39 Varieties and clones of potatoes and known properties.

Name of clone/variety	Resistance to late blight	Earliness
Alouette	yes	Intermediate
KIS 13- 256/249-1	yes	Intermediate
KIS 14-136/256-26	yes	Late
KIS 14-235/271-3	no	Late
KIS 14-235/276-1	no	Intermediate
KIS 14-277/256-29	yes	Intermediate
KIS 15-184/245-2	no	Intermediate
KIS 15-184/247-8	no	Intermediate
KIS 15-225/247-1	no	Intermediate
KIS 15-271/235-1	no	Intermediate
KIS 15-282/245-8	no	Intermediate
KIS 16-277/256-4	yes	Late
KIS 16-277/256-6	yes	Late
KIS 16-289/261-2	yes	Intermediate
KIS Kokra	yes	intermediate
Levante	yes	intermediate

Ten tubers were planted for each clone or variety. Planting took place between 8 April and 1 May 2023 using a semi-automatic planting machine. Fertilisation, weed control and pest control were carried out by the farmers within the framework of organic farming. The cropping sequences were designed and described by the farmers (Table 40). It varied from one farm to another. The rotation of plants from different botanical families interrupts the cycle of weeds and pests and limits their pressure. The recommended cropping interval for potatoes is at least 4 years. This cultivation interval was observed on 3 plots. Only 1 farm in Ponikva cultivated potatoes with a slightly shorter interval of 3 years. In Šentjernej, vines were grown for 20 years before 2018. The potato harvest took place between August 26 and September 6, 2023.

Table 40 Crop rotation and fertilisation on the potato trial on the 4 farms.

	Videm Dobrepolje	Grosuplje	Šentjernej	Ponikva
2019	Grassland	Buckwheat	Rutabaga	Grass-clover mix
2020	Grassland	Millet	Triticale	Potato
2021	Grassland	Wheat	Spelt	Carrot
2022	Barley	Spelt	Oat / Buckwheat	Onions and turnip
2023	Potato **Compost 30t/ha (4.2023)**	Potato **Previous straw left for green manuring (2022)**	Potato **Manure = 50t/ha (26.11.2022)** **Liquid manure = 18000L/ha (23.3.2023)**	Potato **Manure = 23t/ha (11.4.2023)**

Funded by European Union
Horizon 2020
Grant agreement No 771367

Fig 25 Potato harvest, on farm Marolt, in Videm Dobrepolje, 4 September 2023 (left) and on farm Zagorc in Šentjernej, 5 September 2023 (right).

2023 was an exceptionally wet summer (example Grosuplje – Fig 26). Some fields or parts of fields were flooded during part of the summer. In Grosuplje (20 km from Ljubljana), it rained 320 mm more than in the previous season (1,533 mm between October 2022 and September 2023; 1,214 mm between October 2021 and November 2022).

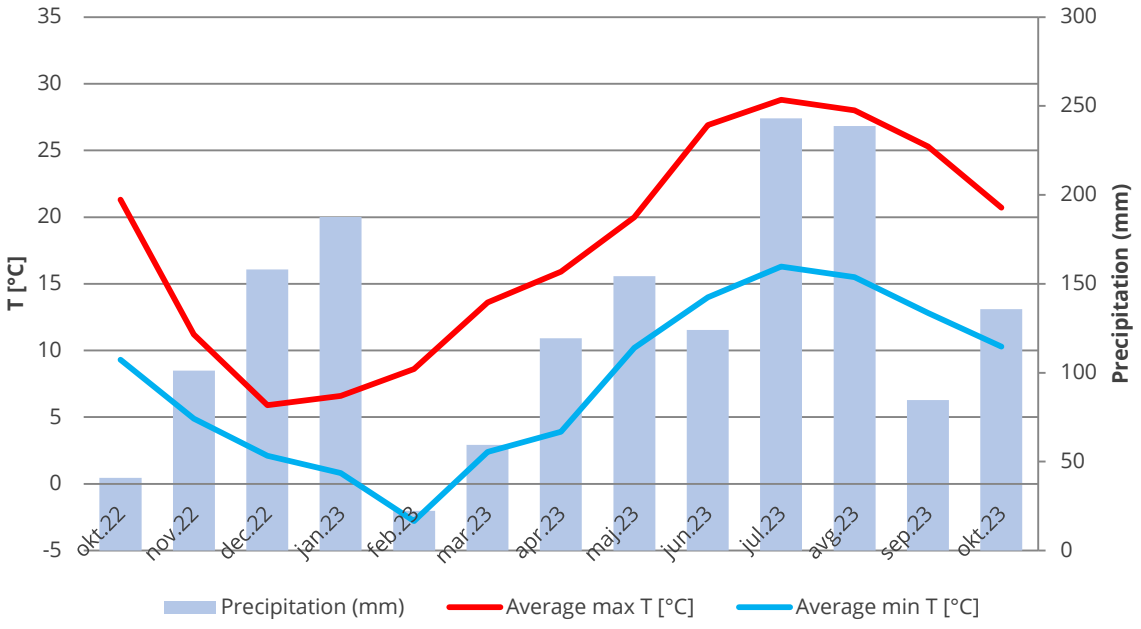


Fig 26 Weather conditions for season 2022 / 2023 (data for Grosuplje).

Funded by European Union
Horizon 2020
Grant agreement No 771367

Fig 27 Observation of trials and infected tubers in farm production, 28 June 2023 (left) and trial after storm on farm Zdolšek in Ponikva, 25 July 2023 (right).

3.2.2 Results:

3.2.2.1 Yield and state of the crop

The conditions in 2023 were challenging; with cold temperatures in spring and high temperatures in summer, the high rainfall and storms in summer which affected various locations in Slovenia. According to the farmers, the health of the potato plants was satisfactory considering the extreme weather conditions. The plants at all 4 locations were not damaged by leaf diseases or pests. The trial at Ponikva was healthy until a storm at the end of July. Colorado potato beetle and weeds were not perceived as a major problem by the farmers. On one farm, the weed infestation and the drought in August posed a major challenge, which was reflected in low yields. At the end of the season, the farmers were asked several questions to characterise the season with its difficulties and successes: “In your opinion, what were the main problems on this potato field this year?” and “What was satisfactory about this potato trial?” (Table 41).

Table 41 Difficulties and success described by farmers at the 4 locations,

	Videm Dobrepolje	Grosuplje	Šentjernej	Ponikva
Difficulties	Heavy precipitation delayed the harvest	Weather conditions	Water stagnated in the test area. Too much rain	Cold spring. Abundant rain throughout the year. On July 25, hail destroyed a large part of the potato leaf mass, which considerably affected the yield of many late maturing varieties.
Satisfaction /	Observe the difference between clones in our own field and participate in the future of selection lines.	no answer	no answer	Considering the extremely difficult weather conditions throughout the year (cold spring, lots of rain, 2x light "drought" in between, hail, etc.) for potato cultivation, certain varieties/crosses performed well despite everything. In fact, the leaf mass was relatively healthy and free of serious disease until the hailstorm.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Fig 28 Potato clone trials (PPB) on the farm Marol, Videm Dobrepolje, 28 June 2023 (left) and on Pucihar, Grosuplje, 28 June 2023 (right).

Across the 4 locations, the range of yields varied, but we can see that KIS 14-235/276-1, KIS 15-225/247-1 and 15-271/235-1 appear at the top of the yield range 4, 4 and 3 times respectively (Table 42). The yields that were 30% above the average of all varieties per location were highlighted in green. The yields that were 30% below the average are marked in red. The yield of KIS 15-225/247-1 was between (+21 and +96%) above the yield average at 4 locations. The yield of KIS 15-271/235-1 was always above the yield average at 3 locations between (+21 and +78%). The yield of KIS 14-235/276-1 was also above the yield average at 4 locations between (+27 and +42%). KIS 13-256/249-1, KIS 14-136/256-26, KIS 14-277/256-29, KIS 15-184/245-2, KIS 16-277/256-6, KIS 16-289/261-2 had good yields close to the average for each location. KIS 15-282/245-8 performed poorly at 4 locations this year, with a difference of -9%, -45%, -50% and -71% to the average values per location. The 3 already registered varieties showed contrasting results compared to the average values at the individual locations.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 42 Comparison of yield (kg) per 10 plants for each location.

Name of clone or variety	Videm Dobrepolje	Grosuplje	Šentjernej	Ponikva
13-256/249-1	4.27	2.27	3.54	5.19
14-136/256-26	6.07	2.12	2.41	9.93
14-235/271-3	5.05	2.57	2.07	3.39
14-235/276-1	6.66	3.37	3.99	9.77
14-277/256-29	4.33	2.08	2.51	7.33
15-184/245-2	3.65	2.04	2.77	5.34
15-184/247-8	3.35	1.71	3.63	2.55
15-225/247-1	6.37	3.94	4.83	13.60
15-271/235-1	4.91	4.24	3.48	8.42
15-282/245-8	2.64	0.70	1.55	6.33
16-277/256-4	6.19	1.29	1.17	6.96
16-277/256-6	4.68	1.95	3.63	7.62
16-289/261-2	5.49	2.66	3.55	5.83
ALOUETTE	6.88	2.32	1.68	5.59
KIS KOKRA	8.99	2.91	3.30	4.79
LEVANTE	4.36	1.86	1.14	8.66
AVERAGE	**5.24**	**2.38**	**2.83**	**6.96**

The average number of tubers per plant across the 4 locations was between 5.3 and 10.2, with the average for each location being 7.2. The plants of clones 15-225/247-1 and 15-271/235-1 performed better at all locations, with the number of tubers per plant being above average at 9.6 and 10.2 respectively. The 3 registered varieties showed greater differences between locations. Tuber size (Fig 29) was determined (weighed and counted) on square meshes of sizes < 25mm, 25-45mm, 45-65mm, > 65 mm. 16-289/261-2, 14-235/276-1, 15-225/247-1 were the 3 clones with the largest tubers, averaging 84 g, 79 g and 72 g, respectively. 14-235/276-1 had more tubers in the 45-65 mm fraction than the other two clones. Clones 15-225/247-1 and 14-235/276-1 were more successful than the others at all locations this season (Fig 29). The clone 15-282/245-8 was unfortunately not successful at 3 locations and was close to the average at 1 farm.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 43 Comparison of clones and varieties for each location.

Legend: light red = 1st decile, light green = 9th decile. Underlined numbers are clones or varieties selected by farmers according to their own interests (use, yield, shape and external appearance, etc.).

	Videm-Dobrepolje			Grosuplje			Šentjernej			Ponikva		
Name of clone or variety	Yield (kg) for 10 plants	Number of tubers per plant	Average tuber weight (g)	Yield (kg) for 10 plants	Number of tubers per plant	Average tuber weight (g)	Yield (kg) for 10 plants	Number of tubers per plant	Average tuber weight (g)	Yield (kg) for 10 plants	Number of tubers per plant	Average tuber weight (g)
13-256/249-1	4.27	10.9	39	2.27	5.8	39	3.54	12.2	29	5.19	8.8	59
14-136/256-26	6.07	11.8	51	2.12	3.1	68	***2.41***	***4.8***	***50***	***9.93***	***11.8***	***84***
14-235/271-3	5.05	7.2	70	2.57	4.6	56	2.07	4.9	42	3.39	4.5	75
14-235/276-1	***6.66***	***8.7***	***77***	***3.37***	***4.6***	***73***	3.99	6.6	60	9.77	9.4	104
14-277/256-29	4.33	9.6	45	2.08	4.4	47	***2.51***	***5.0***	***50***	7.33	11.0	67
15-184/245-2	3.65	7.3	50	2.04	4.0	51	2.77	6.5	43	5.34	7.8	68
15-184/247-8	3.35	7.6	44	1.71	3.8	45	***3.63***	***7.5***	***48***	2.55	3.5	73
15-225/247-1	6.37	8.9	72	3.94	6.0	66	***4.83***	***9.6***	***50***	***13.60***	***13.8***	***99***
15-271/235-1	4.91	10.9	45	4.24	6.9	61	3.48	10.5	33	8.42	12.4	68
15-282/245-8	2.64	7.0	38	0.70	2.0	35	1.55	4.2	37	6.33	9.5	67
16-277/256-4	6.19	8.3	75	1.29	3.7	35	1.17	4.2	28	6.96	8.2	85
16-277/256-6	4.68	8.6	54	1.95	3.8	51	3.63	9.2	39	7.62	10.0	76
16-289/261-2	5.49	5.9	93	2.66	3.6	74	3.55	5.8	61	5.83	5.4	108
ALOUETTE	6.88	7.1	97	2.32	4.4	53	1.68	4.8	35	5.59	9.2	61
KIS KOKRA	8.99	9.2	98	2.91	4.3	68	3.30	8.5	39	4.79	8.9	54
LEVANTE	4.36	7.1	61	1.86	3.6	52	1.14	2.8	41	8.66	13.3	65
AVERAGE	5.24	8.51	63	2.38	4.29	55	2.83	6.69	43	6.96	9.2	75.8

The composition of the clone sample was described by the percentage of tubers in 4 different size fractions: above 65 mm, between 45 and 65 mm, between 25 and 45 mm, below 25 mm (Figure 29). Some clones and varieties did not show the smaller size fraction (13-256/249-1, 14-277/256-29, 15-184/245-2, ALOUETTE, LEVANTE). Only 15-225/247-1 had no tubers >65 mm at the 4 locations.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Fig 29 Composition of tuber size fractions for each clone and variety at 4 locations.

At harvest time, we asked the farmers: "What is your favorite clone?" with varied answers (Table 44). It would be interesting to ask this question at different stages of production: Emergence, flowering, after bad weather, after attacks, at harvest, during storage or during organoleptic tests. From the farmers' point of view, the choice of the best clones depended on their own criteria, which included components such as yield, tuber health, shape, external aspects and homogeneity of tuber weight. For different farmers, these components are pronounced depending on their system and personal preferences.

Table 44 Choice of clones for each farmer.

	Videm-Dobrepolje	Grosuplje	Šentjernej	Ponikva
Name of chosen clones or varieties	14-235/276-1	14-235/276-1 15-225/247-1 15-271/235-1	14-136/256-26 14-277/256-29 15-184/247-8 15-225/247-1	15-225/247-1

Funded by European Union
Horizon 2020
Grant agreement No 771367

3.2.2.2 Visual, organoleptic and chemical aspects of harvest

The dry matter determines the quality of the potato and values above 19 - 20% give the potato its special taste and aroma. It depends on the genotype, the growing conditions, and the length of the growing season. The average value for 4 locations was 20.2%, which is above the optimum dry matter for storage (approx. 20%). Clones 14-136/256-26, 16-277/256-6 and 15-282/245-8 had the highest percentage of dry matter (average of the 4 locations 25.4%; 22.5% and 22.2%, respectively; Fig 30).

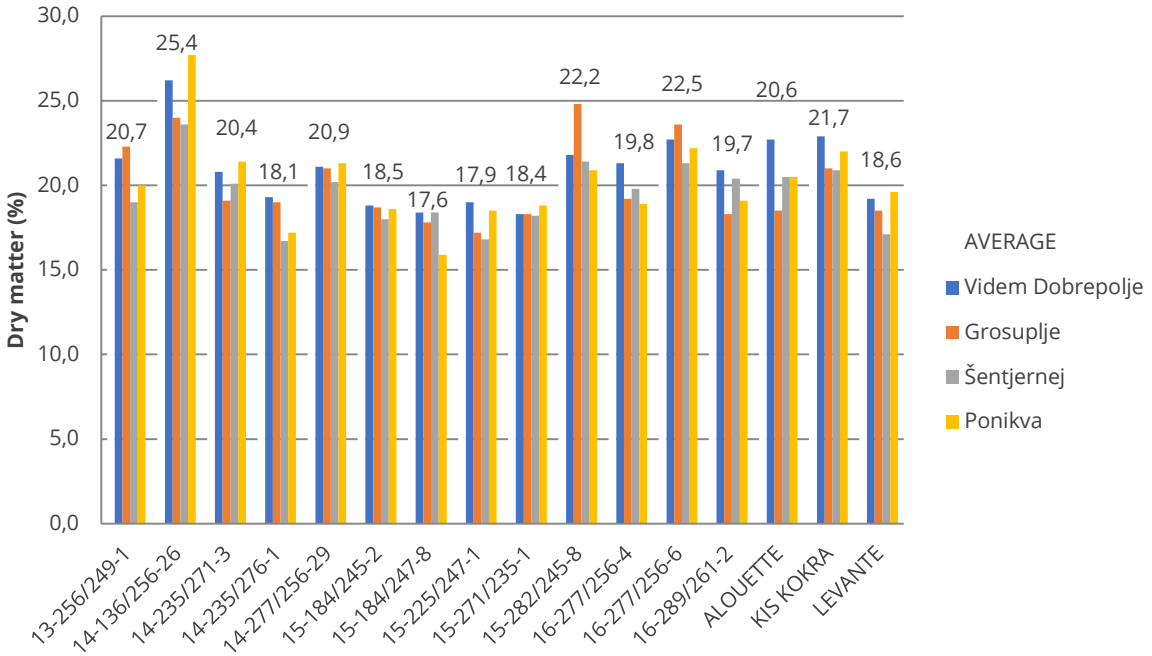


Fig 30 Dry matter (%) for each variety at 4 locations

The characteristics of cooking quality are summarised (Table 45) with the average score for each clone or variety for the 4 locations. The visual characteristics and sensory analysis were carried out by experts at the Agricultural Institute of Slovenia. Due to the size of the trial and time constraints, we could not perform taste tests with the farmers for the variety samples. Most varieties achieved a good taste score for the 4 locations. Most varieties at all 4 sites had at least a good flavor with scores between 1.5 and 4.5. Cut surface uniformity scored the highest for all clones and varieties. There was no discoloration of the flesh after 20 minutes of cooking. Tuber decay was absent or very low (scores between 1 and 1.5). The highest scores were most frequently achieved with Šentjernej. The firmest clones, which reached a consistency of 1.5, were 13-256/249-1 and 14-136/256-26. The softer clones, which reached a consistency of 3, are 15-225/247-1 and 15-271/235-1. In terms of flouriness, all clones and varieties were non-floury or moderately floury (values between 1.5 and 2.5). The structure was relatively fine in 15-225/247-1 and 15-271/235-1 with a value of “2” and relatively coarse with a value of “3” in 13-256/249-1, 14-136/256-26, 15-184/247-8, 16-277/256-6 and Alouette. The clone panel achieved high scores for flavour with “good” or “very good”. There were 3 instances of tubers having “different flavor" in only 2 clones at 1 or 2 locations: 15-184/247-8 and 13-256/249-1. All clones had moderate to complete stickiness and offered a wide range of

Funded by European Union
Horizon 2020
Grant agreement No 771367

uses. All clones and varieties had a good overall impression with average scores between 2 and 4.

Table 45 Cooking quality for each variety, average for 4 locations.

	Surface colour of flesh	Uniformity of cut surface	Discoloration after 20 min	Disintegration	Consistency	Mealyness	Moisture	Structure		Taste	Other taste	Stickiness	General impression
13-256/249-1	3	1	1	1.5	1.5	2.5	2.5	3		2.5	2	2.5	3
14-136/256-26	2	1	1	1.5	1.5	2.5	2.5	3		2	1	3.5	2.5
14-235/271-3	4	1	1	1.5	2.5	2	2	2.5		2.5	1	1.5	3
14-235/276-1	4	1	1	1.5	2.5	2.5	2	2.5		3	1	2	3.5
14-277/256-29	2	1	1	1	2	2	2	2		2.5	1	2	2.5
15-184/245-2	4	1	1	1.5	2	2	2	2		2.5	1	2.5	2.5
15-184/247-8	2.5	1	1	1.5	2	2	2	3		3	1.5	2.5	4
15-225/247-1	2	1	1	1.5	3	1.5	1.5	2		3	1	1.5	3.5
15-271/235-1	3	1	1	1.5	3	2	2	2		3	1	1.5	3
15-282/245-8	4	1	1	1	2	2	2	2.5		2	1	3	2
16-277/256-4	2.5	1	1	1.5	2.5	2	2	2.5		2.5	1	2	2.5
16-277/256-6	2	1	1	1	2	2.5	2.5	3		2.5	1	3	3
16-289/261-2	2.5	1	1	1.5	2.5	2	2	2.5		3	1	2.5	3
ALOUETTE	4	1	1	1	2	2.5	2	3		2.5	1	2.5	3
KIS KOKRA	2.5	1	1	1.5	2.5	2	2	2.5		2.5	1	2.5	3
LEVANTE	4	1	1	1	2	2	2	2.5		3	1	1.5	3

Legend: Surface color of flesh (1 white, 2 creamy, 3 light yellow, 6 dark yellow), Uniformity of cut surface (1 uniform, 4 non-uniform), Discolouration after 20 minutes (1 no discolouration, 4 heavy discolourations), Disintegration (1 none, 4 heavy), Consistency (1 firm, 4 soft), Mealiness (1 not mealy, 4 mealy), Moisture (1 moist, 4 dry), Structure (1 fine, 4 coarse), Taste (1 excellent, 2 very good, 3 good, 4 acceptable, 5 worse, 6 unsuitable), Oder taste (1 none, 4 heavy strange tastes), Stickiness (1 none, 4 sticky), General impression (1 excellent, 10 unsuitable).

The cooking types were also rated on a four-point scale (A firm-fleshed - salads, B versatile, C mealy, D floury; Table 9). They can also be intermediate types of AB, BC.... The most popular type among consumers is lettuce type A, as the potato does not disintegrate. Type B is the most usable multi-purpose type, while BC is mealier and better suited for baking and frying. C is very floury and is suitable for bread etc. The cooking types of BC and C or D correlate with a higher dry matter content. 15-282/245-8 had type A or AB at 3 locations. Some varieties were very stable in terms of cooking type B at the 4 locations (14-235/271-3, 14-235/276-1, 14-277/256-29, 15-225/247-1, 15-271/235-1, 16-289/261-2, KIS KOKRA, LEVANTE), while some other varieties fluctuated between A and BC depending on the growing conditions (13-256/249-1, 14-136/256-26, 16-277/256-6).

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 46 Cooking type for each variety from the 4 locations.

Name	Videm Dobrepolje	Grosuplje	Šentjernej	Ponikva
13-256/249-1	BC	A	B	AB
14-136/256-26	A	AB	AB	BC
14-235/271-3	B	B	B	B
14-235/276-1	B	B	B	B
14-277/256-29	B	B	B	B
15-184/245-2	B	B	B	AB
15-184/247-8	AB	AB	B	B
15-225/247-1	B	B	B	B
15-271/235-1	B	B	B	B
15-282/245-8	A	AB	AB	B
16-277/256-4	B	AB	B	B
16-277/256-6	BC	B	AB	BC
16-289/261-2	B	B	B	B
ALOUETTE	B	BC	B	B
KIS KOKRA	B	B	B	B
LEVANTE	B	B	B	B

3.3 Potato farmer participatory trials in Poland

In 2022, 15 breeding lines and in 2023, 10 breeding lines were planted at three locations (Tuligłowy, Połomia and Jadwisin). In each location breeding lines were planted in three replications. During the growing season, farmers assessed the date of planting, harvest, emergence, plant height, damage caused by pathogens and pests. In September the materials were harvested. Described traits after harvested were: total yield (kg/bush), tuber shape, depth of eyes, regularity of tuber shape and % starch. In 2022 the highest yield was noted for line 21 – IX – 2 (1.3 kg/bush), while the lowest for lines 21 – IX –10 in Połomia (0.2 kg/bush) and 21 – IX – 14 in Jadwisin (0.2 kg/bush) (Fig 31). In 2023, the best yielding was line 23 – IV – 6 in Tuligłowy (1.0 kg/bush), whereas the lowest line 23 – IV – 7 in Jadwisin (0.3 kg/bush) (Fig 31). In Połomia higher yield was obtained (0.61 kg/bush) than in Tuligłowy (0.59 kg/bush) and Jadwisin (0.54 kg/bush). On average, the best yields for breeding lines were obtained in 2022 (Fig 32). Breeding lines (in 2021 and 2022) were also evaluated in a laboratory test for resistance to *P. infestans*. In 2022 and 2023 all breeding lines were very resistant to *P. infestans*. Mean values ranged from 8.6 to 9.0 (in scale 1-9; where 9 – very resistant).

Funded by European Union
Horizon 2020
Grant agreement No 771367

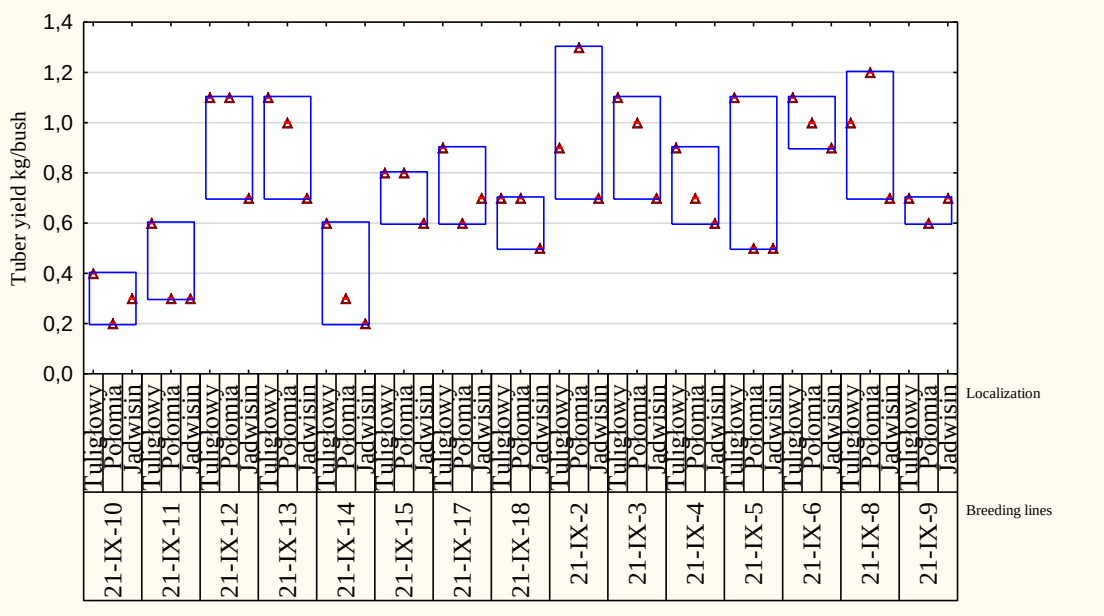


Fig 31 Total yield (kg/bush) for 15 breeding lines at three locations (Tuligłowy, Połomia, Jadwisin) (PL 2022).

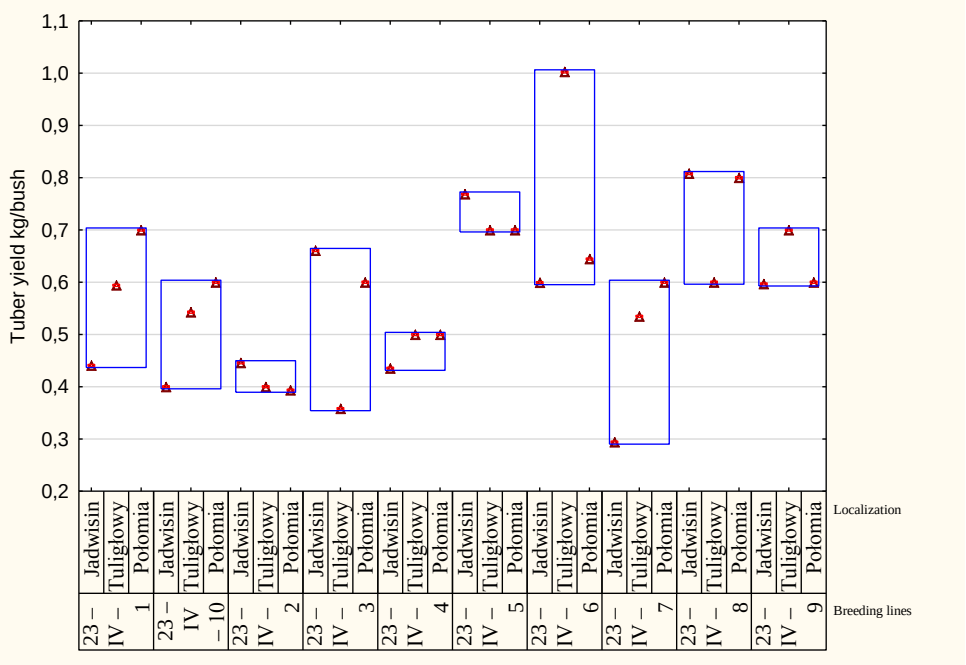


Fig 32 Total yield (kg/bush) for 10 breeding lines at three locations (Tuligłowy, Połomia, Jadwisin) (PL 2023).

Funded by European Union
Horizon 2020
Grant agreement No 771367

4 Soybean

4.1 Soybean farmer participatory trials in Serbia

In line with results from 2022, farmers were able to select a soybean variety that was appropriate for their agro-ecological conditions and production objectives after two years of executing participatory trials for organic production. In total, 3 soybean varieties and NS CCP were tested at 3 locations in Serbia. The average soybean yield at different areas ranged from 1.2 to 3.1 t/ha and protein content 38 to 43% (DM). NS CCP seeds were prepared for 12 locations (Slovenia, Romania, Germany and Austria). Locations for Serbian CCP testing were agreed (Šuljam, Rimski šančevi, Čurug). Harvest and taking the samples with farmers were performed during September and October 2023. Trial results have big variations within country and specific locations (different variety responses). Farmer participatory trials are a crucial milestone to define local criteria for variety selection and for increased adoption of new and improved soybean varieties to low-input and organic production.

Fig 33 Soybean NS CCP 2023.

4.2 Soybean farmer participatory trials in Germany and Austria

The 2023 soybean trials were established at five farms in Germany and one in Austria. In Germany the farmer participatory trials and participatory plant breeding trials took place at different farms. The reason was the late maturity of the Serbian population NS CCP that could not be harvested on two of the three farms in 2022. Therefore, the three trials with NS CCP took place in the warm Rhine valley between Basel and Karlsruhe. In Austria both trials took place at the same farm LFS Güssing.

The farmers in Germany liked the soybean trials 2021 and 2022 very much so we decided to continue on two farms in 2023. The farms Hopf in South of Bavaria and

Funded by European Union
Horizon 2020
Grant agreement No 771367

Endres in North of Bavaria were already demonstration farms in previous years. The focus in the 2023 trials was on testing new varieties. Only GL Melanie was continued on both farms and was grown at all farms from 2021 – 2023. At Endres farm 10 varieties were grown with 15 varieties at Hopf farm. SZ Gleisdorf delivered their new varieties GS Susanna, GL Crème and Simpol (only Endres). Both farms only grow varieties with 000-maturity. The weather was dry until the end of July but then lots of rainfall occurred. The later maturing varieties were able to better utilize the late rainfall. Nevertheless, both trials were harvested in late September. The yields of both farms were very high up to 6.5 and 5.7 t/ha. We were able to assess lodging for the first time. Best yields at Endres farm had GL Melanie and PZO Cantate, lowest had GL Susanna. Apollina, Arcardia and (the farm variety) SY Livius had the highest yields, GL Melanie had the lowest yield. GL Crème showed good results for protein at both locations. both trials successful demonstration events wre organized with more than 80 participants at Hof farm.

In Austria the trial at Güssing was almost destroyed by hail so no useful data was obtained.

Table 47 Yield and protein content in Germany 2023.

	Yield dt/ha		Protein %	
Variety/farmer	Hopf	Endres	Hopf	Endres
Simpol		54,9		40,7
GL Susanna	53,6	44,6	40,4	40,0
GL Crème	47,0	50,7	42,9	42,7
GL Melanie	42,6	57,0	41,4	40,5
Nessi PZO	47,4	50,9	42,3	41,1
Cantate PZO	51,2	57,0	42,9	40,1
Ascada	56,3	52,2	40,7	37,3
Alicia		51,4		40,2
ES Comandor	48,9	54,0	42,9	39,8
BTX		56,3		41,3
Apollina	65,8		42,4	
Merlin	47,1		41,7	
Royka	52,0		42,3	
Achilllea	46,9		43,4	
Sussex	48,3		43,0	
Arcardia	59,2		40,8	
Abaca	49,8		42,0	
SY Livius	58,0		43,1	
Average	52,9	51,6	42,1	40,4

In 2022 the Serbian population NS CCP was grown at three farms in Germany. Two of the three farms could not be harvested because of very late maturity. At the third farm Binder/Lindenbrunnerhof in Rhine valley it was no problem to harvest in late September, but yield was the second lowest. Only NS Mercury was lower.

In Austria NS pop was grown together with three SZ Gleisdorf populations at Jugovits Farm. The populations were selected together with the farmer. No yield was measured. Sadly, this activity at that farm had to be stopped because the farmer died in winter.

The harvest of NS CCP from Binder Farm was used for sowing at three farms in Rhine valley at 2023: Binder again, LTZ Karlsruhe-Grötzingen and Ruesch Farm at Buggingen.

Funded by European Union
Horizon 2020
Grant agreement No 771367

At Binder Farm a field day took place on 29 August 2023 conducted by the Agricultural Technology Center at Emmendingen. NS CCP looked much better than in the year before (also at the other two farms). Farmers were surprised and reacted positively. It was the longest in straw (10 cm than the second longest) but showed almost no lodging. Maturity was only 10 days later than the late 00 varieties Primus or Lenka. At LTZ Grötzingen yield of NS CCP was higher than the important variety Lenka (53:43 dt) and at Binder Farm was higher than ES Montor (32:29 dt) and on the same level as the best varieties. NS CCP did not look heterogenous to the eyes of farmers, so selection was not an option for the farmers. At Ruesch Farm yield was not measured.

In Austria two generation of NS CCP and four populations from SZ Gleisdorf were sown. Due to heavy hail the trials were almost destroyed and only some plants could be harvested.

Table 48 Yield and protein content of NS CCP in Germany

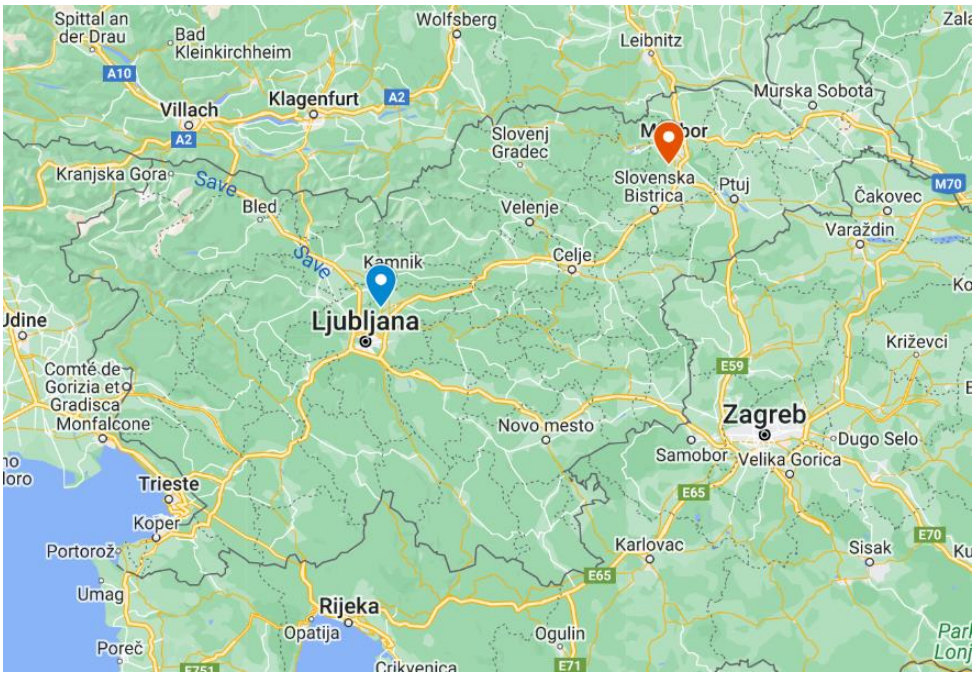
	Yield dt/ha		**Protein %**	
Variety/farmer	Binder	LTZ	Binder	LTZ
ES Mentor	28.6	58.4	42.5	42.2
Primus	33.5	59.0	44.4	44.8
Lenka	33.6	43.0	46.2	45.2
NS CCP	33.2	53.0	42.2	41.9

Funded by European Union
Horizon 2020
Grant agreement No 771367

4.3 Soybean farmer participatory trials in Slovenia

4.3.1 Methods

In Slovenia, soybean PPB trials within the ECOBREED project were established in 2023 in fields at the location Infrastructure Centre Jablje and Pohorski dvor (Fig 34).



Name place	Farm Elevation	Type of landscape	Pedo-climatic zones/regions
Infrastructure Center Jablje	300	Plain	Continental temperate climate
Pohorski dvor / Maribor	360	Valley / "plateau"	Continental temperate climate

Fig 34 Location of soybean trials and main characteristics.

Soybean trials comprised four varieties and one cross composite population (CCP). The latter was provided by the Institute of Field and Vegetable Crops Novi Sad which was selected for the testing by researchers and variety experts (Table 49).

Table 49 List of soybean varieties and CCP and their maturity groups selected for farmer participatory trials in Slovenia.

Variety	Earliness group	Definition
ALTONA	00	Early
AURELINA	000	Very Early
ARTESIA	0	Mid Early
LENKA	00	Early
CCP NS institute	No data	No data

Trials were carried out in Jablje and in Maribor with a density of 60 seeds/m². The following traits were evaluated to assess the development and agronomic performance of soybean: date of emergence, plant height (cm), lodging susceptibility, identification

Funded by European Union
Horizon 2020
Grant agreement No 771367

and scoring of disease and pests, grain yield (kg/ha) and grain moisture at harvest (%). Samples of collected grains were taken for the analysis of protein content. The crops before soybean trial were different at both locations (Table 50).

Table 50 Crop rotation before soybean trial at Jablje (SLO).

("1st crop /2nd crop": 1st crop following by a 2nd crop in a same year)

	2020	2021	2022	2023
Jablje	Maize or Potato	Fodder peas	Wheat	Maize / buckwheat trial

4.3.2 Results

The basic weather conditions in 2023 are provided (Fig 35) with a summary of records from two weather stations near the trials. Unfavorable weather conditions such as excessive cold weather led to poor emergence at Jablje, so the trials had to be reseeded. Precipitation from May to August was abundant and excessive in August in Jablje (414mm). September was dry at both locations (40mm).

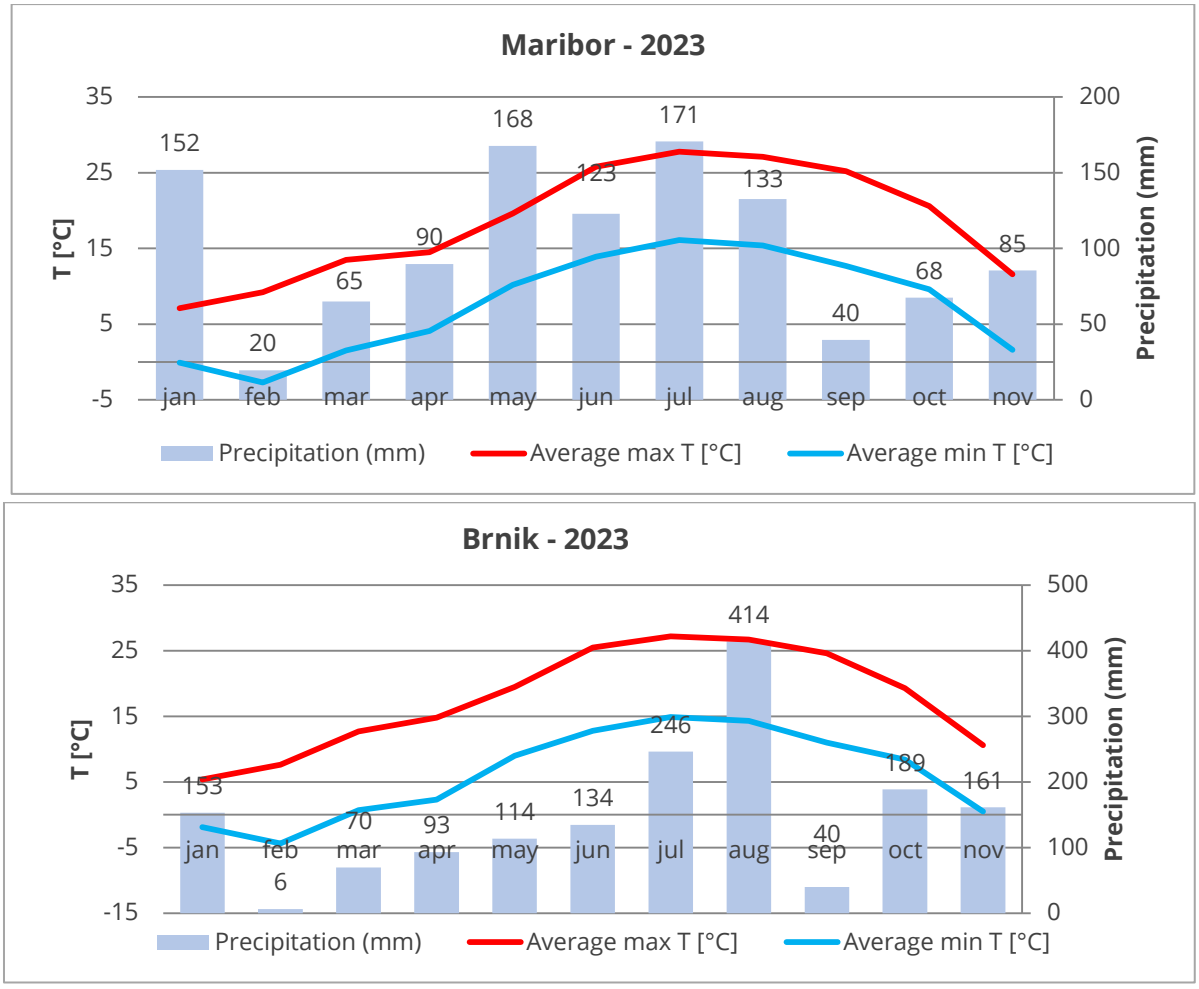


Fig 35 Weather conditions in 2023 data for Maribor (Edvard Rusjan Airport weather station) and Brnik (Jože Pučnik Airport weather station).

Funded by European Union
Horizon 2020
Grant agreement No 771367

Due to the animal grazing damage and weed overgrowth, the trials at Maribor were not maintained (Fig 37). No damage from pests or diseases was reported from the trial in Jablje (Fig 36).

Fig 36 Soybean trial at the Infrastructure Centre Jablje, 5 October 2023.

Fig 37 Soybean damaged by wild animal grazing at Pohorski dvor, 19 June 2023.

Funded by European Union
Horizon 2020
Grant agreement No 771367

At both locations, the variety AURELINA was the tallest and variety ARTESIA the shortest (Fig 38). The plant height of the CCP NS Institute was 67 cm, just below the average (68 cm).

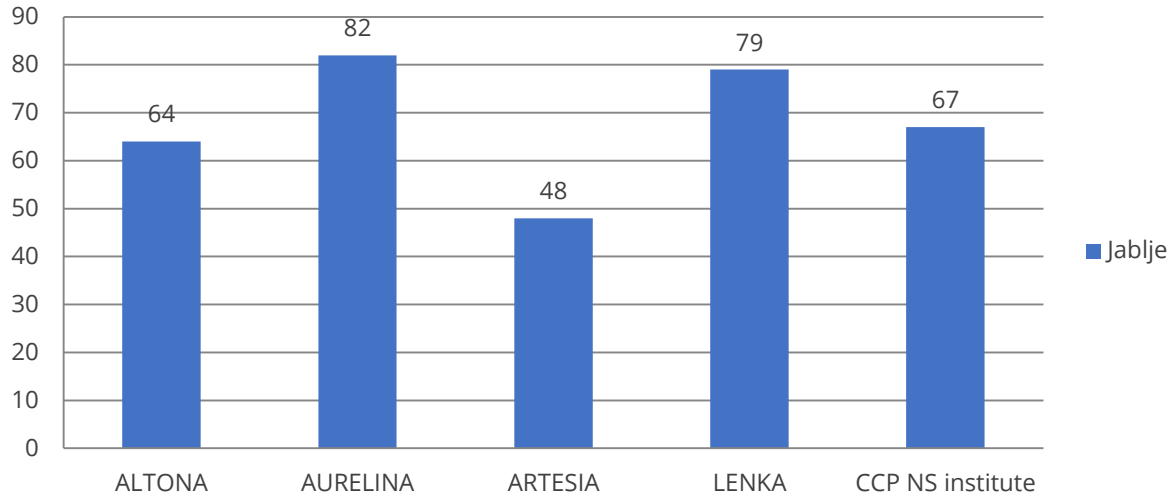


Fig 38 Mean height (cm) of soybean plants for each variety in Jablje (SLO).

The differences between maturity groups were noticeable in the yield results. All varieties from the Jablje trial reached maturity and there was no significant seed loss. The low yields can be explained by the late sowing date and the abundant rainfall. The highest yielding variety was Aurelina (9.6 dt/ha). This variety is from the maturity group 000 “very early”. The lowest yielding varieties were ARTESIA (3.8dt/ha) from maturity group 0 “mid early” and CCP NSI with 4.3dt/ha. Yield that are 30% above average, are marked in green, while yields that are 30% below average are marked in red.

Table 51 Harvest yield of soybean at Jablje (SLO).

Harvest yield (kg/ha)	Jablje	Yield / average of yield (%)
ALTONA	770	116
AURELINA	957	144
ARTESIA	379	57
LENKA	791	119
CCP NS institute	434	65
Average	**666**	

The chemical analyses are presented in Table 52. Protein content increases with yield (Fig 39) with the varieties Lenka and Aurelina having highest yield and protein content while Artesia and CCP NSI had lower protein content and lower yield. The oil content was lower when the variety had a higher yield (Table 52). Lenka and Aurelina had highest yield and lower protein content. Artesia had higher oil content. Altonia proved to be a good compromise choice in terms of yield and oil content. Table 52 shows that the protein content was lower, while to the oil content was higher. Aurelina and Artesia are contrasted in the three following figures. Maturity group determines the possibilities for yield, protein and oil content. The use of soybeans is a decisive factor in the choice of variety.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 52 Results of chemical analysis for each variety from the trial in Jablje (SLO).

	Protein content (%)	Relative Protein content with respect to average	Oil content (%)	Relative Oil content (%)	maturity / water content
ALTONA	33.7	92.4	21.9	104.0	15.30
AURELINA	39.4	108.1	20.1	95.4	16.70
ARTESIA	33.8	92.7	22.4	106.4	15.70
LENKA	40.4	110.8	20.4	96.9	16.20
CCP NS institute	35.0	96.0	20.5	97.3	16.10
Average	36.5		21.06		16.00

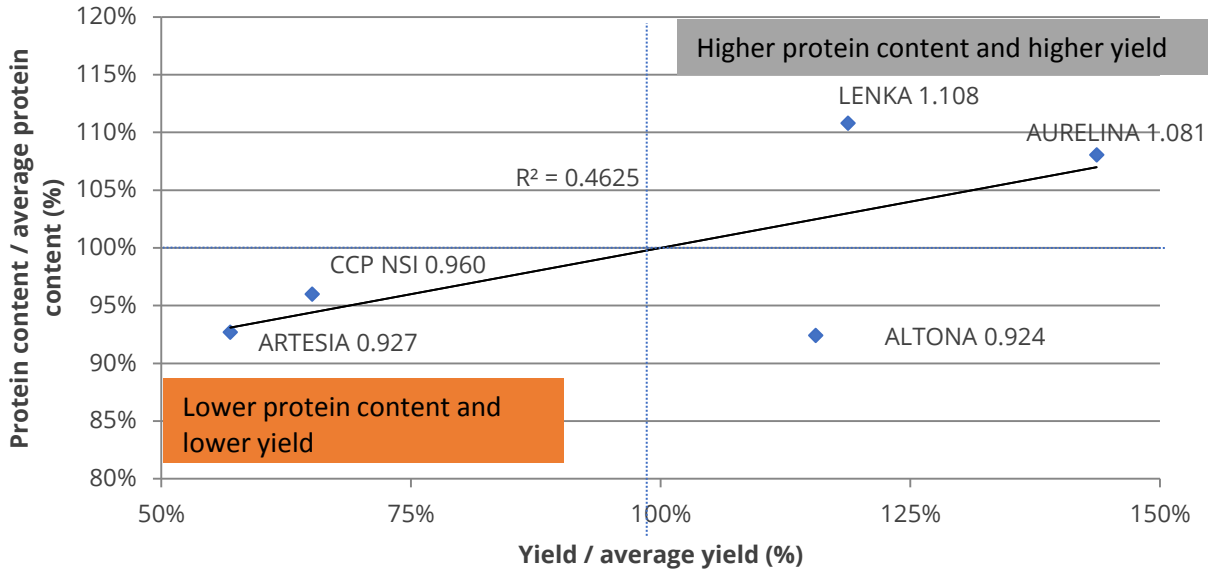


Fig 39 Comparison of varieties by yield and protein content in Jablje (SLO).

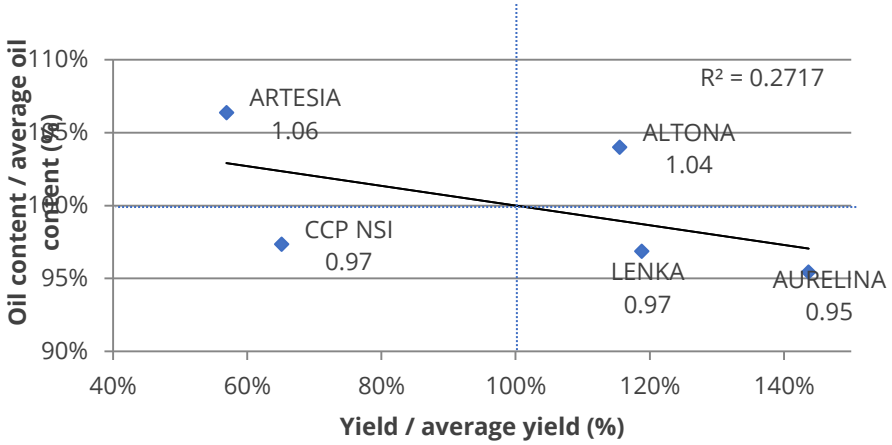


Fig 40 Comparison of varieties by yield and oil content in Jablje (SLO).

Funded by European Union
Horizon 2020
Grant agreement No 771367

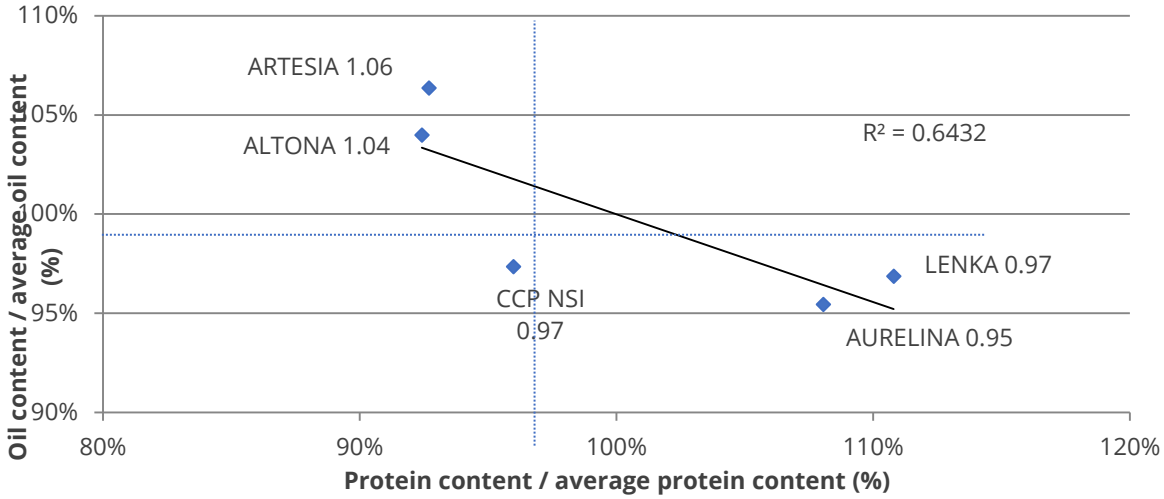


Fig 41 Comparison of varieties according to protein and oil content in Jablje (SLO).

4.4 Soybean farmer participatory trials in Romania

Identification of the soybean demo units (3): Agroecological Research and Innovation Centre of NARDI Fundulea; ECOFRUCT Stefan cel Mare and SC ADAFLOR Zebil/Tulcea (Fig 42). NARDI Fundulea received in 2023, 2.4 kg NS (CCP) which was cultivated at NARDI Fundulea Demo farm, and results are shown in 2023_FPT_assessments. Based on very good results obtained for the mixture wheat varieties, in the last 2 years (2022 & 2023) we tested different mixtures of soybean varieties and results are shown in 2022 and 2023_FPT_assessments and Bulletins.

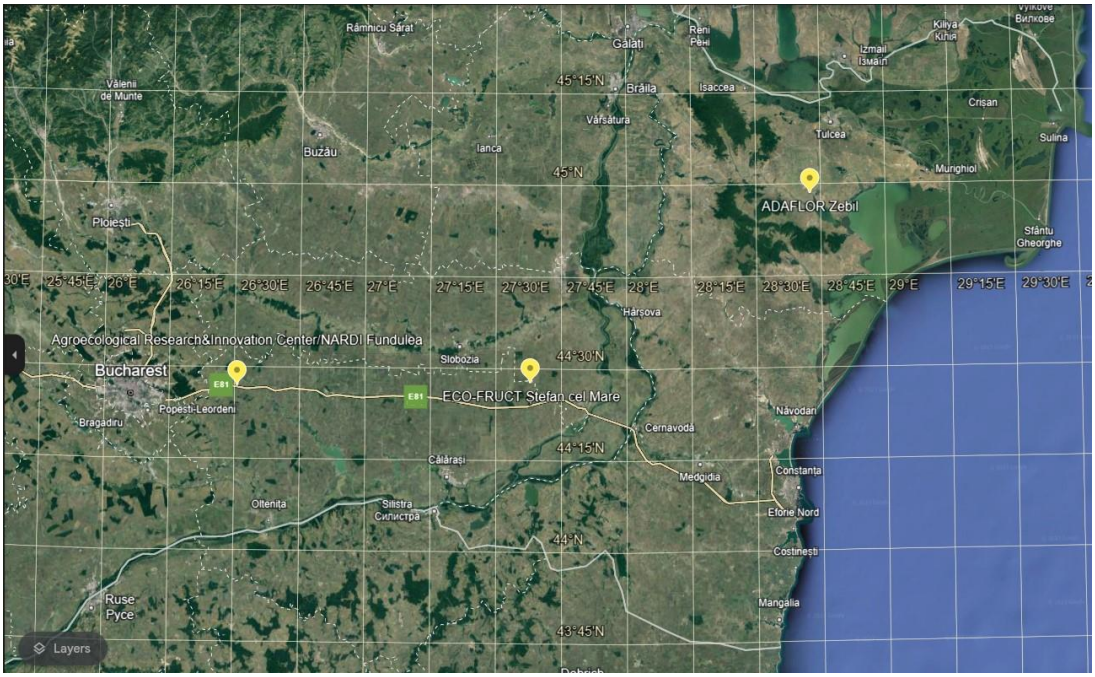


Fig 42 Map of Romanian ECOBREEED Soybean Demo Farms 2023.

Funded by European Union
Horizon 2020
Grant agreement No 771367

During the April – June 2023 period:

- Sowing of organic soybean varieties: 9 at ECO FRUCT SRL, Ștefan cel Mare, Călărași (5 May 2023), 10 at Agroecological Research & Innovation Centre of NARDI Fundulea (12 May 2023), 9 at SC ADAFLOR SRL, Zebil, Tulcea (17 May 2023).

Fig 43 ECO-FRUCT Ștefan cel Mare, county Călărași (left) and ADAFLOR Zebil (right) county Tulcea.

- Carrying out weeding and hoeing twice as weed infestation was the main problem in all demo fields.
- Irrigation twice at ECO-FRUCT Stefan cel Mare, Călărași and at SC ADAFLOR SRL, Zebil, Tulcea.
- Collecting phenotyping data: emergence date, flowering time and flower colour.

During the July – September 2023 period:

- Observation on weed, pest and disease infestation, maturity.
- Measurements: Climate parameters, Canopeo (%), Plant height (cm), Insertion height (cm) of the first pods.
- Irrigation 2 times at ECO-FRUCT Stefan cel Mare, Călărași and at SC ADAFLOR SRL, Zebil, Tulcea.
- Harvesting plant monoliths for productivity parameters analyses at ADAFLOR Zebil.
- Harvesting DEMO experiments at NARDI Fundulea and ECO – FRUCT Ștefan cel Mare Călărași.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Fig 44 Soybean trials at NARDI Fundulea (3 August 2023), ADAFFLOR Zebil (10 August 2023) and ECO-FRUCT Stefan cel Mare (17 August 2023).

During October – November 2023 period:

- Observation and measurement of plant, pod and seed characteristics of soybean varieties from DEMOs sites – NARDI Fundulea, ADAFLOR Zebil and ECO-FRUCT Ștefan cel Mare.
- Seed protein and fat content analyses with INSTALAB 660.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 53 Results of trials at NARDI Fundulea in Romania.

	ECOFRUCT	date	FAVORIT	MERCURY	OVIDIU F	FABIANA F	FAVORIT+ OVIDIU F	MERCURY+ FABIANA F	STK01+ OVIDIU F	PR92B63	PR92B63 Double rows
Sowing date		05/05	05/05	05/05	05/05	05/05	05/05	05/05	05/05	05/05	05/05
sowing density	seeds /m²	05/05	50	50	50	50	50	50	50	50	100
emergence	plants /m²	25/05	35.6	24.8	22.8	16.0	18.4	18.4	18.5	24.8	50.0
canopy/youth development	%	17/08	72.0	87.9	83.6	81.9	76.6	81.8	83.2	83.6	89.9
pest 1 *Nezara viridula/Haliomorpha halys*	1 to 9										
plant height	cm	11/10	58.56	82.22	59.1	83	69.5	73.5	56.88	96.2	92.18
lodging	1-9	17/08	1	1	1	1	1	1	1	1	1
maturity/water content	time/ %	11/10	8.28	8.28	8.24	8.36	8.4	8.28	8.33	8.32	8.28
harvest yield	dt/ha	11/10	21.41	28.67	25.61	28.71	23.76	30.96	25.34	30.85	35.11
protein*	%	6/12	39.64	37.49	38.3	37.79	38.15	37.45	38.76	35.31	35.67
fat (oil)*	%	6/12	19.18	19.68	19.68	19.58	19.49	19.78	19.43	19.63	19.56

Table 54 Results at ECOFRUCT.

	ADAFLOR	date	FAVORIT	MERCURY	OVIDIU F	FABIANA F	FAVORIT+ OVIDIU F	MERCURY+ FABIANA F	STK01 + OVIDIU F	FLORINA F	FLORINA F Double
Sowing date		17/5	17/5	17/5	17/5	17/5	17/5	17/5	17/5	17/5	17/5
sowing density	seeds/m²	17/5	30	30	30	30	30	30	30	30	60
emerge	plants/m²	30/5	16.6	19.3	18.6	12.6	13.8	9.6	11.2	15.9	29.7
canopy/youth development	%	10/8	39.7	38.86	40.1	35.99	30.69	30.35	38.06	37.01	47.09
pest 1 *Nezara viridula*	1 - 9										
plant height	cm	10/8	41.4	48.9	38.3	44.4	38.9	43	44.1	47.3	39.6
lodging	1 - 9	20/9	1	1	1	1	1	1	1	1	1
maturity/water content	time/%	20/9	7.7	7.78	8.33	8.33	8.48	8.47	8.53	8.29	8.39
harvest yield	dt/ha	20/9	5	12.90	11.14	9.77	7.16	6.87	8.26	9.36	9.28
protein*	%	5/12	39.39	38.72	40.58	38.71	40.71	38.83	39.81	38.46	38.6
fats (oil)*	%	5/12	18.83	18.96	18.75	19.38	18.54	19.15	18.99	19.12	18.91

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 55 Results at ADAFLOR.

	NARDI – Fundulea	date	Favorit	Mercury	Ovidiu F	Fabiana F	Favorit+	Mercury+	STK01+	NS WP 6	STK 01	STK 03
Sowing date		12/5	12/5	12/5	12/5	12/5	12/5	12/5	12/5	12/5	12/5	12/5
sowing density	seeds/m²	12/5	55	55	55	55	55	55	55	35	55	55
Emerge	plants/m²	1/6	35.0	32.0	29.7	20.4	22.6	19.3	20.7	13.8	16.7	17.1
canopy / youth developement	%	3/8	41.26	51.05	43.45	45.99	45.89	51.35	45.09	46.19	49.8	52.04
pest 1 *Nezara viridula/Haliomorpha halys*	1 - 9											
plant height	cm	18/8	51.8	53.5	45.8	45.1	53.8	53.3	42	53.2	41.5	47.6
Lodging	1 - 9	18/8	1	1	1	1	1	1	1	1	1	1
maturity/water content	time/%	12/9	6.60	6.45	6.55	6.55	6.50	6.20	6.65	6.70	6.80	6.75
harvest yield	dt/ha	12/9	2.89	3.25	2.74	2.66	2.26	2.11	2.07	0.81	0.93	1.06
protein*	%	7/12	40.61	39.55	40.21	39.37	40.03	39.67	39.55	38.55	35.33	39.55
fats (oil)*	%	7/12	16.78	16.7	17.19	16.54	16.93	16.54	17.35	17	17.44	16.72

Funded by European Union
Horizon 2020
Grant agreement No 771367

5 Buckwheat

5.1 Buckwheat farmer participatory trials in Czech Republic

Three organic farms participated in farm trials in 2023. All three farms were in the cadaster of Velké Hostěrádky in Southern Moravia. 8 different buckwheat varieties, including 4 populations were sown in plots with a minimum plot size of 300 m^2. The sowing density was 200 plants per m^2 at each location. The list of varieties and their origin is:

- Zita (Czech Republic)
- Kora (Poland)
- Lifago (Germany)
- MHR Smuga (Poland)
- Syn 21. (Slovenia)
- Syn P1 22.1 (Slovenia)
- Syn P1 22.2 (Slovenia)
- Syn P2 22.3 (Slovenia)

Fig 45 Sowing trials on 29 June 2023 (Photo: Adam Brezáni).

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 56 Days to maturity/vegetation period of different buckwheat varieties at different locations

Varieties	Locations		
	Velké Hostěrádky – EKOFARMA PROBIO s.r.o.	Velké Hostěrádky – Sonnentor s.r.o.	Velké Hostěrádky – Bohuslav Fiala
Zita	120	Not grown	Not grown
Kora	105	Not grown	Not grown
Lifago	120+	Not grown	Not grown
MHR Smuga	98	Not grown	Not grown
Syn 21.	120+	Not grown	Not grown
Syn P1 22.1	120+	Not grown	120+
Syn P1 22.2	120+	120+	Not grown
Syn P2 22.3	120+	Not grown	Not grown

Buckwheat is one of the riskier crops in the crop rotation of organic farmers. Therefore, it is always necessary to have thorough analysis when to include buckwheat in a crop rotation. In the Czech Republic PROBIO suggests farmers to grow it as a substitution crop or a second main crop due to its relatively short vegetation period, but this is also variety dependent. Populations included in these trials had a very long vegetation period, with uneven maturation and long flowering. Therefore, we would not recommend them to grow for grain production, but they can act as an excellent forage for bees.

Fig 46 Demonstration event organised by PRO-BIO and CRI. Dagmar Janovská (CRI) and Martin Hutař (PRO-BIO) (Photo: Adam Brezáni).

The plant length varied from 109 to 129 cm for Zita, which was the tallest and the most robust variety. Lodging was not recorded this year most likely due to the relatively dry summer and early autumn.

A demonstration event on 16 September 2023 was organised. About 700 people (mostly general public) have attended this event.

Funded by European Union
Horizon 2020
Grant agreement No 771367

5.2 Buckwheat farmer participatory trials in the UK

In May, six buckwheat varieties (2 May) and three newly developed CCPs (19 May) were drilled at Thornton Farm near Berwick upon Tweed. The buckwheat trials were harvested on 14 September, with 1m^2 quadrant samples collected for analysis by Newcastle University. The cross-composite populations seemed to perform well. The least competitive with the weeds were Kora and Panda. Data from the trials are presented in Table 58.

At Nafferton Farm the buckwheat FPT trial was drilled on 15 May and harvested on 18 September 2023. In total 3 varieties (Panda, Čebelica, La Harpe) and 3 CCPs (CCP8, CCP4 and Syn 21 were drilled. The trial established very well (Fig 48) but close to harvest extensive deer and/or bird damage occurred (Fig 49) with a considerable amount of seed loss to the ground as a result of which only the variety Panda and CCP 4 and CCP could be harvested with a very low seed yield in Panda. The aim had been to harvest the trial at Nafferton Farm with the plot combine but with considerable crop damage and seed loss this was not carried out.

At both sites quadrat samples of 1m^2 were cut (two duplicate samples per plot at Nafferton Farm and a single sample at Thornton Farm) at ground level and returned to the laboratory for processing. The data from Nafferton Farm (Table 57) show a clear variation in seed weight (recorded at 0% moisture content) likely due to the extensive deer/bird damage in the variety Panda together with Syn 211, Čebelica and La Harpe that were not harvested.

At Thornton Farm the highest seed yield was in the variety Panda (197g/m^2) and the lowest in the variety Kora (92 g/m^2) with the 3 CCPs being at the lower end of the range (125-154 g/m^2). The high seed weight in Panda combined with the low biomass resulted in a HI of 0.78 which was considerably higher than for any other variety (0.29-0.43).

Fig 47 Buckwheat FPT at Thornton Farm in 2023.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Fig 48 Buckwheat at Nafferton Farm in the UK taken in June 2023.

Fig 49 Buckwheat in September 2023 in the UK showing extensive damage by birds and/or deer.

Table 57 Crop growth and yield traits of Buckwheat FPT trial at Nafferton Farm in the UK 2023.

	Total FW (kg)	No of Plants	Plant length (cm)	Flower clusters per cyme	Seed clusters per cyme	Seed weight (g)
CCP 4	3.23	116	117	180	1261	133.5
CCP 8	1.81	70	121	20	378	158.5
Panda	2.85	84	129	26	703	53

Table 58 Crop growth and yield traits of Buckwheat FPT trial at Thornton Farm in the UK 2023.

Variety/population	Biomass (g)	Plant number	Seed weight (g)	HI
Panda	330	100	197	0.78
Spacinska	554	62	184	0.42
CCP 4	486	77	154	0.39
CCP 8	409	56	125	0.37
Hajnalka	432	117	145	0.40
CCP Syn 21	425	74	128	0.36
Kora	538	52	92	0.29
Lileja	746	70	186	0.43

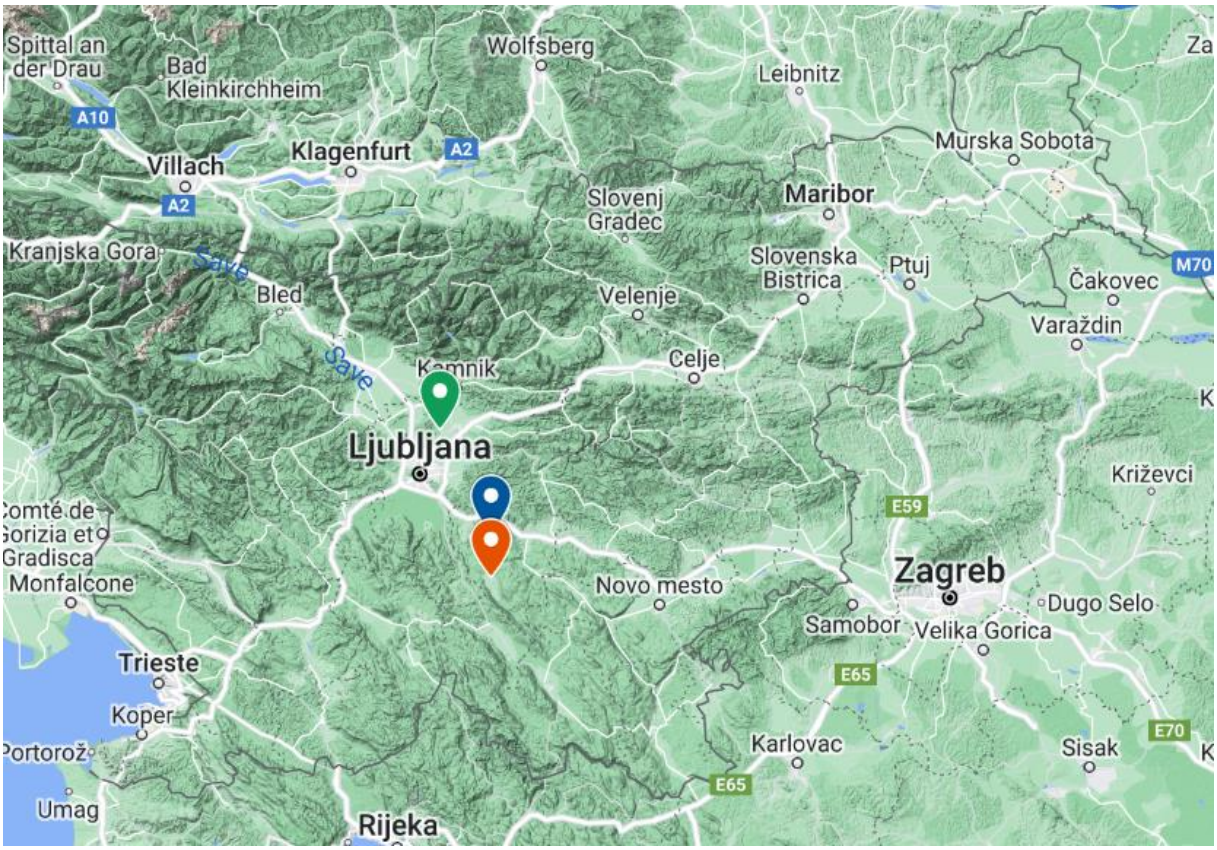
Funded by European Union
Horizon 2020
Grant agreement No 771367

Zita	518	61	173	0.41

5.3 Buckwheat farmer participatory trials in Slovenia

5.3.1 Methods

The participatory plant breeding (PPB) trials of buckwheat within the ECOBREED project were conducted on two organic farms and on organic fields of the Institute in central Slovenia (Fig 50).



Name place	Farm Elevation	Type of landscape	Pedo-climatic zones/regions	Farm size	Farm type	Organic since (years)
Grosuplje	335	Valley	Continental temperate climate	12	Mixed	+20
Videm Dobrepolje	441	Valley / "plateau"	Continental temperate climate	24	Mixed	+12
KIS	300	Plain	Continental temperate climate			+5

Fig 50 Locations of buckwheat trials and main characteristics of the locations.

A total of 4 buckwheat varieties and composite crossing populations (Čebelica, CCP1, CCP6, CCP7) were selected for testing by researchers and variety experts. The varieties were selected based on competitiveness against weeds, growth duration, seed weight, flower colour and other characteristics. The preceding crops before the buckwheat trial

Funded by European Union
Horizon 2020
Grant agreement No 771367

were different on the individual farms and institutes (Table 59). At all sites, buckwheat was already included in the crop rotation and the farmers were familiar with the buckwheat technique. Sowing took place on June 30 and July 1 on both farms with a sowing rate of 90 kg/ha and 100 kg/ha on the farms and 80 kg/ha at the institute. The trials were harvested on October 8 and November 4 on the two farms and on November 9 at the Institute. All varieties at the site were harvested on the same day.

Table 59 Crop succession before buckwheat trial at 4 locations.

("1st crop /2nd crop": 1st crop following by a 2nd crop in a same year)

	2019	2020	2021	2022	2023
Grosuplje	Clover- grass mixture	Maize	Barley / Buckwheat	Maize	Barley / buckwheat trial
Videm Dobrepolje	Grassland	Grassland	Grassland	Barley	buckwheat trial
KIS	Wheat	Maize	Fodder peas	Wheat	Maize / buckwheat trial

To assess the development and agronomic performance of the varieties, the following characteristics were evaluated: plant height, growth height, lodging, plant branching, number of leaves, length and width of leaf blades, compactness of inflorescence, number of seeds per cyme, 1000-seed weight, abiotic stress, biotic stress, seed yield, chemical analysis (crude protein content, rutin content). In Slovenia, additional characteristics such as growth and shoot growth, plant branching, number of leaves, leaf blade length, leaf blade width, compactness of the inflorescence and number of clusters per cyme were also evaluated. Farmers managed the cultivation and were responsible for sowing and harvesting and provided some information on yield, abiotic stress and biotic stress.

The weather conditions during the growing period were extremely wet in summer (Fig 51). A hailstorm occurred on Videm, which caused considerable damage to the Čebelica and CCP1 trial. After that, weeds outcompeted the crop and wild animals damaged buckwheat plants at the trial.

Funded by European Union
Horizon 2020
Grant agreement No 771367

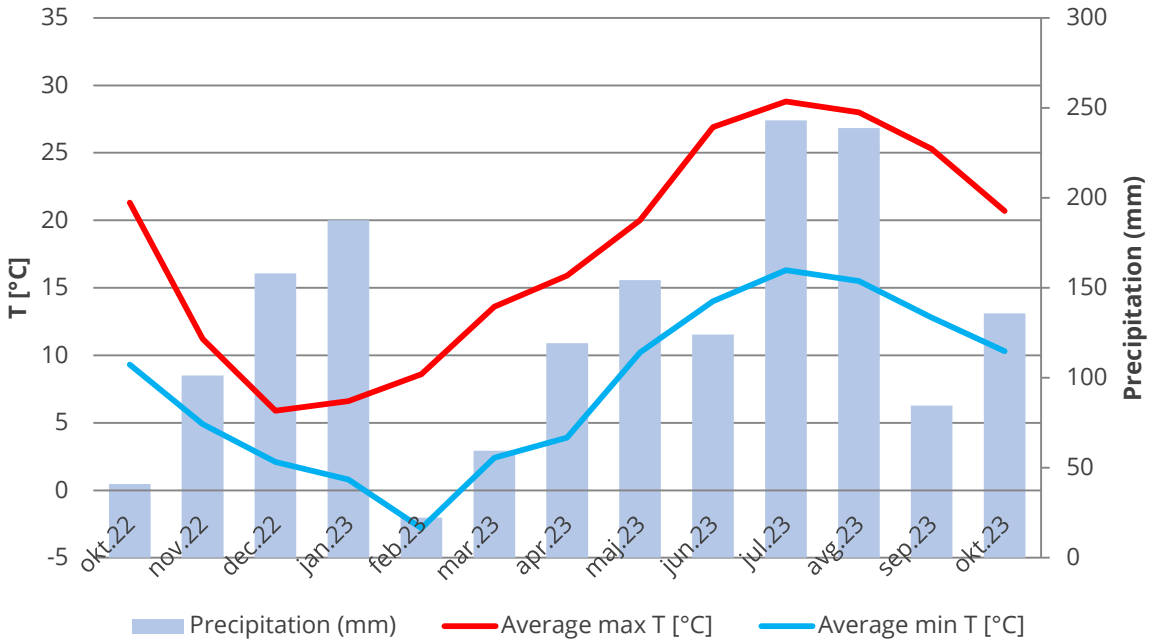


Fig 51 Weather conditions for season 2022/23 (data for Grosuplje).

5.3.2 Results

At Videm Dobrepolje, the abiotic stress and biotic stress were high. Hail, lodging of plants and deer affected both varieties (Photo 52 and Photo 53). Trial was carried out, but the yield was obviously affected.

Fig 52. Trials injured by heavy storms in Marolt Farm at Videm Dobrepolje, July 2023.

Funded by European Union
Horizon 2020
Grant agreement No 771367

Figure 53. Lodging of the trial in Marolt Farm at Videm Dobrepolje, 29th of September 2023

Plant height is presented in Fig 52 and crop height in Fig 53. Čebelica was the tallest at Videm Dobrepolje (127 cm) and Grosuplje (85 cm). CCP6 had the lower plant height in Grosuplje (71cm). CCP1 and CCP6 were shorter compared to Čebelica and CCP1 was less affected by lodging compared to Čebelica in Videm Dobrepolje (Fig 54).

Funded by European Union
Horizon 2020
Grant agreement No 771367

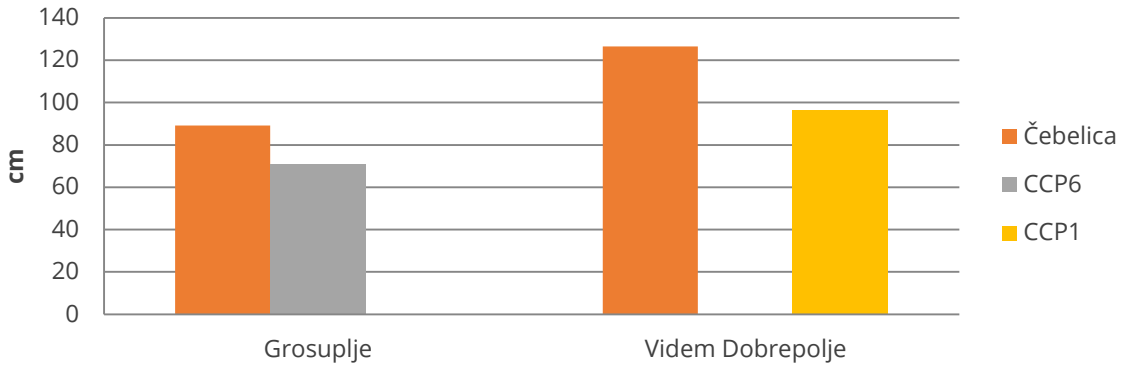


Fig 52 Plant height of buckwheat on 2 farms.

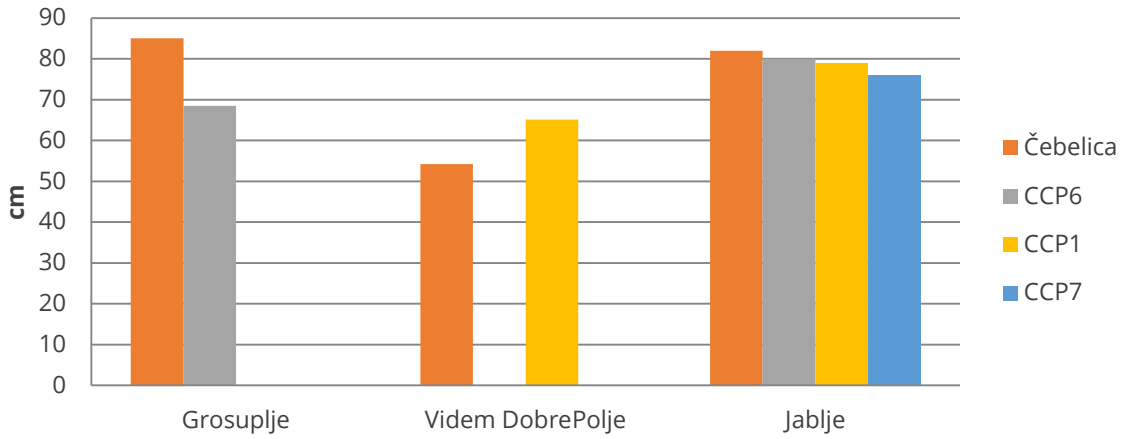


Fig 53 Crop height of buckwheat varieties grown at 3 locations.

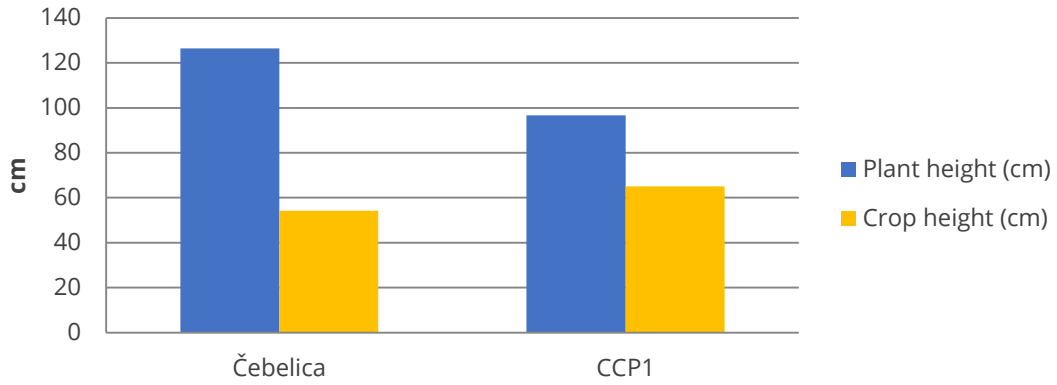


Fig 54 Comparison of plant and crop height of buckwheat varieties at Videm Dobrepolje.

The grain yields are listed in Table 60. Yields at Videm Dobrepolje were lower due to biotic and abiotic stress. Čebelica achieved the highest yield (700 kg/ha) and CCP1 the lowest (280 kg/ha). In Jablje, where the 4 varieties and populations were tested, Čebelica achieved the lowest yield (424 kg/ha) and CCP1 the highest yield (565 kg/ha).

Funded by European Union
Horizon 2020
Grant agreement No 771367

Table 60. Grain yields of buckwheat varieties at the locations Grosuplje, Šentjernej and Ponikva

Yield (kg/ha)	Grosuplje	Videm Dobrepolje	Jablje
Čebelica	700	333	424
CCP6	600	-	461
CCP1	-	280	565
CCP7	-	-	462

The varieties were described according to various criteria, which are shown Fig 57-61. CCP 1 achieved the highest score for plant branching compared to CCP6 and Čebelica (Fig 57). The number of leaves was very low in CCP6 because maturity was reached (Fig 58). CCP6 appeared as an earlier variety compared to Čebelica.

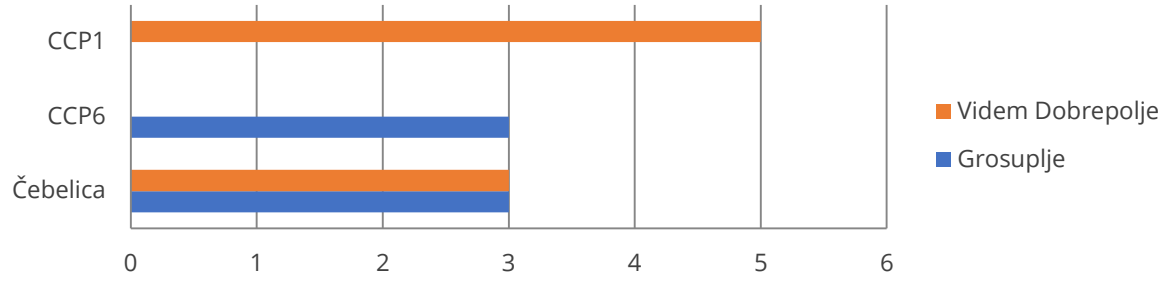


Fig 55 Comparison of plant branching of buckwheat varieties for 2 locations (from 1 to 9)

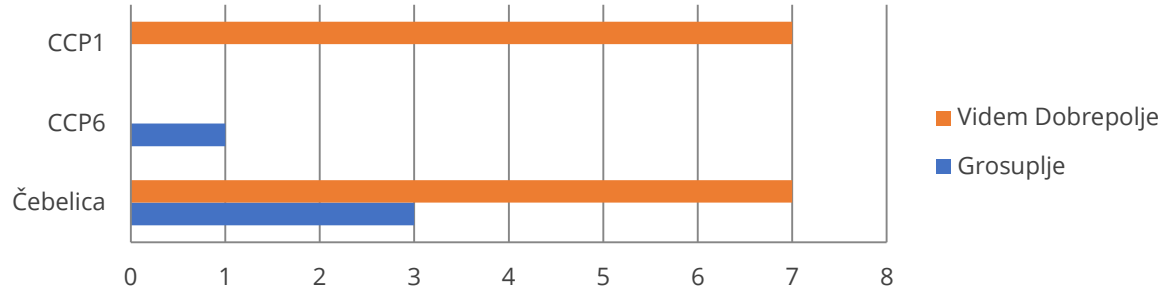


Fig 56 Comparison of leaf number of buckwheat varieties for 2 locations (from 1 to 9)

The flowering of buckwheat was compared with the number of flower clusters per cyme (Fig 59). Čebelica achieved the higher number of clusters per cyme (4 and 6). CCP1 had the lower number of flower clusters (3), and the flower colours of CCP1 varied from plant to plant. This was considered a strange feature by farmers compared to the colour of Čebelica, which was more uniform (Fig 60).

Funded by European Union
Horizon 2020
Grant agreement No 771367

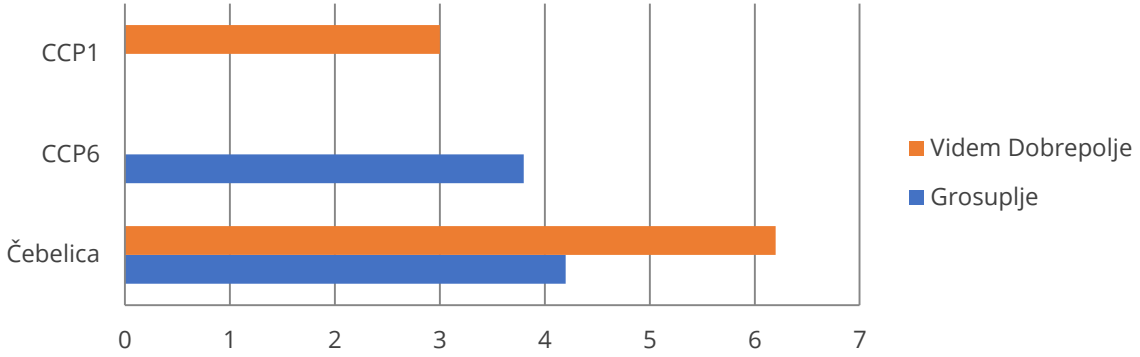


Fig 57 Comparison of number of flower clusters per cyme.

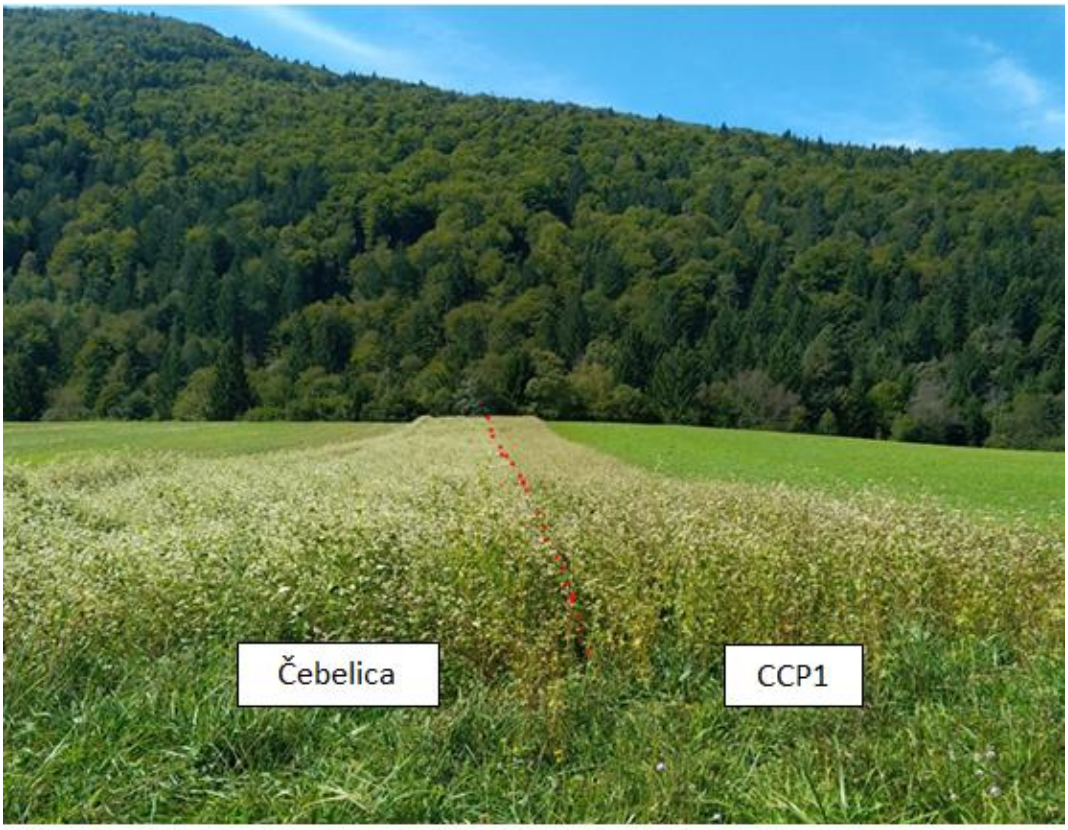


Fig 58 Buckwheat trial on Marolt Farm at Videm Dobrepolje, 4 September 2023.

CCP1 reached the highest number of seeds per cyme (24) (Fig 61). Čebelica had an average of 8 seeds per cyme in Grosuplje and 18 in Videm Dobrepolje. CCP6 had the lowest number of seeds per cyme (4). CCP6 reached the higher 1000-seed weight (23.9 g) (Fig 62). Čebelica had the lower average of 20.6 g for 2 locations.

Funded by European Union
Horizon 2020
Grant agreement No 771367

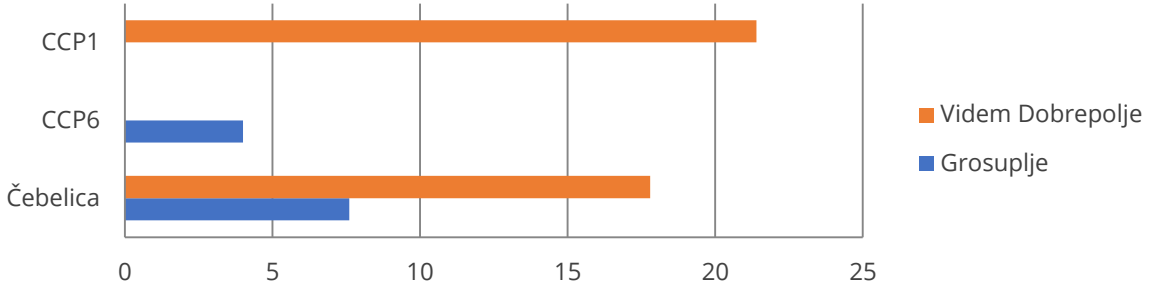


Fig 59 Comparison of seeds per cyme.

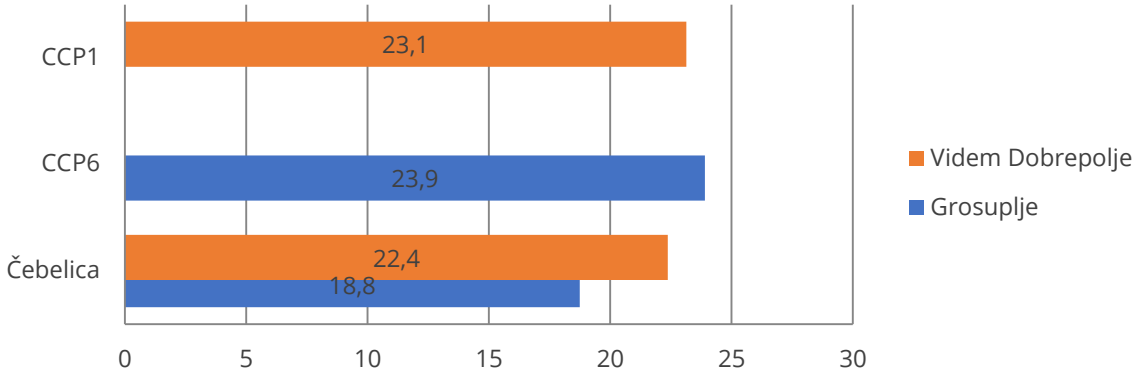


Fig 60 Comparison of 1000-seed weight (g).