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Report on Participatory Plant Breeding

Werner Vogt-Kaute,
Miroslava Apacsová-Fusková,
Maria Bernhart, Adam Brezáni,
Marion Champailler, Peter Dolničar,
Vuk Đorđević, Pavol Hauptvogel,
Katarina Janovicková, Bojan Jocković,
Aleš Kolmanič, Peter Mikó, Simon Ograjšek,
Mario Pagnotta, Jarosław Plich, Zsolt Polgár,
Anna Pearce, Beata Tatarowska, Ion Toncea

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ABSTRACT (FOR DISSEMINATION)	Participatory plant breeding started with wheat and potatoes in 2021. Soybeans and buckwheat were added in 2022 and 2023. At 62 farms populations or breeding lines were evaluated or selected. With the distribution of CCPs (composite cross populations) and breeding lines ECOBREED gave farmers the chance to identify future possibilities for activities on their farms both in seed multiplication and breeding. The trials gave the opportunity for exchange between researchers, farmers and stakekholders and increased awareness on organic breeding and increase the use of organic seed, organic varieties and organic heterogenours material
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Executive summary

The ECOBREED consortium was able to mobilise 68 farmers in 12 countries to carry out farmer participatory trials. The FPTs gave the base to spread know-how to other farmers and stakeholders, increase awareness on organic breeding and increase the use of organic seed, organic varieties and organic heterogenous material. This was done by field visits, training events, demonstration events, other meetings, publications and presentations.

At 62 farms populations or breeding lines were evaluated or selected. With the distribution of CCPs (composite cross populations) and breeding lines ECOBREED gave farmers the chance to identify future possibilities for activities on their farms both in seed multiplication and breeding.

The situation on availability of populations was different in the different crops. In wheat some CCPs were already available at the beginning of the project (Wakelyn's, Liocharls, MV elit CCP) and could be used from the beginning of the project in the pre-trials 2019-2020. As the CCP developed by KIS/RGA did not show promising results in the first trials at ATK work on that CCP was not continued. The MAGIC population was developed by BOKU and other partners and could by grown by some partners 2022-2023. IFVC developed the new CCP NS Obi, ATK MV Bio 2020.

For soya and buckwheat populations had to be developed in the ECOBREED project. Formation and multiplication were done by IFVC for soya and RGA for buckwheat. Distribution of soya and buckwheat CCPs had to be postponed from month 36 to month 48 to have enough seed to conduct several trials.

Wheat selection by farmers was done especially in Hungary. In other countries it was more an evaluation that was done. Therefore, the trials in Hungary delivered the most interesting results on creation of sub-populations by farmers. In 2023, the trials were overshadowed by a heavy attack of yellow rust not known before in Hungary and by occurrence of common bunt in the populations. In UK the farmers liked the Wakelyn's population. The population grew well. It was stable, never the highest yielding and never the lowest. Wakelyn's population did however show a good protein level: Tendency to lodging was too high in locations with potential for high yield. Farmers started to do trials with variety mixtures in 2023 but did not see any benefit to growing the mixtures in terms of yield and quality. The mixture results were very similar to the average of the pure varieties that made up the mixtures. In the Slovak Republic MV elit CCP had medium results. In 2023 new populations were tested with a wide range of yield results. In Austria the populations Liocharls and MV elit CCP did not have good results, but these populations were not developed for Austrian conditions. There is a huge competition in wheat breeding activities for organic farming, so it is very hard for a population to become

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popular. There are more activities necessary in breeding populations. The results from Hungary show how a ready to use system can work. Environmental stability of the populations was often lower than expected.

It was interesting that trials with populations increased farmers' interest in variety mixtures. Variety mixtures seem to be easier to understand for farmers and can show good results. We also see a growing interest in variety mixtures in different countries (United Kingdom, Germany, Romania, France) but we need more knowledge to create variety mixtures that outperform the individual varieties.

As soya and buckwheat populations were new to farmers selection of those CCPs did not start yet. The CCPs did not look so heterogeneous to be attractive to start selection immediately. Usually, evaluation and selection is done by researchers and farmers together (Saatzucht Gleisdorf) which has a similarity to the potato breeding system that was chosen in the project. But there seems that what happened was an adaption of CCPs in some locations in the second year so it is interesting to see what will happen in future. Buckwheat populations had very long vegetation period, with uneven maturation and long flowering duration. Such populations are not suitable for grain production, but they can act as an excellent forage for bees.

With the observations and results of the ECOBREED we have to notice that CCPs/OHM are still far away from having a high percentage in production. The ECOBREED gave some basics for future activities. Many breeding efforts in many crops are needed to develop competitive CCPs.

For potatoes a different strategy for participatory plant breeding was chosen. There were discussions with farmers and partners. Farmers do not wish to get potato CCPs. Instead of distribution of CCPs early lines were distributed to farmers for evaluation (similar to the Dutch system). IHAR started this in 2021 with distribution of 14 lines to 2 farms (10 tubers per line and farm).

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Introduction

Participatory Plant Breeding 2020 - 2021

Participatory plant breeding on wheat started in 2021 according to plan. Distribution of soya and buckwheat CCP's had to be postponed to 2022 due to insufficient seed to conduct several trials. In Poland the first two evaluation trials on farms could start.

Wheat CCPs could be distributed to farms and were sown in most wheat FPTs.

- Total number of farms that have sown CCPs: 18
- Total number of CCPs: 25

The CCPs that were sown were:

- Wakelyn's YQ: 4 (UK)
- Liocharls: 3 (UK, AT)
- 1109: 1 (UK)
- Mv elit CCP: 14 (AT, SK, HU, RS)
- Mv Bio2020: 3 (HU)

Potatoes:

- In Poland 15 selected breeding lines were evaluated on two farms.

Table 1 Number of wheat farms and CCPs in 2021.

	SMA	GS	IFVC	BOKU	MTA	BIOMILA	NPPC
Farms	4	1	2	4	3	3	1
CCPs	6	1	2	6	6	3	1

Participatory Plant Breeding 2021-2022

Participatory plant breeding on wheat was continued according to plan. A new CCP (NS Obi) could be sown in one trial in Serbia. Early breeding lines of potatoes were distributed to four farms in Poland, three farms in Slovenia and two farms in Hungary. There were delays and problems with the shipment of buckwheat and soya so the full amount of PPB trials was reached in 2023.

MS24 (formation and distribution of CCP to farmers) was reached on 28th September 2022.

Wheat

Wheat CCPs were distributed to farms and were sown in most wheat FPTs.

Table 2 Number of wheat farms and CCPs 2022.

	SMA	IFVC/GS	BOKU	MTA	BIOMILA	NPPC	IFVC	UNITUS	PRO-BIO
Farms	4	1	3	5	3	1	1	3	1
CCPs	6	1	4	7	3	1	2	3	2

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Total number of farms that have sown wheat CCPs: 22

Total number of wheat CCPs: 29

The CCPs that were sown were:

- Wakelyn's YQ: 2 (UK)
- Liocharls: 7 (UK, AT, CZ)
- Mv elite CCP: 12 (AT, SK, HU, RS, CZ)
- Mv Bio2020: 2 (HU)
- NS Obi: 1 (RS)
- Mix population: 3 (IT)

Soybean

There were a few problems with distribution of soya CCP. Shipment from Serbia to Slovenia was held up by customs and partially lost by the courier. The back-up sample was transported to the general assembly meeting (30-31.5.2022) in Hungary and brought by KIS staff to Slovenia. Due to late arrival, CCP was sown only at one farm PUCIHAR. Amount of seeds was too small for farmers in Romania so they could only sow one trial for further multiplication. SZG has sown three additional CCPs at Jugovits farm in Austria.

Table 3 Number of soybean farms and CCPs 2022.

	NAT D	NAT/SZG AT	IFVC	KIS	NARDI
Farms	3	1	4	1	1
CCPs	3	4	4	1	1

Buckwheat

Buckwheat CCP was distributed too late by RGA. It could only be sown in two trials in Slovenia and at CRI in Czech Republic. Seeds for UK were transferred at EB meeting in Prague on 28 September 2022.

Table 4 Number of buckwheat farms and CCPs 2022.

	KIS	PRO-BIO	SMA
Farms	3	1	-
CCPs	3	1	-

Potatoes

Early potato lines were tested on four farms in Poland, three farms in Slovenia and two farms in Hungary.

Table 5 Number of potato farms and early lines 2022.

	KIS	IHAR	MATE
Farms	3	4	2
Breeding lines	42	60	12

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Participatory Plant Breeding 2022-2023

Wheat

More wheat populations based on two populations were distributed and sown on two farms. Trials with variety mixtures started in the UK.

Table 6 Number of wheat farms and CCPs 2023.

	SMA	IFVC/GS	BOKU	MTA	BIOMILA	KIS	IFVC	UNITUS
Farms	5	1	3	6	1	1	1	1
CCPs	5	1	12	21	22	1	1	1

Total number of farms that have sown wheat CCPs: 19

Total number of wheat CCP plots: 64

The CCPs that were sown were:

- Wakelyn's YQ: 5 (UK)
- Liocharls: 2 (SI)
- Mv elite CCP: 8 (AT, HU)
- Mv Bio2020: 2 (HU)
- NS Obi: 1 (RS)
- Mix population: 1 (IT)

New wheat populations 2023:

- SK 1 farm with 22 different populations (BOKU OHM)
- AT 1 farm with 8 different populations (BOKU OHM)
- HU 2 farms with 8 populations (sub 1-8)

New: variety mixtures in UK

5 farms with 4 different mixtures in total 10 plots.

Soybean

Two more populations were developed and tested. Amount of seeds was again too small for farmers in Romania.

Table 7 Number of soybean farms and CCPs 2023.

	NAT D	NAT/SZG AT	IFVC	KIS	NARDI
Farms	3	1	3	2	1
CCPs	3	6	3	2	1

Total number of farms that have sown soya CCPs: 10

Total number of soya CCP plots: 15

New populations 2023: SZG has sown 2 more CCPs at Güssing Farm in Austria.

New variety mixtures in RO: 3 farms with 3 different mixtures in total. 9 plots

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Buckwheat

Table 8 Number of buckwheat farms and CCPs 2023.

	KIS	PRO-BIO	SMA
Farms	3	3	2
CCPs	3	6	6

Total number of farms that have sown buckwheat CCPs: 8

Total number of buckwheat CCPs plots: 15

New populations in 2023: 6 more CCPs/Snys sown in UK and CZ (Syn 21, Syn 22.1, Syn 22.2., Syn 22.3, CCP 4, CCP 8).

Potato

Early potato lines were tested on 3 farms in Poland, 3 farms in Slovenia and 3 farms in Hungary.

Table 9 Number of potato farms and early lines 2023.

	KIS	IHAR	MATE
Farms	3	3	3
Breeding lines	40	29	9

Total number of farms that have sown potato early lines: 9

Total number of potato early lines plots: 78

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Wheat

Participatory plant breeding in Serbia

2022

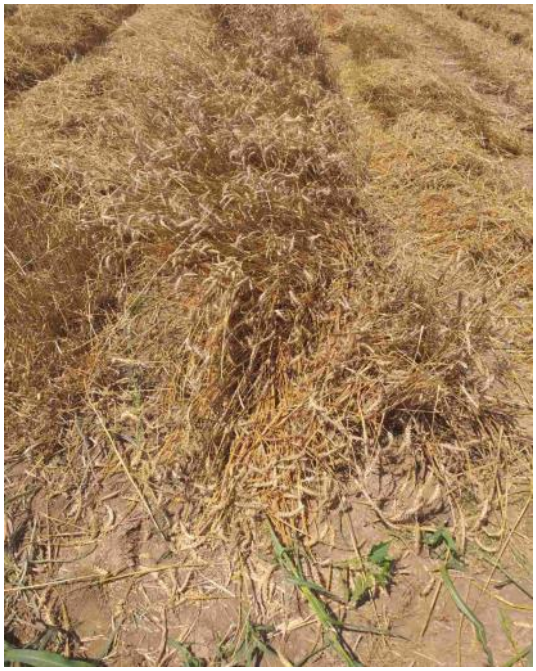
In 2021/2022 we conducted Task 6.3. wheat trial on one location in Serbia. Golden Grain (Zlatno zrno) Farm is certified organic. The trial consisted of 3 plots (plot=2x1 m), 6 rows per plot, hand sowed. NS OBI-CCP is the name of the wheat population.

- Šuljam-Ignjat Jurišić (Zlatno zrno)
- Sowing date: 17.11.2021.
- Harvest date: 08.07.2022.
- GPS: 45.05'33.4'' N, 19.41'04.7'' E

2023

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 consisted of 1 plot (plot=20x1m), 10 rows. Sowing date was 02.11.2022. Sowing was done at the optimal time (HEGE sowing machine) and sowing density was 500 seeds/m^2. Pre-crop was soybean. Yellow rust occurred, as it was a big problem in Serbia during 2023. NS OBI was harvested on 18 July 2023, using a Wintersteiger plot harvester. After harvest, all samples were collected and data analysis was performed – results are available in data sheet (disease screening, sedimentation, falling number, protein and etc.).

NS OBI-CCP, 2023



NS OBI-CCP, 2023

Fig 1 NS OBI CCP in Serbia 2023.

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Participatory plant breeding in Italy

During the visits at the farmer' fields as well as during the training events several discussions with farmers on breeding goals have taken place. In addition, the farmers were asked to evaluate the lines present in the field by filling a questionnaire and giving different scores of some traits.

In 2021, the material provided to the farmers for their evaluation was a series (nine) of lines; moreover, a mixed population which consisted of an equal proportion of the above-mentioned lines. The mix population was harvested in 2022 and the re-own with the idea was that the different environments select for the most resistant accessions.

Participatory plant breeding in the Slovak Republic

Participatory plant breeding was established during 2020 - 2023 on the following farms:

- SEMA HŠ s.r.o., Nový Dvor, 92521 Sládkovičovo
- Biomila SK, s. r. o., Rudník 428, 906 23
- SHR Vladimír Zeman
- SHR Martin Kolárik
- Research station at Borovce

SEMA HŠ s.r.o., Nový Dvor, 92521 Sládkovičovo

During the season 2020/2021, the following varieties were sown: Aurelius, Hungary population MV Elit CCP, Ehogold, Viki, Wendelin, PS Dobromila, IS Laudis, and Arnold. The list includes one population.

The trial was established on 24th September 2020 in plots with a minimum plot size of 300 m^2, and the harvest was done on 27 July 2021. Prior to the seeding, weeds were controlled using the stale seedbed method. The sowing density was 450 plants per m^2 at each location.

Approximately 1kg of representative grain sample was used for moisture and quality analyses (proteins, moisture, starch, volume weight, sedimentation index, falling number, dry matter, and nitrogen).

Hungarian population showed a protein content of 11.83%, which was surpassed. The highest was reached by Wendelin 12.81%. The worst performer in this regard was IS Laudis 11.49%. The sedimentation index also revealed the quality gap between Hungary population and the others. Hungary population achieved 39 ml, while the best result was Wendelin's 43 ml and the worst was Ehogold's 34 ml. The wet gluten percentage ranged from 26.4% (Wendelin) to 21.8% (Ehogold), with the Hungarian population scoring 24.6%. The starch content varied from 62.3% (Ehogold) to 58.9% (Viki), and Hungarian population had a moderate 60.2%. Hungarian population impressed with the highest test weight of 82.5 kg/hl, leaving behind the others, especially Viki with a low 75.3 kg/hl.

Hungarian population also excelled in yield, reaching 6.65 t/ha, which was the third-best among the group. The top yielder was IS Laudis with 7.15 t/ha, but this variety also suffered more from diseases and pests, especially Septoria, which rated 4 on the severity

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scale and pests with number 9. Hungarian population had a medium plant height of 108 cm, compared to the tallest Ehogold (118 cm) and the shortest Wendelin (103 cm).

The populations were absent from the trial in the season 2021/2022, as they faced two major problems: a severe infestation by grain weevil (*Sitophilus granarius*), which damaged the seeds, and a shortage of seed material, which prevented replanting of the affected plots.

The trial in SEMA HŠ s. r. o. in season 2022/2023 was sown on the 8th of October 2022, but the list did not include any CCPs because of the lack of seed material again.

BIOMILA SK, s.r.o./ SHR Vladimír Zeman/ SHR Martin Kolárik

The season of 2020/2021 was a tough one for the trial in Polianka and Rudník, which included eight varieties: Aurelius, the Hungarian population MV Elit CCP, Ehogold, Viki, IS Laudis, PS Dobromila, Wendelin, and Arnold. The trial faced many difficulties, such as late sowing dates due to bad weather and a lack of agricultural machinery. The trial also suffered from the attacks of wild animals, such as wild boars, fallow deer and red deer, which destroyed the crops and made the harvest impossible. The population was discontinued in the following seasons 2021/2022 and 2022/2023, as there was not enough seed material left to replant the damaged plots.

Borovce experimental fields

The season of 2022/2023 was a new opportunity for the trial with populations. The trial included 22 *Gpc-B1* materials, which were sown on October 14th and showed healthy and promising growth. However, some of them were more prone to rust, Septoria glume blotch and leaf spot diseases than others, and some also exhibited enhanced leaf senescence. The harvest was completed on 15th July 2023 and the yield data was collected and analysed. A representative grain sample of 1 kg was used for moisture determination and quality analyses, which measured the levels of protein, moisture, starch, volume weight, sedimentation index, falling number, dry matter and nitrogen. First six materials were sown in two replications.

The trial showed a wide range of yield results, from the impressive 4.37 kg/plot of 6110 BTX609 to the dismal 0.42 kg/plot of 7208 06IFAFS227 159, which was almost wiped out by mice. The sedimentation index also varied greatly, with 6408 BTX501-GpcB1 leading the pack with 48 ml and 6206 EBLK579-86-88 lagging with 31 ml. The starch content was inversely related to the sedimentation index, as 6408 BTX501-GpcB1 had the lowest value of 58.8 % and 6208 EBLK586-609 had the highest value of 61.6 %. The protein content was another important quality indicator, and 6710 06IFAFS3 stood out with 12 %, while 6209 EBLK580-1-2-90 had 8.6 %. The wet gluten percentage followed a similar pattern, with 6408 BTX501-GpcB1 reaching 24.7 % in the first repetition and 6209 EBLK580-1-2-90 dropping to 15.6 %.

The season of 2023/2024 will be another exciting one for the trial, which expanded to include the Early and Late Magic populations, with a plot size of 10 m^2. The sowing date was 20th October 2023 and the trial is expected to produce valuable results.

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Fig. 2 SEMA HŠ s. r. o. season 2020/2021.

Fig. 3 BIOMILA SK, s. r. o. season 2020/2021.

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Fig. 4 SHR Vladimír Zeman and SHR Martin Kolárik season 2020/2021.

Fig. 5 Research station in Borovce season 2022/2023.

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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 for 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. All farms are part of the on-farm trial network of ÖMKi (Hungarian Research Institute of Organic Agriculture), the research partner of ATK (Centre for Agricultural Research).

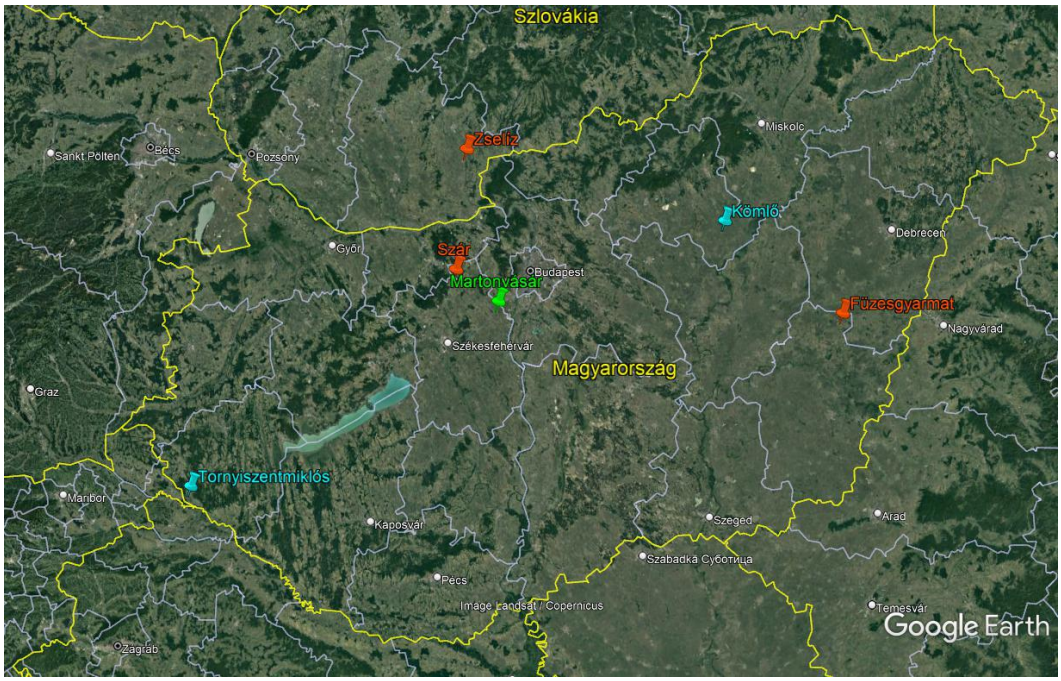

Fig. 6 Locations of participatory plant breeding trials organised by ATK. Participating organic farms are in red (2021-2023) and blue (2022-2023), breeding station (ATK) in green.

Similarly to the previous years, cultivars were evaluated by farmers during the vegetation period in 2023. After farmer variety selection carried out in 2022, the 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 of ATK visited the farms and they discussed the steps of observation, selection and harvest of trials with farmers. Unlike the year 2022, precipitation was not a limiting factor in 2023, but due to the mild winter and cool Spring, fungal pathogens caused severe symptoms on the 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 1 m^2 areas of each medium sized plots on the farms. Trial on the farm near Szár was operating with smaller plots, thus they were harvested in total using a small plot combine harvester. Yield and quality data for the 2023 on-farm

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trials are shown in Table 1 (medium sized plots) and Table 2/Fig 2 (small plots). Yield results of participatory trials are hard to be used for comparison, because of 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) produced milling quality wheat samples. In most farms, the variety Mv Pántlika exceeded 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 average in 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 could perform 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 10).

Table 10 Agronomic results of Mv cultivars tested in 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/100L	% 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%

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The small-plot PVS trial was harvested in Szár, and after 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. Significant difference was not found between the cultivars, because the standard deviation was too high. The two populations were below the trial average, showing similar yielding ability.

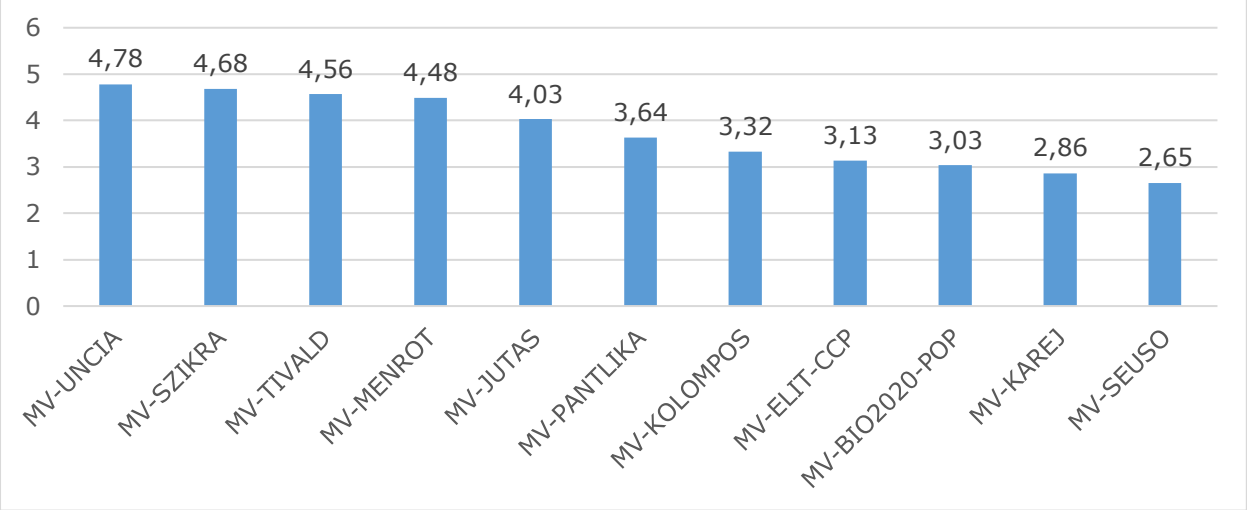

Fig. 7. Grain yield (t/ha) of 11 Mv cultivars grown on organic replicated small plots (Szár, 2023).

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 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 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 11).

Table 11 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/hl)	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	22.00	21.0	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

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Our participatory plant breeding (PPB) programme 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. 8). 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. 8 Farmer selecting his own spikes as a first step in 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 trial 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 could be scored for their tolerance against this fungal disease in 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 the sub-population selected in Szár, which was infected similarly. Average heading date of the sub-populations was similar to 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. In the same time, the farmer in Szár preferred shorter plants, thus the height of his sub-population was similar to that of the mother population.

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Table 12 Assessment data and grain yield of PPB sub-populations developed by the participating farmers and grown on 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	avg.	on-station	on-farm	avg.	on-station	on-farm	avg.	on-station	on-farm	avg.	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	5.5	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-population. 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. On the basis of this, it can be concluded that yielding ability of Mv Elit CCP decreased by 7.5 %, while this trait was improved by 18.1 % in the case of the other, more diverse population (Tables 12 and 13).

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Table 13 Analysis of variance of the grain yield of 2 winter wheat populations and their subpopulations developed by the participating farmers and grown in organic fields of ATK (on-station) and Szár (on-farm) (Hungary, 2023).

2-factor ANOVA, randomized 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	0.94		

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%

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As the participatory trials on populations were resown for four years, severe bunt infection was detected during the latest harvest, i.e. in 2023. Therefore, as a consequence, all harvested seed samples had to be destroyed to avoid the 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. 4). The demonstration event was co-organised by ÖMKi and ATK.

Fig. 9 Organic Field Day at Szár, 21 June 2023.

Participatory plant breeding in the United Kingdom

Cross composite populations

We have grown YQ Wakelyn's Population cross composite population in every year of wheat trials in the UK (one site 4 years, 3 sites 3 years, one site 1 year). Wakelyn's YQ population was bred by Organic Research Centre and is made up of 190 crosses among 20 different parent varieties – 19 modern wheats and one old wheat (1930-2000).

The population grew well. It is very stable, never the highest yielding and never the lowest. Wakelyn's population did however show a good protein level, being the highest in 2023 after Wendelin and Alessio (varieties grown in continental Europe).

It is significantly taller than most UK varieties available. This meant that it performed better than others in trials with high weed competition. The height however caused issues in 2023 harvest as plots on two farms lodged close to harvest, making combining difficult. This lodging in turn meant that Wakelyn's population had the lowest average falling number across all of the sites in 2023.

We did also endeavour to grow Liocharls Population, however there was a mix up in the plant breeding and incorrect, pure varietal seed was delivered and sown.

Varietal mixtures

For Crop year 2022/2023, we trialled crop mixtures. At each of the five locations, we grew a wheat crop mixture of all of the previous years harvested wheat trial. We also grew three wheat mixtures arranged in NABIM groups (Group 3 soft, Group 4 soft, Group 4

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hard). The idea was that the end use for the wheat would not be impacted by the use of a mixture if the wheats in the mixture all had the same end use.

We did not see any benefit to growing the mixture in our trials, the mixture results were very similar to the average of the pure varieties that made up the mixtures. This may be due to a number of reasons:

- The varieties in the mixtures were too similar, i.e. they were not selected for the strengths and weakness', e.g. a variety susceptible to yellow rust but good yield was not matched with one with strong resistance but poor yield.
- There is some element of variety already by the nature of a trial. With 4m strips of each variety, so there is already diversity within the field, albeit not quite so mixed.

Potato

Participatory plant breeding in Poland

In 2021, 15 breeding lines were planted at two locations (Tuligłowy and Połomia). In 2022, 15 breeding lines and in 2023, 10 breeding lines were planted in 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 harvest: total yield (kg/bush), tuber shape, depth of eyes, regularity of tuber shape and % starch. In 2021 a high level of damage caused by the Colorado potato beetle was recorded in Połomia. Breeding line damage ranged from 75% to 100%. The damage influenced the low total yield of tubers obtained for the breeding lines in this locality (mean 0,2 kg/bush). The highest tuber yield in 2021 was noted in Tuligłowy for breeding line EB – 21 – 151(2.03 kg/bush). The lowest tuber yield was noted in Połomia for breeding line EB – 21 – 112 (0.07 kg/bush) (Fig 9). 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 10). 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 11). In Połomia was obtained higher yield (0.61 kg/bush) then in Tuligłowy (0.59 kg/bush) and Jadwisin (0.54 kg/bush). On average, the best yields for breeding lines were obtained in 2022 year (Fig 12). Breeding lines (in 2021 and 2022) were also evaluated in laboratory test on resistance to *P. infestans*. Both in 2021 and 2022 all breeding lines were very resistant to *P. infestans*. Mean value range from 8.3 to 9.0 (in scale 1-9; where 9 = very resistant).

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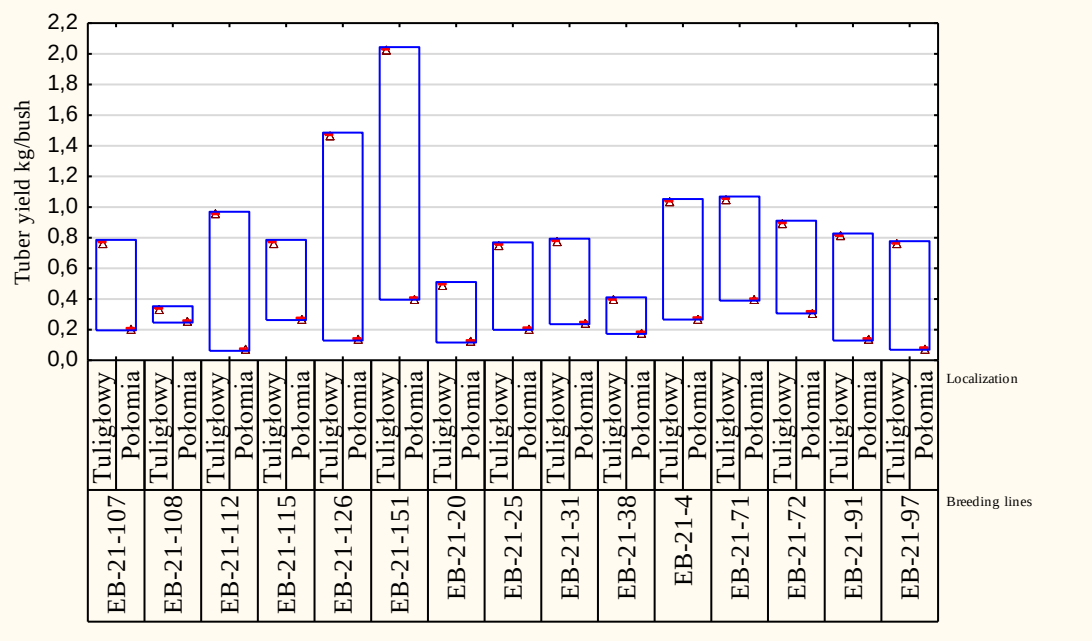

Fig. 10 Total yield (kg/bush) for 15 breeding lines in two locations (Tuligłowy, Połomia) (PL 2021).

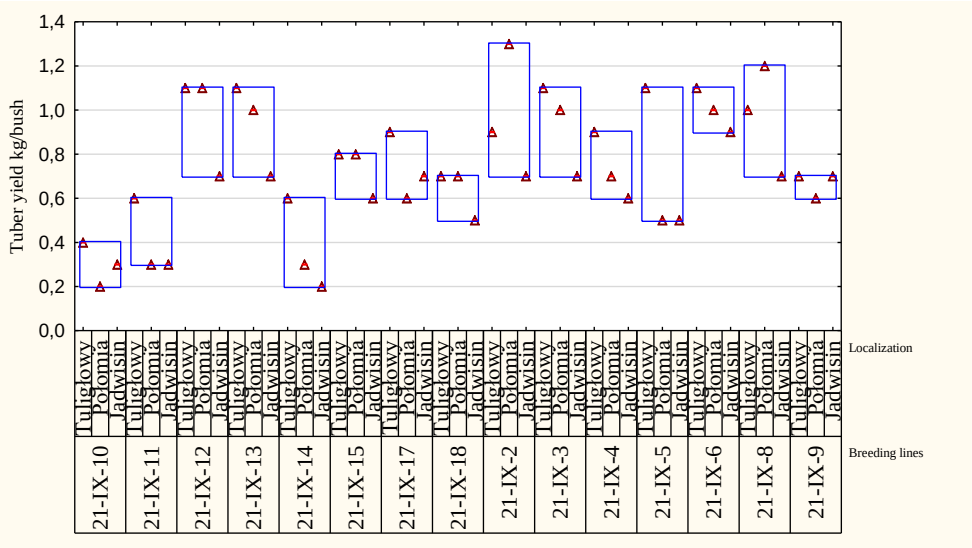

Fig. 11 Total yield (kg/bush) for 15 breeding lines in three locations (Tuligłowy, Połomia, Jadwisin) (PL 2022).

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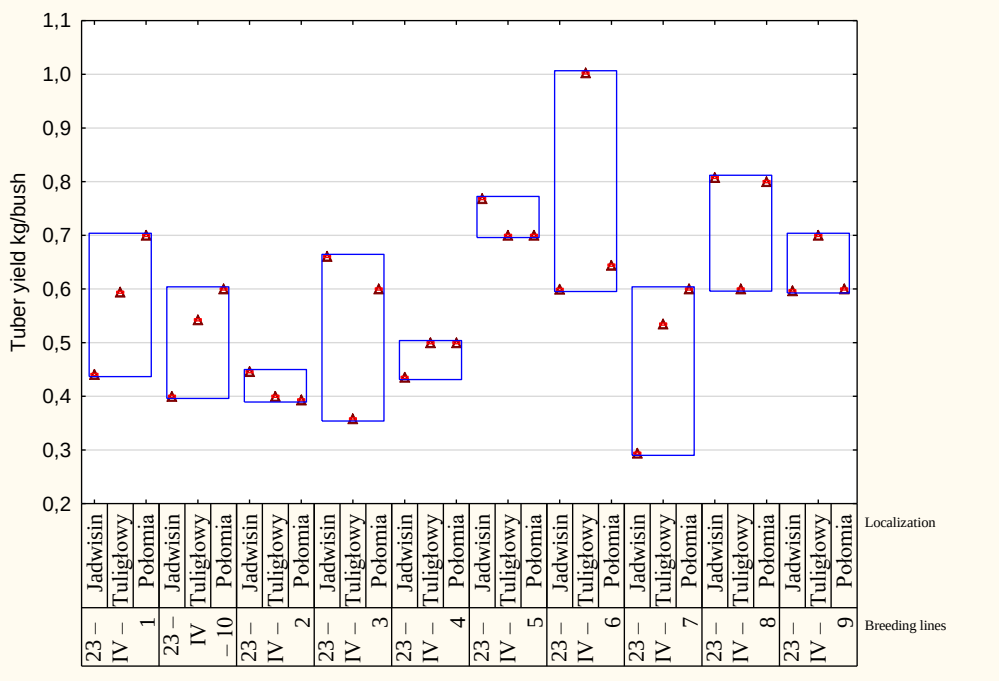

Fig. 12 Total yield (kg/bush) for 10 breeding lines in three locations (Tuligłowy, Połomia, Jadwisin) (PL 2023).

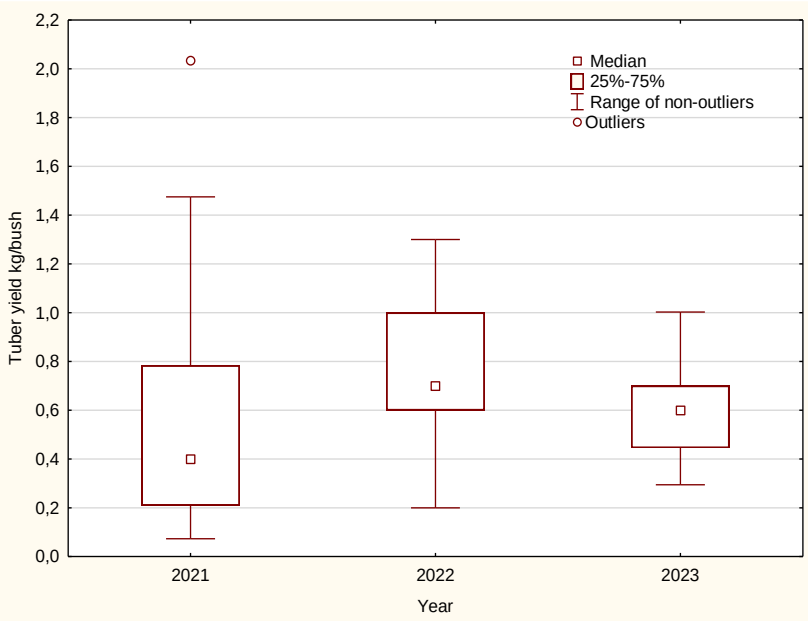

Fig. 13 Results for mean tuber yield (kg/bush) for breeding lines (PL 2021 – 2023).

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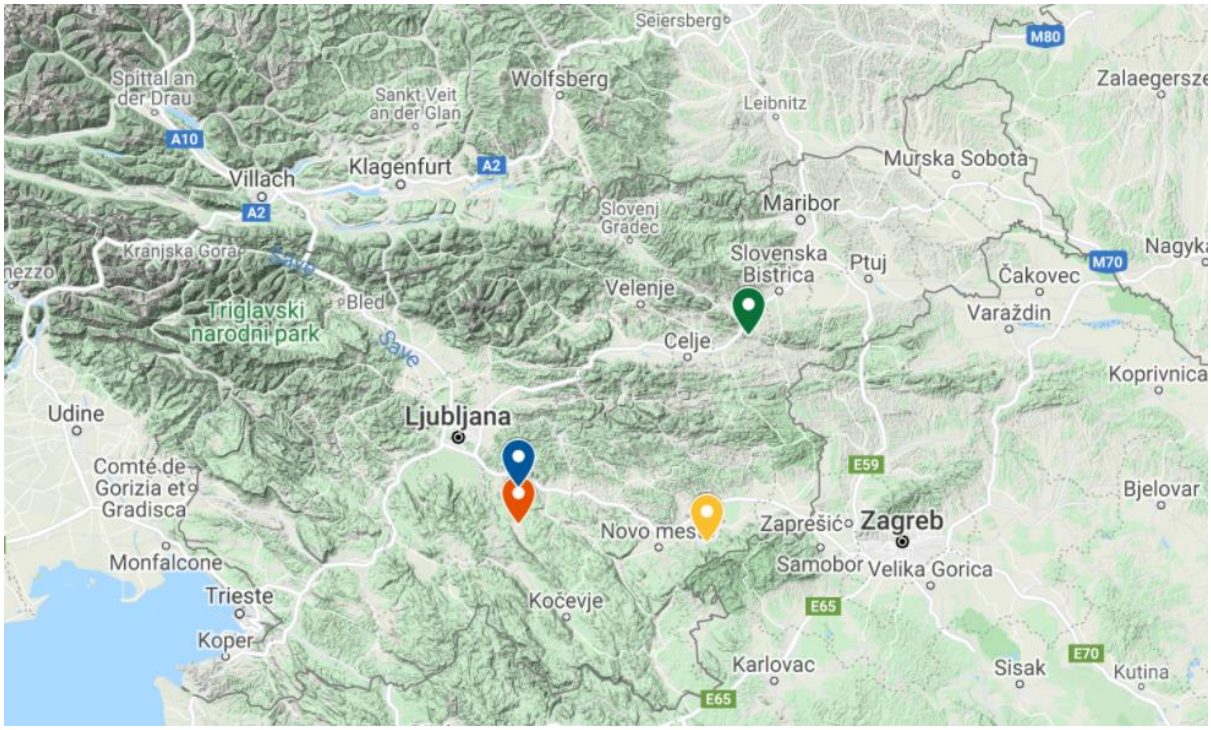
Participatory plant breeding in Slovenia

Methods: Locations and conditions of trials

In 2022, 14 advanced potato clones were planted in PPB trials on four organic farms in Slovenia. After harvest in August, final yield and sensory analyses were carried out at the Agricultural Institute of Slovenia between October and December. Based on this data, a bulletin was prepared for the farmers containing information on the performance of the different potato varieties and clones during the season.

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.



Name place	Localisation	Farm elevation	Type of landscape	Pedo-climatic zones/regions	Farm size (ha)	Farm type	Organic since (years)
Grosuplje	45.93997, 14.69966	335	Valley	Continental temperate climate	12	Mixed	+20
Šentjernej	45.81536, 15.32823	262	Plain	Continental temperate climate	5,5	Mixed	+5
Videm Dobrepolje	45.85744, 14.70223	441	Valley / "plateau"	Continental temperate climate	24	Mixed	+12
Ponikva	46.28915, 15.46301	520	On the hills	Continental temperate climate	8,3	Mixed	+20

Fig. 14 Locations of potato trials and main characteristics

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Trial conditions: The selection of 3 varieties and 13 clones was partly carried out by researchers, farmers and advisors. The aim was to obtain a group of varieties and clones with different characteristics in terms of yield, resistance to late blight and PVY, recovery, skin and flesh colour and other traits.

Table 14 Varieties and clones of potatoes and known properties.

Name of clones or 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

Researchers and farmers/advisors established a set of criteria to compare varieties in different locations with different management: planting date, yield, tuber size, dry matter, cooking type, flavour discoloration of flesh after cooking, tuber disorders, regularity of tuber shape, and depth of eyes. Ten tubers were planted for each clone or variety. Planting took place between April 8 and May 1, 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 cultivation sequences were designed and described by the farmers (Table 15). They varied from one farm to another. The alternation of crops from different plant families interrupts the cycles 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. Vines were grown in Šentjernej for 20 years before 2018.

Table 15 Crop rotation and fertilisation of potato trials on 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)**

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2023 was an exceptionally wet summer. Some fields or parts of fields were flooded during part of the summer (Fig 14). In Grosuplje (20 km from Ljubljana), it rained 320 mm more than in the previous season (1,533.5 mm between October 2022 and September 2023; 1,214.3 mm between October 2021 and November 2022).

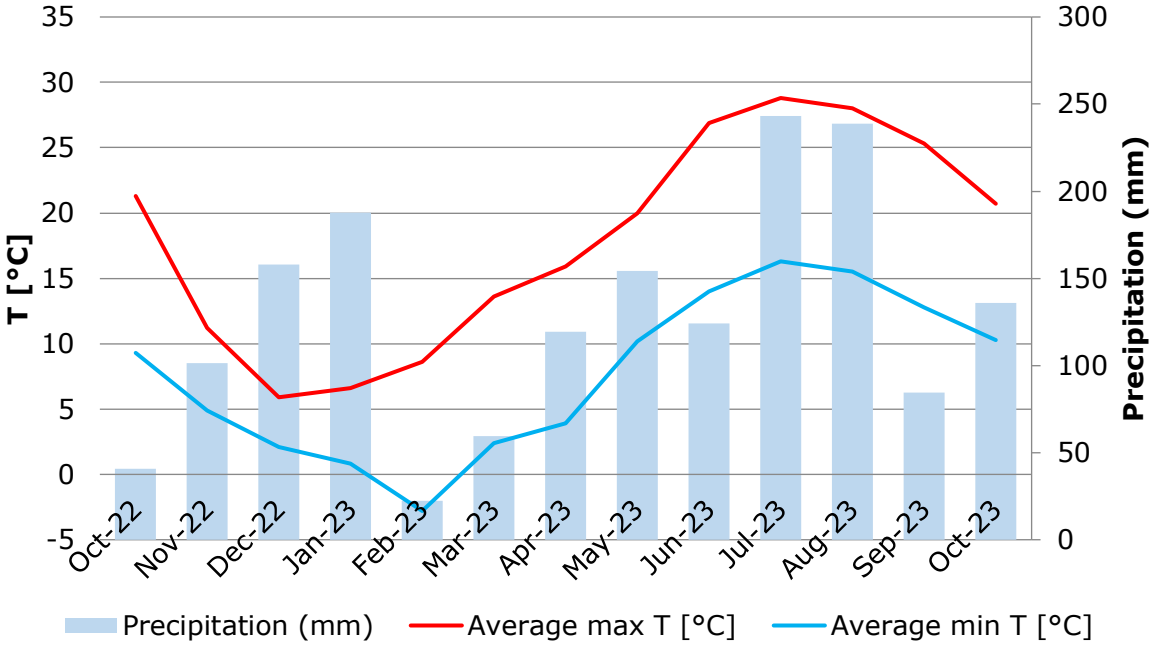

Fig. 14 Weather conditions for season 2022 / 2023 (data for Grosuplje).

Results:

Yield and state of crop:

The conditions in 2023 were challenging; with cold temperatures in spring and high temperatures in summer, the high rainfall and storms in summer affected various locations in Slovenia. According to 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 the storm at the end of July. The Colorado potato beetle and weeds were not perceived as a major problem by farmers. At the end of the season, the farmers were asked several questions to characterise the season with its difficulties and successes: »What do you think were the biggest problems on this potato field this year? « and » What was satisfactory about this potato trial?«.

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Table 16 Difficulties and success described by farmers on 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. Plenty of rain throughout the year. On 25 July, hail destroyed a significant part of the potato leaf mass, significantly affecting the yield of (mainly) late varieties.
Satisfaction /	Observe the difference between clones on our own field and participate in the future of selection lines.	no answer	no answer	Given the extremely difficult weather conditions throughout the year (cold spring, lots of rain, 2x slight "drought" in between, hail, etc.) for potato production, certain varieties/crosses have performed well in spite of everything. In fact, until the hailstorm, the leaf mass was relatively healthy and free of serious disease attacks.

Across the 4 locations, the range of good 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. The variety yields are shown in the table for each location. 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 four locations. The yield of KIS 15-271/235-1 was always above the yield average at three 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 four locations this year, with a difference of -9%, -45%, -50% and -71% to the average values per location. The three already registered varieties showed contrasting results compared to the average values at the individual locations.

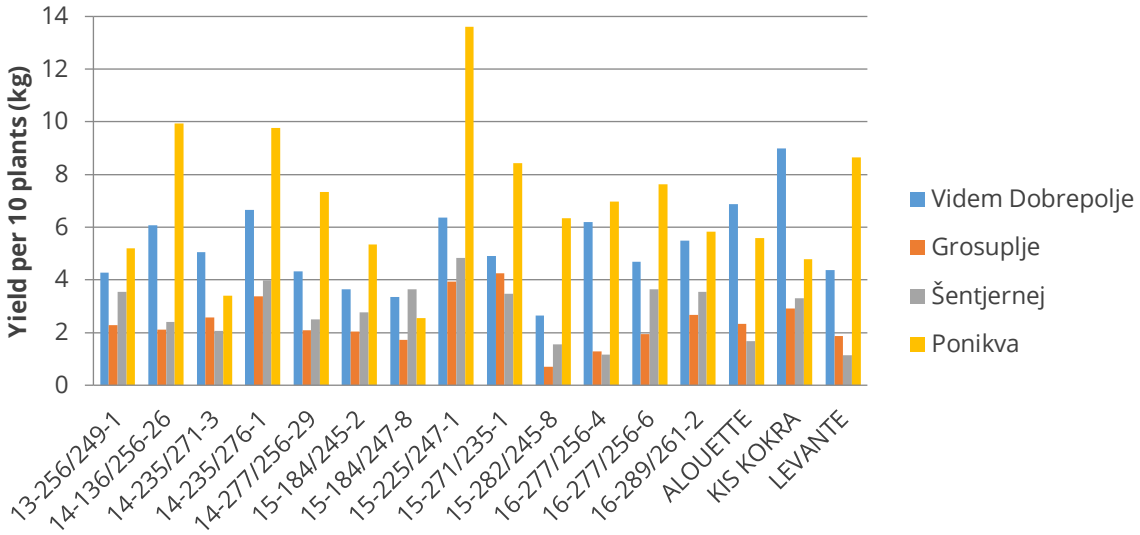

Fig. 15 Comparison of yield per 10 plants for each clone and variety in each location.

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Table 17 Comparison of varieties yields 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 (Fig 16) at 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. There were major differences between the locations for the 3 registered varieties.

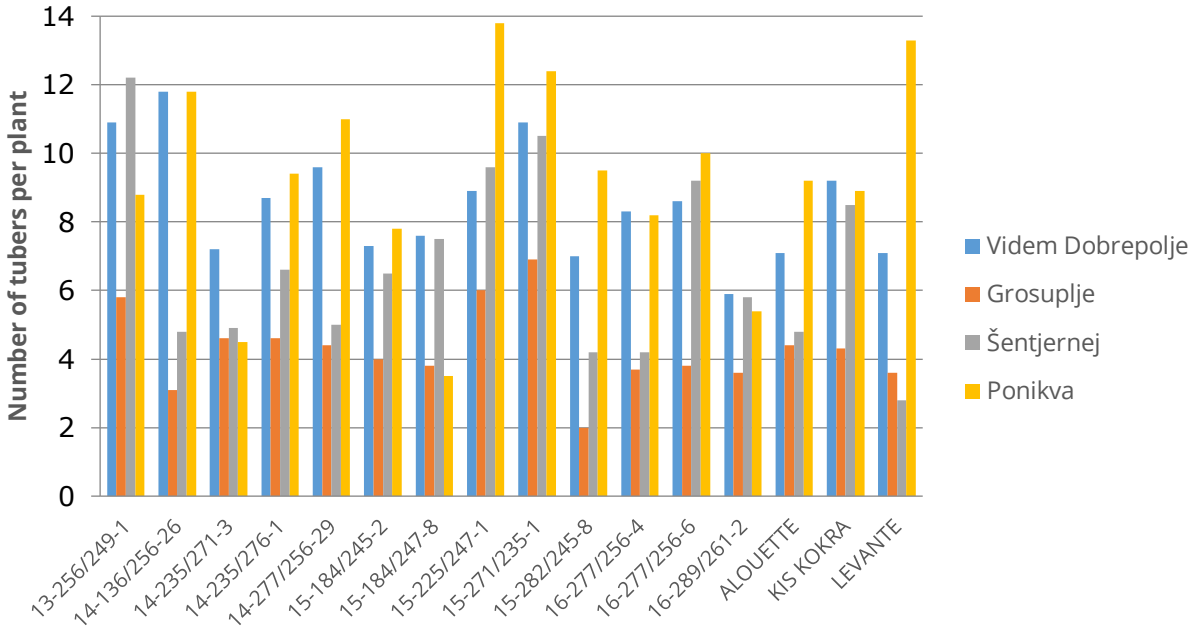

Fig. 16 Number of tubers per plant for each clone or variety in four locations.

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Table 18 Number of tubers per plant for each clone or variety in 4 locations and average.

Name	Videm Dobrepolje	Grosuplje	Šentjernej	Ponikva	AVERAGE
13-256/249-1	10.9	5.8	12.2	8.8	9.4
14-136/256-26	11.8	3.1	4.8	11.8	7.9
14-235/271-3	7.2	4.6	4.9	4.5	5.3
14-235/276-1	8.7	4.6	6.6	9.4	7.3
14-277/256-29	9.6	4.4	5.0	11.0	7.5
15-184/245-2	7.3	4.0	6.5	7.8	6.4
15-184/247-8	7.6	3.8	7.5	3.5	5.6
15-225/247-1	8.9	6.0	9.6	13.8	9.6
15-271/235-1	10.9	6.9	10.5	12.4	10.2
15-282/245-8	7.0	2.0	4.2	9.5	5.7
16-277/256-4	8.3	3.7	4.2	8.2	6.1
16-277/256-6	8.6	3.8	9.2	10.0	7.9
16-289/261-2	5.9	3.6	5.8	5.4	5.2
ALOUETTE	7.1	4.4	4.8	9.2	6.4
KIS KOKRA	9.2	4.3	8.5	8.9	7.7
LEVANTE	7.1	3.6	2.8	13.3	6.7
AVERAGE	8.5	4.3	6.7	9.2	7.2

The tuber size was determined (weighed and counted) on square mesh of the 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. 14-235/276-1 had more tubers in the 45-65 mm fraction than the other two clones.

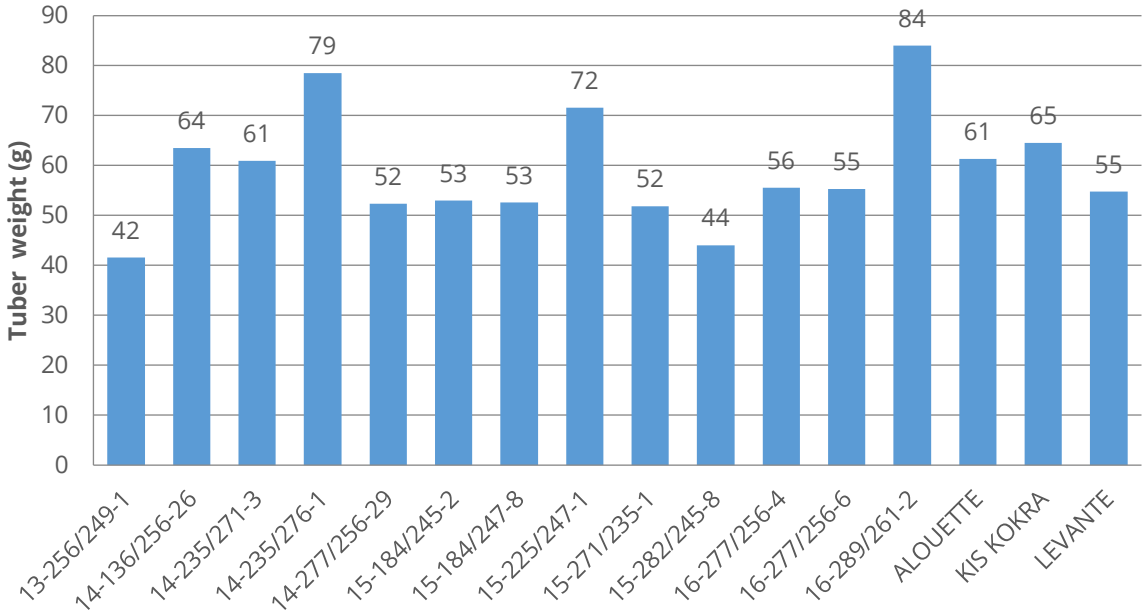

Fig. 17 Average tuber weight (g) for each clone and variety.

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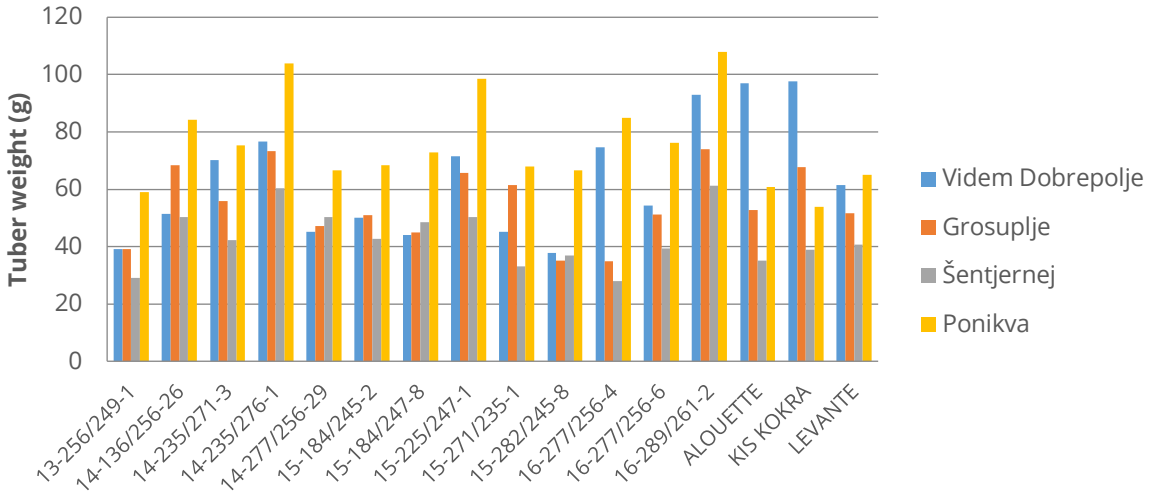

Fig 18 Average tuber weight (g) for each clone or variety in four locations.

Clones 15-225/247-1 and 14-235/276-1 were more successful than the others at all locations this season. The clone 15-282/245-8 was unfortunately unsuccessful at 3 locations and almost average at 1 farm.

Table 19 Comparison of clones and varieties for each location.

	Videm-Dobrepolje			Grosuplje			Šentjernej			Ponikva		
Name of clone or variety	Yield per 10 plants	Number of tubers per plant	Average tuber weight	Yield per 10 plants	Number of tubers per plant	Average tuber weight (g)	Yield per 10 plants	Number of tubers per	Average tuber weight	Yield per 10 plants	Number of tubers per	Average tuber weight
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

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

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The composition of the clone sample was described by the percentage of tubers in 4 different size fractions: >65 mm, between 45 and 65 mm, between 25 and 45 mm, < 25 mm (Fig 19). 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 4 locations.

Fig. 19 Composition of tuber size fractions for each clone and variety at four locations.

At harvest time, we asked the farmers: "What is your favourite clone?". The answers varied (see Table 20). 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.

Table 20 Choice of clones or varieties 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

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 more or less pronounced depending on their system and personal preferences.

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Visual, organoleptic and chemical aspects of the 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 genotype, growing conditions, agricultural technology 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 20).

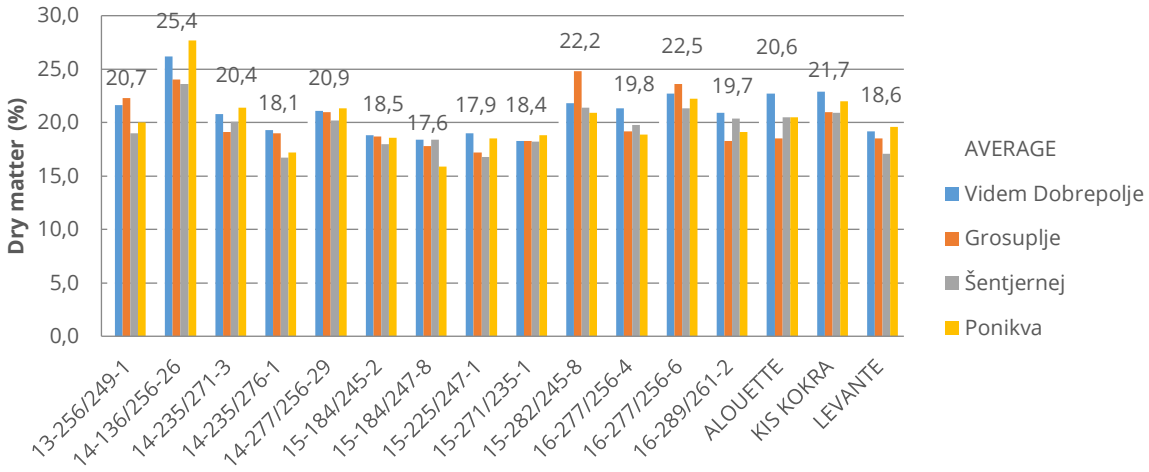
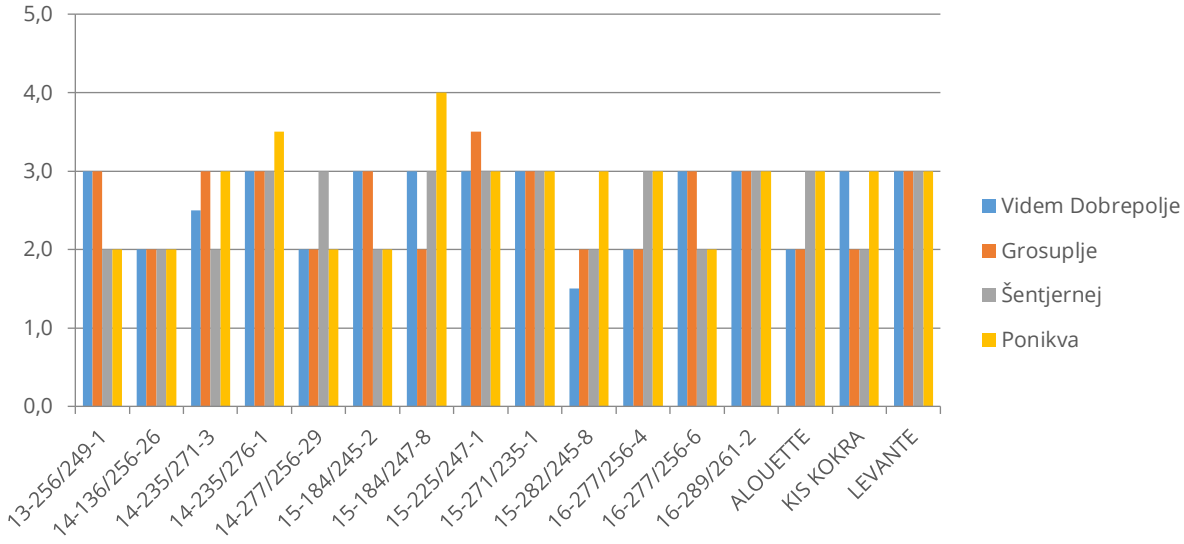


Fig. 20. Dry matter (%) for each variety in four locations.

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 conduct taste tests with the farmers for the variety of samples. Most varieties achieved a good taste score for the four locations (Fig 21).



Fig, 21, Taste (aroma) of tuber for each variety in four locations (1 excellent, 2 very good, 3 good, 4 acceptable, 5 worse, 6 unsuitable).

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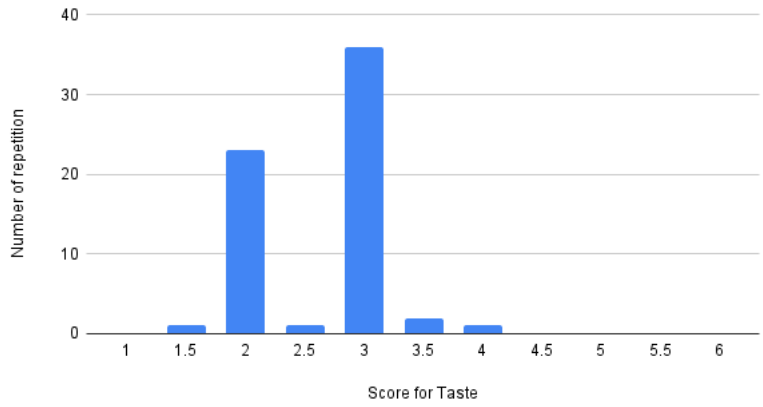

Fig. 22. Repetition of scores for taste for the panel of clones and varieties in 4 locations

Most of the varieties in all 4 locations had at least good taste with values between 1.5 and 4.5 (Fig 22).

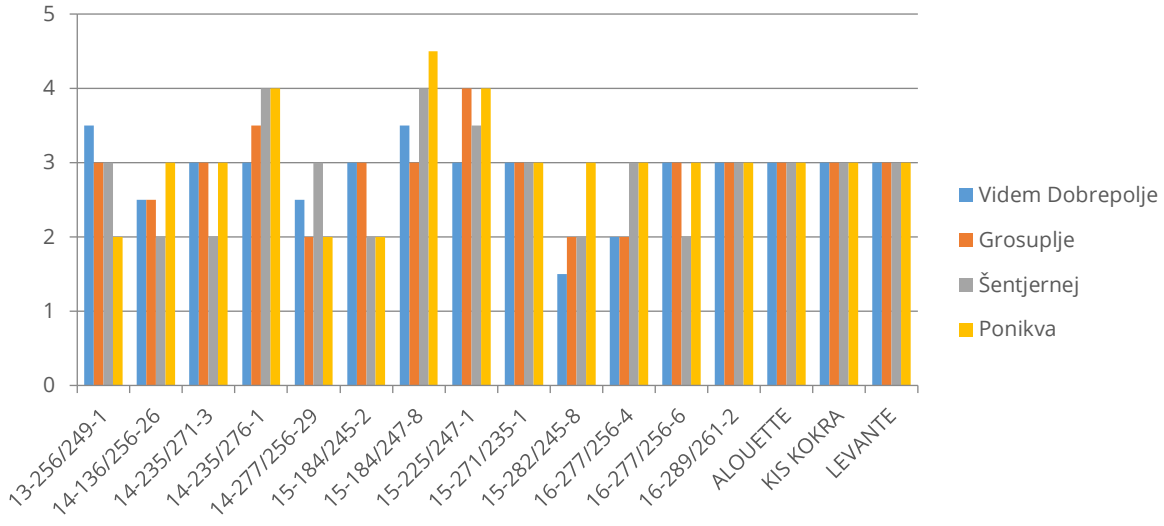

Fig 23 General impression for each variety in 4 locations (1 excellent, 10 unsuitable).

The characteristics are summarised (Table 21) with the average score for each clone or variety for the 4 locations. The uniformity of the cut surface achieved the highest score 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, are 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 flavor 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

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stickiness and offered a wide range of uses. All clones and varieties had a good overall impression with average scores between 2 and 4.

Table 21. Cooking quality for each variety, average for four locations.

	Surface colour	Uniformity of	Discoloration	Disintegration	Consistency	Mealyness	Moisture	Texture	Flavor	Other flavors	Stickiness	General impress
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 cream, 3 light yellow, 6 dark yellow), uniformity of the cut surface (1 uniform, 4 uneven), discoloration after 20 minutes (1 no discoloration, 4 strong discoloration), decay (1 none, 4 strong), consistency (1 firm, 4 soft), mealiness (1 not mealy, 4 mealy), moisture (1 moist, 4 dry), texture (1 fine, 4 coarse), flavor (1 excellent, 2 very good, 3 good, 4 acceptable, 5 poor, 6 unsuitable), other flavor (1 none, 4 strong foreign flavors), stickiness (1 none, 4 sticky), overall impression (1 excellent, 10 unsuitable).

The cooking types were also rated on a four-point scale (A firm meat - salads, B versatile, C floury, D mealy; Table 22). They can also be intermediate types AB, BC.... Lettuce type A is the most popular with consumers, as the potato does not disintegrate. Type B is the most usable multi-purpose type, while BC is more mealy and better suited for baking and frying. C is very floury and is suitable for bread etc. The cooking types 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).

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Table 22 Cooking type for each variety samples in four 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

Participatory plant breeding in Hungary

Goals

To involve and educate organic potato growers how to test and evaluate potato breeding lines/variety candidates to identify new genotypes with high potential under organic production conditions by a mutual work with professional breeders.

Methods

Participatory breeding trials were set up in 2020-2023 in Hungary (Fig 24). During the first two years at four organic farms (Rábcakapi, Zalavár, Szár and Szakály) and at three farms in 2022/2023 (Rábcakapi, Zalavár and Szakály).

Fig. 24. Location of organic farms involved into the trials.

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General conditions of trials

Five advanced breeding lines plus three variety candidates were tested using the same methodology as for Farmers Participatory Field Trials. The list of tested potato genotypes and testing years is presented in Table 23. One hundred tubers were planted from each variety at all locations in a non-replicated trial. The plantings were done in April, while the harvest in September. Each partner used its own regular farming methodology to manage the trials (nutrition, weed and pest management). Evaluation of tested genotypes was done parallel to the scoring of Participatory Variety Trials (WP6.2.). Measured parameters were recorded partially by the involvement of farmers (total yield, late blight resistance, early blight resistance, PVY resistance, tuber parameters) at harvest, while the quality characteristics (dry matter content, cooking type, taste, raw and after cooking discoloration) were done by the Potato Research Station of MATE.

Farms of Zalavár and Szakály worked under non irrigated conditions on middle heavy soils, while the farms at Szakály and Rábcakapi worked on lither soils with irrigation. Weather conditions of all the four seasons could be characterised by less precipitation and higher summer temperatures than the long-term average. From the beginning of the summers, a high degree of drought was characteristic for each of the years, which reached its peak in general during second half of July and early August. Several times, highest daily temperatures reached 35 °C or above. Especially the year of 2022 was dramatic from this point of view when the drought period lasted for almost three months and the highest temperatures could reach 40 °C. Damage by Colorado potato beetle was present in each year but could be effectively managed by farmers with 1-2 times spraying with organic insecticide LASER PLUS. Weeds were controlled by commercial practices and did not affect the results of trials. Weather conditions in general did not favour to the epidemy of fungal diseases (early and late blight), but was very much favourable for the spreading of aphid transmitted viruses (especially for PVY).

Table 23. List of tested genotypes, years and locations.

	Breeding line/variety candidate																													
Location	10.437				13.361				14.21				18.146				18.159				Balatoni sárga				Red river				Golden river			
Year	2020	2021	2022	2023	2020	2021	2022	2023	2020	2021	2022	2023	2020	2021	2022	2023	2020	2021	2022	2023	2020	2021	2022	2023	2020	2021	2022	2023	2020	2021	2022	2023
Zalavár	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			*	*			*	*
Szár	*	*			*	*			*	*			*	*			*	*			*	*										
Rábcakapi	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			*	*			*	*
Szakály	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			*	*			*	*

Results

Accumulated results of measured or scored parameters of the tested breeding lines and variety candidates are presented in Table 24. Total yield and distribution of yields according to the years are visualised by Figure 25 and 26.

The highest average yield was reached by the late maturing breeding line 10.437 with 39.2 t/ha, while the lowest was for the chipping breeding line 13.361 (24.3 t/ha). The absolute highest yield was reached by variety candidate Red river in 2020 (44.9 t/ha). In 2022 all the tested genotypes had their lowest average yield due to the extreme heat and

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drought of the season. The average yield of the varieties was 22 t/ha. The starch content of the genotypes varied between 11.2 % (10.437) and 16.6 % (13.361). Balatoni sárga and Golden river was the two best tasting varieties. Lowest, but still acceptable score, 4 was given to the line 10.437. In general the tested genotypes had regular tuber shape independent to season and location. In terms of tuber eyes depth, the genotypes have got rather good scores (7-9). The line 10.437, 14.21 and variety candidate Red river produced the largest tubers. In the tuber quality test, considering raw and after cooking darkening all the genotypes had good results (score 1-3). For the infection of late blight and early blight disease the lines in general showed a moderate resistance (5-6) only. For late blight the highest score was 7 for Golden river. For early blight sore seven was given to line 10.437, 13.361 and Golden river. No symptoms of PVY infection were detected on any of the tested genotypes.

Table 24. Summarised test results of breeding lines and variety candidates (2020-2024).

Character	Breeding lines/variety candidates							
	10.437	**13.361**	**14.21**	**18.146**	**18.159**	**Balatoni sárga**	**Red river**	**Golden river**
Maturity	late	middle	middle	middle	middle	late	early	late
Skin colour	red	yellow	red	yellow	yellow	yellow	red	yellow
Flesh colour	pale yellow	yellow	pale yellow	yellow	yellow	yellow	yellow	yellow
Yield t/ha	39,2	24,3	32,2	26,8	30,2	30,5	38,6	32,6
Starch content, %	11,2	16,6	12,3	12,9	12,6	13,1	12,6	13,4
Cooking type	B	C	B	B/C	B	B/C	B/C	B/C
Taste	4	2	3	2	2	1	2	1
Regularity of tuber shape	7	8	7	8	8	8	8	8
Depth of eyes	7	7	7	8	8	9	8	9
Tuber size	8	6	7	6	6	6	7	6
Raw discoloration	2	3	3	2	2	1	2	1
Cooked discoloration	2	3	2	2	2	1	1	1
Late blight resistance	6	6	6	5	5	6	6	7
Early blight resistance	7	7	6	6	6	6	6	7
PVY resistance	9	9	9	9	9	9	9	9

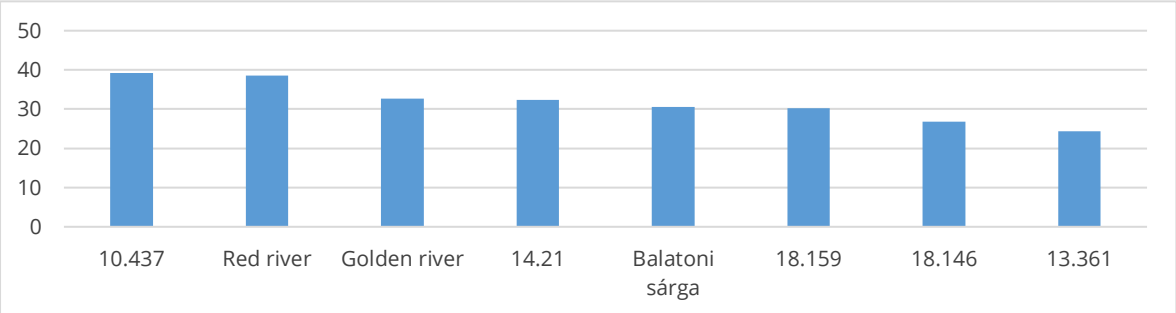

Fig. 25. Total yield of tested breeding lines and variety candidates as the overall average of locations and years (t/ha).

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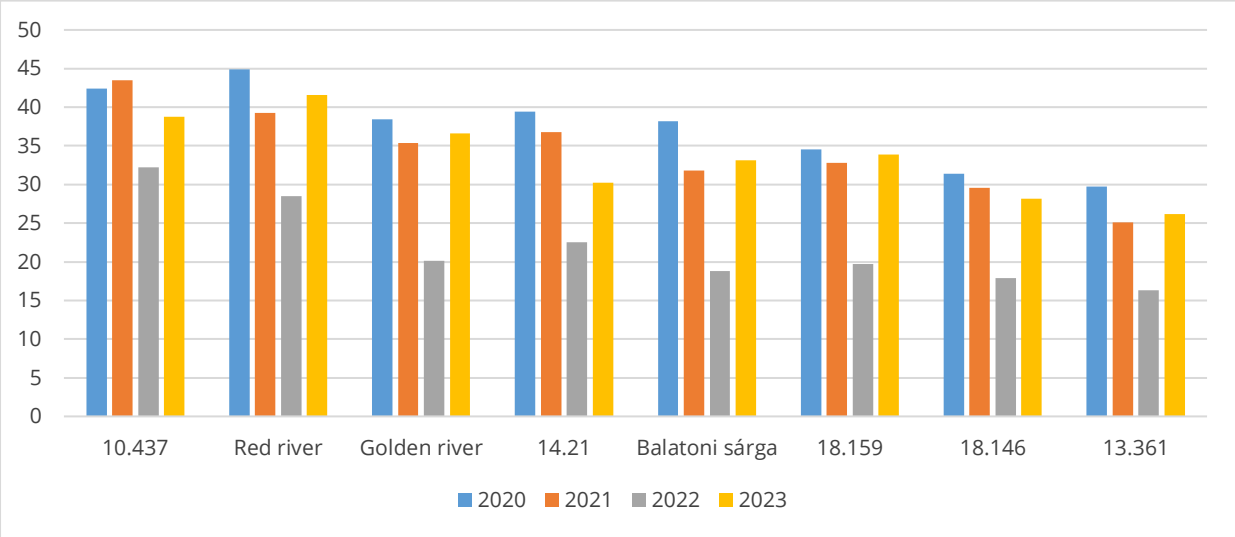

Fig. 26. Distribution of yields according to testing years and genotypes (t/ha).

Summary

Summarising the results and personal discussions with the organic growers, we can conclude that both the growers and researchers have gained a lot of valuable experience of on-farm testing of potato lines. The growers were able to familiarise themselves with some new breeding lines and new candidate varieties. They extended their experience on testing methodologies and importance of individual traits of potatoes. They realised and accept the high needs of resistance in organic potato production, especially for viruses and late blight. In terms of yielding ability and quality characters, all tested genotypes showed acceptable results allowing to be involved them into further evaluations and some of them showed potential for entry into future registration trials.

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Soybean

Participatory plant breeding in Serbia

2022

NS CCP seeds were distributed to Slovenia, Romania, Germany and Austria. Locations for Serbian CCP testing were agreed (Šuljam, Rimski šančevi, Čurug).

2023

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.

Locations	CCPs
Čurug (24.04.2023)	NS CCP
Šuljam (3.05.2023)	NS CCP
Rimski šančevi (5.5.2023)	NS CCP

NS CCP, 2023

NS CCP, 2023

Fig. 27. Soybean NS CCP in Serbia, 2023.

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Participatory plant breeding in Romania

Exploitation of PPB was used to enhance the on-farm availability of locally adapted germplasm for organic producers. The obligation of NARDI Fundulea in this task was to grow the segregating, Cross Composite Populations (CCP) and multi-line populations of soybean in a minimum of 3 Demo farms. For this purpose, NARDI Fundulea received in 2023, 2.4 kg NS (CCP) which was cultivate at NARDI Fundulea Demo farm, and results are shown in 2023_FPT_assessments.

Based on very good results obtained with mixtures of wheat varieties in the last 2 years (2022 and 2023) we tested different mixture soybean varieties and results are shown in 2022 and 2023_FPT_assessments and Bulletins.

Participatory plant breeding in Germany and Austria

In 2022 the Serbian population NS CCP was grown at three farms in Germany. In two of the three farms it could not be harvested because of too late maturity. At the third farm Binder/Lindenbrunnerhof in the 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 only selected together with the farmer. No yield was measured.

Fig. 28. NS CCP at Binder farm Lindenbrunnenhof.

The harvest of NS CCP from Binder farm in 2022 was used for sowing at three farms in Rhine valley in 2023: Binder again, LTZ Karlsruhe-Grötzingen and Ruesch farm at Buggingen. At Binder farm a field day took place on 29th August 2023 conducted by the Agricultural Technology Center Emmendingen. NS CCP looked much better than in the previous year (also at the other two farms). Farmers were surprised and reacted positively. It was the longest in straw (10 cm longer than the second longest) but showed

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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 it was higher than the very popular variety 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. Therefore 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 at LFS Güssing. Assessments were done by SZ Gleisdorf. Because of heavy hail the trials were almost destroyed and only some plants could be harvested.

Buckwheat

Participatory plant breeding in Slovenia - RGA

During the years 2022 and 2023 experimental synthetic buckwheat varieties were tested on more locations (Slovenia, Czech and UK). The combinatorial effect of the different F1 generations has led to positive heterosis values for both grain yield per plant and thousand grain weight (TGW). However, caution should be taken when interpreting these data, as the values for quantitative parameters such as grain yield per plant are still very low. In order to obtain more reliable data, a larger number of synthetic buckwheat varieties should be tested at more locations and over more years. Considering the complexity of the development of synthetic buckwheat varieties and the lower heterosis compared to F1 hybrids (due the apomixis, presence of parental components), the practical value of synthetic buckwheat varieties is very limited.

Fig. 29. Components (F1 progenies) of buckwheat synthetics.

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From the morphological point of view buckwheat synthetics are heterogeneous material. To understand such kind of genetics in the practice we organised a field day in Krog near Murska Sobota on 23rd October 2023. Beside the demo field we visited also the greenhouse at Cornus company where the single components of buckwheat synthetics were represented.

Table 25. Quantitative parameters for experimental synthetic (Syn 2021) and parents.

♀/♂	Bamby	Čebelica	Darja	Hajnalka
Bamby		×	×	×
Čebelica	×		×	×
Darja	×	×		×
Hajnalka	×	×	×	
	Grain yield [kg/ha]	**Thousand grain weight [g]**	**Grain yield MPH**	**Thousand grain weight MPH**
Syn 2021	1345	24.3	Index 100	Index 100
Bamby	1283	19.4	104.83	125.26
Čebelica	1226	20.3	109.71	119.70
Darja	1245	20.1	108.03	120.90
Hajnalka	1227	22.6	109.62	107.52
x̄	1245	20.6	108.05	118.35

Seeding rate (Syn0, ♀/♂: 90 kg/ha); Sowing date: First decade of July

Table 26. Quantitative parameters for experimental synthetic (Syn 2022.1) and parents.

♀/♂	Bamby	Čebelica	Darja	Lileja	Hajnalka
Bamby		×	×	×	×
Čebelica	×		×	×	×
Darja	×	×		×	×
Lileja	×	×	×		×
Hajnalka	×	×	×	×	
♀/♂	**Grain yield [kg/ha]**	**Thousand grain weight [g]**	**Plant length [cm]**	**Grain yield MPH**	**Thousand grain weight MPH**
Syn 2022.1	1070	22.8	89	Index 100	Index 100
Bamby	876	18.4	103	122.15	123.91
KIS Čebelica	777	19.9	115	137.71	114.57
Darja	689	20.3	117	155.30	112.32
Lileja	1134	18.8	108	94.36	121.28
Hajnalka	1099	20.9	96	97.36	109.09
x̄	940.83	20.18	104.67	121.38	116.23

Seeding rate (Syn0, ♀/♂: 90 kg/ha); Sowing date: First decade of July

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Table 27. Quantitative parameters for experimental synthetic (Syn 2022.2) and parents.

♀/♂	Billy	KIS Čebelica	Darja	Lileja	Hajnalka
Billy		×	×	×	×
KIS Čebelica	×		×	×	×
Darja	×	×		×	×
Lileja	×	×	×		×
Hajnalka	×	×	×	×	
♀/♂	**Grain yield [kg/ha]**	**Thousand grain weight [g]**	**Plant length [cm]**	**Grain yield MPH**	**Thousand grain weight MPH**
Syn 2022.2	1289	24.1	93	100	100
Billy	876	18.4	103	147.15	130.98
KIS Čebelica	777	19.9	115	165.90	121.11
Darja	689	20.3	117	187.08	118.72
Lileja	1134	18.8	108	113.67	128.19
Hajnalka	1099	20.9	96	117.29	115.31
x̄	977	20.4	105	146.22	122.86

Seeding rate (Syn0, ♀/♂: 90 kg/ha); Sowing date: First decade of July

Breeding for organic farming is based on the development of varieties that show high adaptability to given growing conditions. The basis of this adaptability can be offered by the multi-genotype concept. The combination between heterosis breeding and multi-genotype concept is represented in the development of buckwheat synthetic varieties. From the farmer point of view the synthetics are important because this allows the harnessing of heterosis also in the progenies which follows the first filial generation.

Participatory plant breeding in Slovenia - KIS

Methods

In 2022, buckwheat trials were set up on the following farms Pucihar (Grosuplje), Zagorc (Šentjernej), Zdolšek (Ponikva) and Škorjanc (Prebold). The varieties Kora, Panda, Zita, Zoe, Čebelica, Billy, Bamby and La Harpe were sown on all farms (Fig 30). The Zdolšek farm sowed buckwheat as a spring crop, while the other farms sowed it as a summer crop. The CCP seed arrived too late and in limited quantities. Therefore, only two farms (Pucihar and Zdolšek) grew CCP buckwheat.

In 2023, a total of 1 buckwheat variety (Čebelica) and 3 composite cross populations of RGA (CCP1, CCP6, CCP7) were selected for testing by researchers and variety experts. The varieties were selected on the basis of competitiveness against weeds, growth duration, seed weight, flower colour and other traits. The buckwheat PPB trials were conducted on two organic farms and on organic fields of the Institute in the centre of Slovenia. The trials were conducted on the Pucihar Farm in Slovenia with the Čebelica variety and CCP 6, on the Marolt Farm with the Čebelica variety and CCP 1 and at the Jablje infrastructure centre with the variety Čebelica, CCP 1, CCP 3 and CCP 6.

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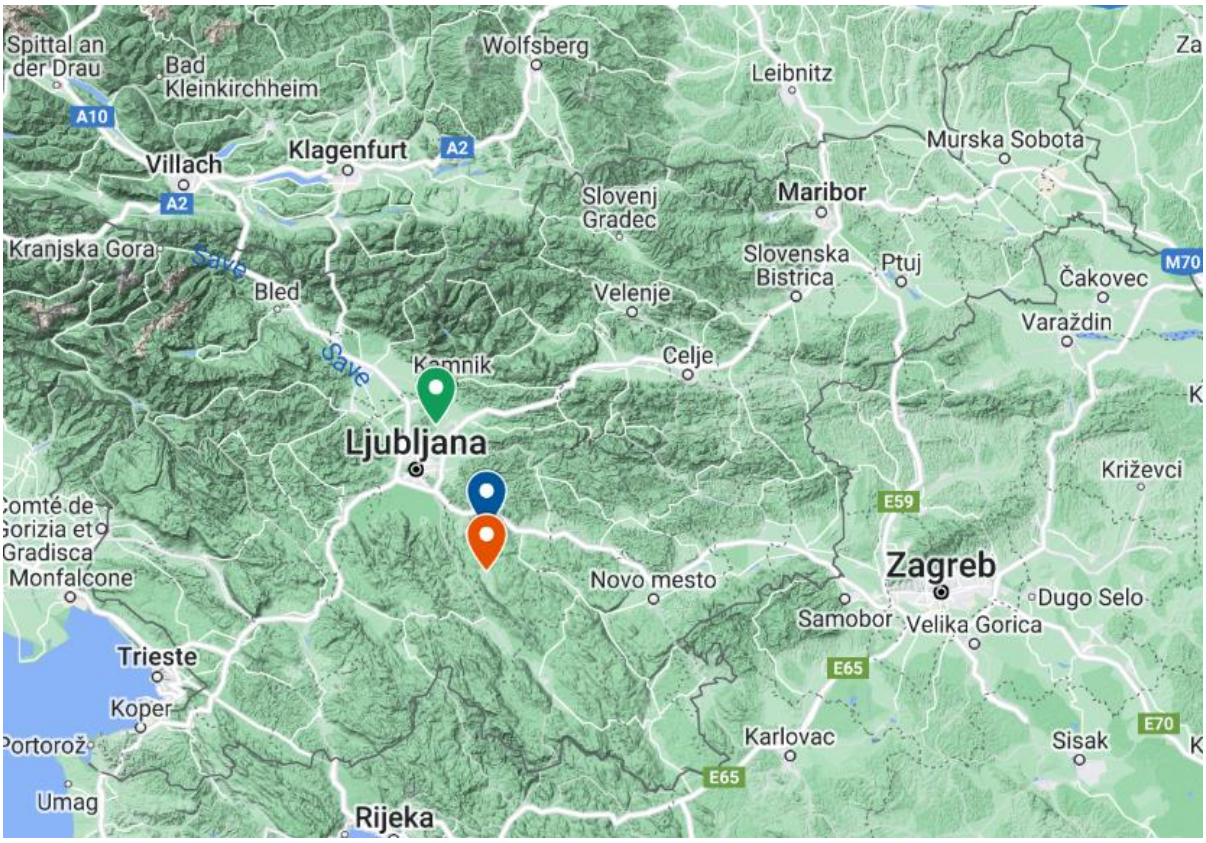

Name place	Farm Elevation	Type of landscape	Pedo-climatic zones/regions	Farm size	Farm type	Organic since (years)
Grosuplje	335	Valley	Continental temperate climate	12	Mixed	+20
Videm Dobrepolje	441	Valley / "plateau"	Continental temperate climate	24	Mixed	+12
KIS	300	Plain	Continental temperate climate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

Fig. 30. Locations of buckwheat trials and main characteristics of the locations.

The preceding crops before the buckwheat trial were different on the individual farms and institute. At all sites, buckwheat was already included in the crop rotation and the farmers were familiar with buckwheat technology.

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 2 farms and all varieties at the site were harvested on the same day.

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Table 28. Crop succession before buckwheat trial at 4 locations in season 2023 ("1st crop /2nd crop": 1st crop following by a 2nd crop in the 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

The following characteristics were evaluated to assess the development and agronomic performance of the varieties: plant height, crop 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 stresses, biotic stresses, seed yield, chemical analysis. In Slovenia, additional characteristics such as shoot growth and branch shoot habit, plant branching, number of leaves, leaf blade length and width, inflorescence compactness and number of clusters per cyme were also assessed. Farmers managed the cultivation and were responsible for sowing and harvesting and provided some information on yield, abiotic and biotic stress.

Weather conditions during the growing season were extremely wet in summer (Fig 31). In July and August, the Marolt farm was hit by severe storms that caused significant damage to the trial. Although the buckwheat started to grow again after the storms, it suffered damage from wild animals.

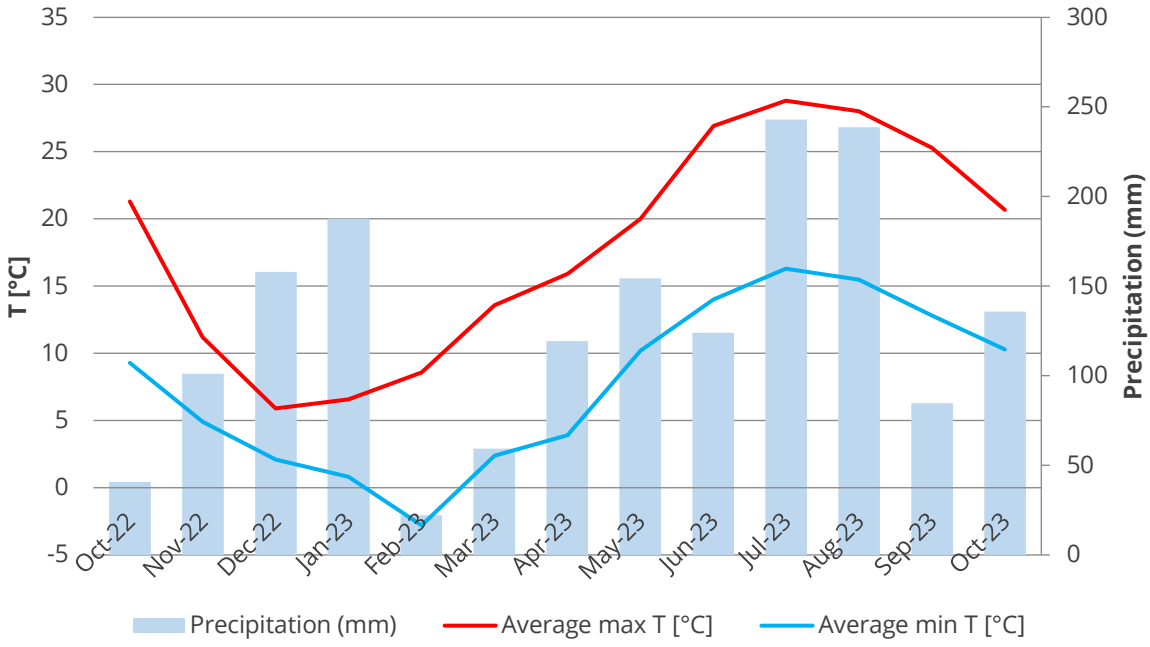

Fig. 31. Weather conditions for season 2022/2023 (data for Grosuplje).

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Fig. 32. Trials injured by heavy storms in Marolt Farm in Videm Dobrepolje, July 2023.

Fig. 33. Lodging of trial in Marolt Farm in Videm Dobrepolje, 29 September 2023.

Results

In 2022, no direct comparisons with the other sown varieties were possible due to the late sowing date. The expected harvest/sampling of the spring-sown buckwheat varieties was at the beginning of September, that of the summer-sown varieties at the beginning of October. The CCP variety did not start flowering until the end of August, so ripening and harvesting was questionable.

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In 2023, we observed the characteristics: the plant height is shown in Fig 34 and crop height in Fig 35. Čebelica reached the higher plant height at Videm Dobrepolje (127 cm) and the higher crop height in Grosuplje (85 cm). CCP6 had the lower plant height in Grosuplje (71 cm). CCP1 and CCP6 were shorter compared to Čebelica. CCP1 was less affected by lodging compared to Čebelica at Videm Dobrepolje compared to Čebelica. In Videm Dobrepolje, abiotic stress and biotic stress were high. Hail, lodging of plants and deer affected both varieties. Although the trial was carried out, the yield was obviously affected. More than 75 % of Čebelica and 50 % of CCP1 had lodged.

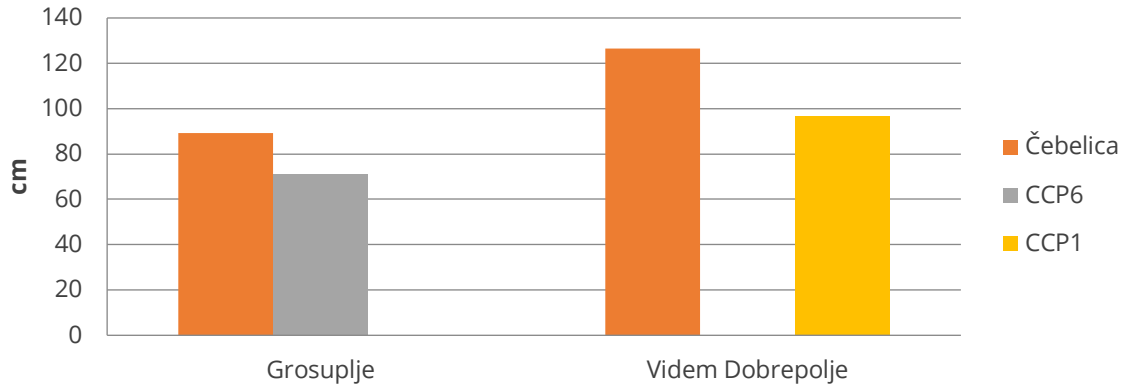

Fig. 34. Plant height of buckwheat on two farms in 2023.

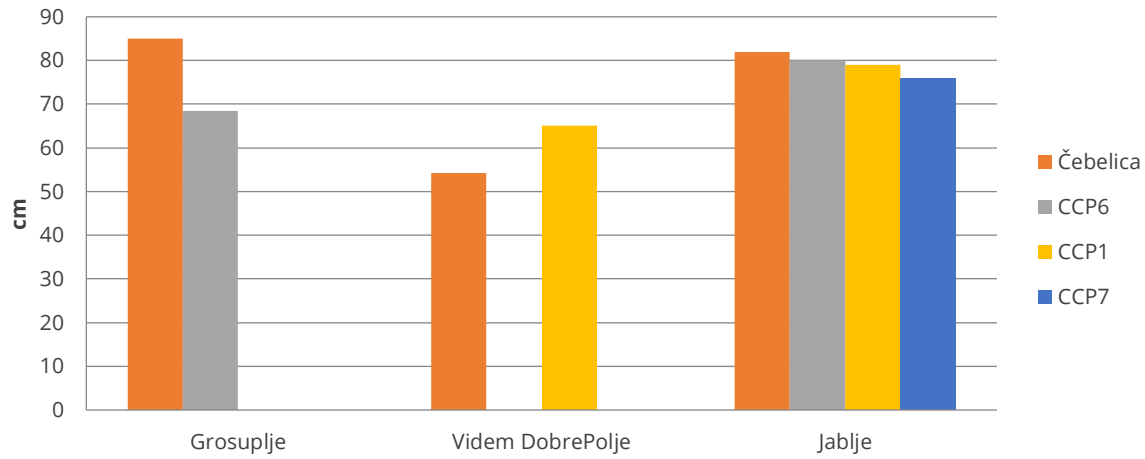

Fig. 35. Crop height of buckwheat varieties grown at three locations in 2023.

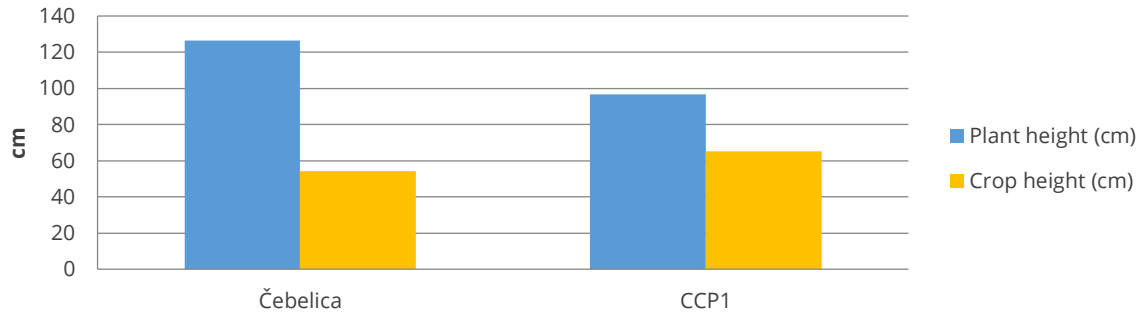

Fig. 36. Comparison of plant and crop height of buckwheat varieties at Videm Dobrepolje in 2023.

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The grain yields are listed in Table 29. The trials on the Pucihar Farm were more successful, despite the delay in harvest due to weather conditions, which finally took place on November 4. In terms of weed competitiveness, CCP6 appears to be less competitive than Čebelica. The electric fences surrounding the field were effective in keeping wildlife out. In Videm Dobrepolje, yields were lower due to biotic and abiotic stress. Čebelica achieved the higher yield in Grosuplje (700 kg/ha) and CCP1 the lower yield in Videm Dobrepolje (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).

Table 29. Grain yields of buckwheat varieties at the locations Grosuplje, Šentjernej and Jablje in 2023.

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 (Figs 37-41). CCP 1 achieved the highest score for plant branching compared to CCP6 and Čebelica. The number of leaves was very low in CCP6 as the maturity stage was reached. CCP6 had already reached maturity on September 29, while Čebelica was still flowering and had not yet reached full maturity, indicating that CCP6 was an earlier variety.

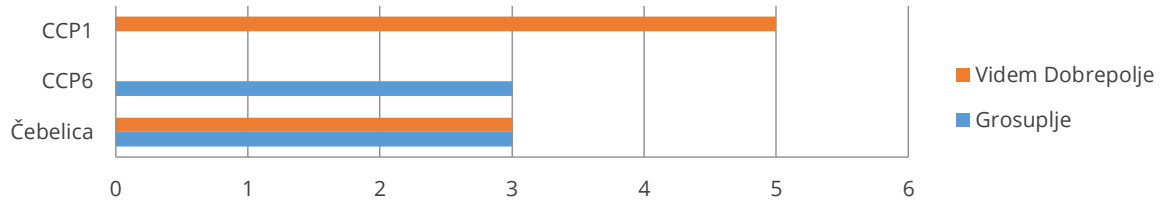

Fig. 37. Comparison of plant branching (from 1 to 9) of buckwheat varieties for two locations in 2023.

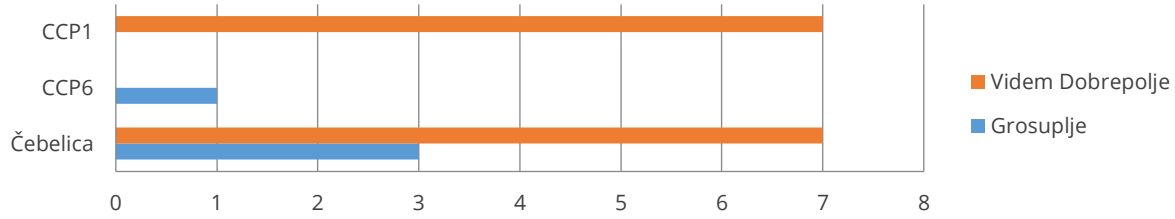

Fig. 38. Comparison of the number leaves (from 1 to 9) of buckwheat varieties at two locations in 2023.

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Čebelica had a longer leaf blade length (4.3 cm) and a larger leaf blade width (3.6 cm). CCP6 had the shorter leaf blade length (3.3 cm) and a narrower leaf blade width (3 cm).

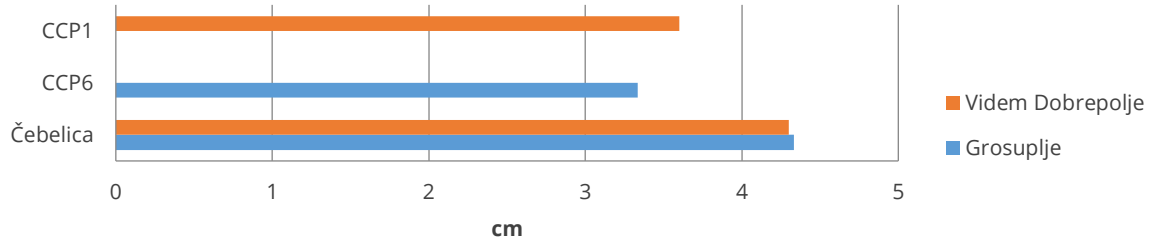

Fig. 39. Comparison of leaf blade length of buckwheat varieties at two locations (cm) in 2023.

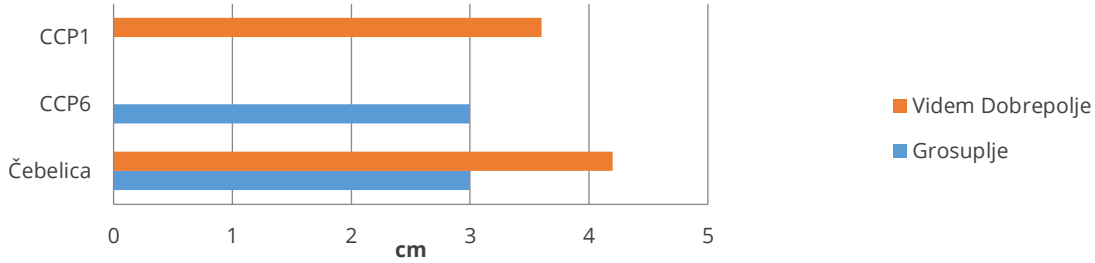

Fig. 40. Comparison of leaf blade width of buckwheat varieties for two locations (cm) in 2023.

Flowering of buckwheat was compared with number of flower clusters per cyme. Čebelica reached the higher number of cluster per cyme (4 and 6). CCP1 had the lower number of cluster (3). The colours of flower of CCP1 were different from one plant to another. It was considered by farmer as an odd feature compared to colour of Čebelica which was more uniform.

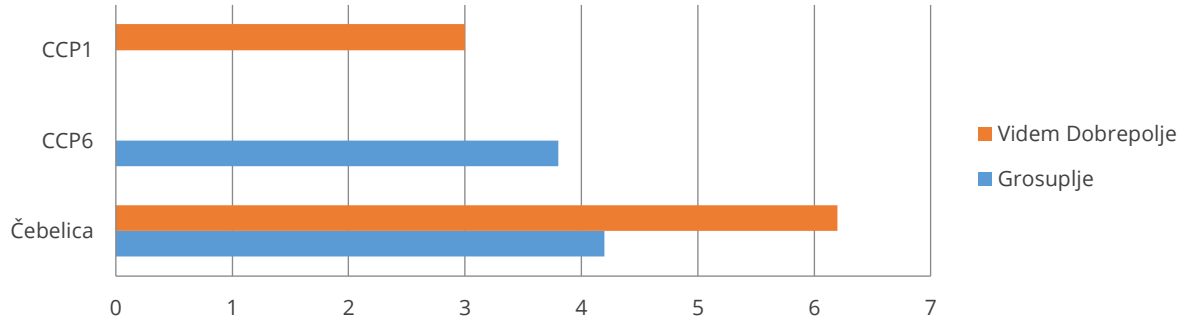

Fig. 41. Comparison of number of flower clusters per cyme in 2023.

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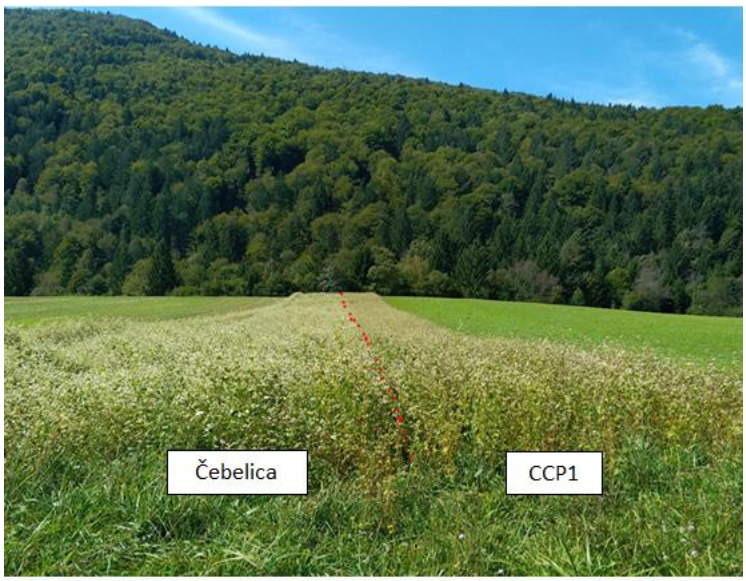

Fig. 42. Buckwheat trial on Marolt Farm, 4 September 2023.

CCP1 reached the highest number of seeds per cyme (24). 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). Čebelica had the lower average with 20.6g for 2 locations (Fig 43).

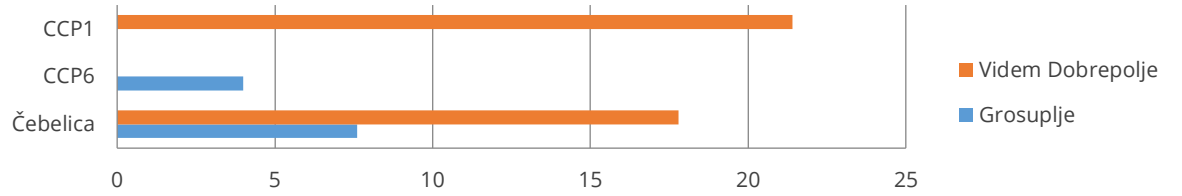

Fig. 43. Comparison of seeds per cyme in 2023.

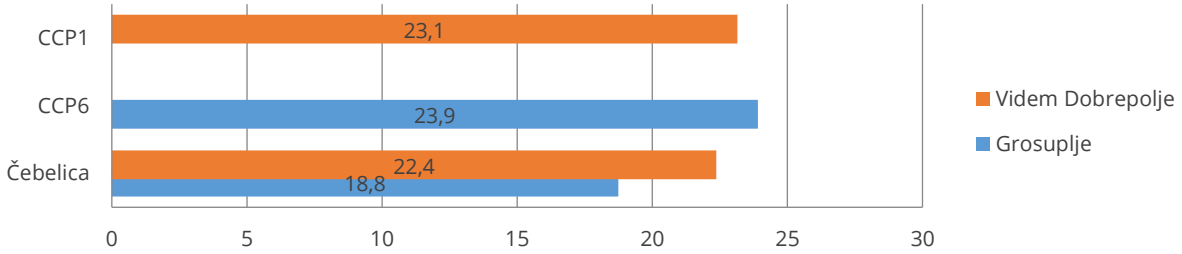

Fig. 44. Comparison of 1000-seed weight (g) in 2023.

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Participatory plant breeding in the Czech Republic

2022

One buckwheat population from RGA was received.

2023

Remaining three buckwheat population from RGA were received. Buckwheat populations were grown at three farms in Velké Hostěrádky cadastre.

Buckwheat populations had very long vegetation period, with uneven maturation and long flowering. Such populations are not suitable for grain production, but they can act as an excellent forage for bees.

Participatory plant breeding in the United Kingdom

Cross composite populations

In 2023, four cross composite populations were grown across two sites in the UK. These have been newly developed by ECOBREED partners. These included CCP4, CCP8, Syn21 & a CCP from VURV, Czech Republic.

The cross composite populations looked strong during the growing season, with a lower number of weeds. Due to deer damage, it was not possibly to harvest the Syn21 population. In general, the remaining cross composite populations had lower seed weight and HI than other varieties in the trials. These were however only grown for one year and sown two weeks later than the other varieties, which may have resulted in differences.

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References

Meglič V, Žibrat-Gašparič A, Vogt-Kaute, W, Grausgruber H, Bernhart M., Bilsborrow P, Pearce A, Kolmanič A, Champailler M, Dolničar P, Tatarowska B, Plich J, Janovská D, Brezáni A, Hauptvogel P, Janovíčková K, Toncea I, Miko P, Megyeri M, Polgar Z, Jocković B, Vasiljevic M, Djordjevic V, Pagnotta M (2022) Ecobreed farmers participatory field trials 2021. ISBN 978-961-6998-65-9 (PDF) https://doi.org/10.5281/zenodo.7219695

Meglič V, Žibrat-Gašparič A, Vogt-Kaute W, Apacsova-Fuskova M, Grausgruber H, Bernhart M., Bilsborrow P, Pearce A, Kolmanič A, Champailler M, Dolničar P, Tatarowska B, Plich J, Janovská D, Brezáni A, Hauptvogel P, Janovíčková K, Toncea I, Miko P, Megyeri M, Polgar Z, Jocković B, Vasiljevic M, Djordjevic V, Pagnotta M, Badut C, Bonfiglioli L, Buso R, Gavurníková S, Hasana R, Hrckova K, Lamurenanu G, Malovcova L, Mendel L, Peturs A, Stan I, Urbanaviciiute I (2023) Ecobreed farmers participatory field trials 2022. ISBN 978-961-6998-71-0 (PDF) https://zenodo.org/records/8270146

Meglič V, Žibrat-Gašparič A, Vogt-Kaute W, Apacsova-Fuskova M, Grausgruber H, Bernhart M., Bilsborrow P, Pearce A, Kolmanič A, Champailler M, Dolničar P, Tatarowska B, Plich J, Janovská D, Brezáni A, Hauptvogel P, Janovíčková K, Toncea I, Miko P, Megyeri M, Polgar Z, Jocković B, Vasiljevic M, Djordjevic V, Pagnotta M, Badut C, Bonfiglioli L, Buso R, Gavurníková S, Hasana R, Hrckova K, Lamurenanu G, Malovcova L, Mendel L, Peturs A, Stan I, Urbanaviciiute I (in preparation) Ecobreed farmers participatory field trials 2023.

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