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BRESOV

Breeding for Resilient, Efficient and Sustainable Organic Vegetable production

Deliverable No. D5.4

Performance of the varieties in on-farm trials: Quality assessment (resistance to diseases, yield, physical appearance, ease of harvest, acceptability from the farmers) of each new variety and analysis of soil samples during the two years rotation model

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1. Introduction

The first two objectives of WP5 were i) to evaluate a shortlist of breeding lines compatible with organic farming for the production of crops of enhanced quality and marketing value and ii) to provide farmers with new materials to be tested alongside commercial organic varieties on farm. These test materials of tomato, broccoli and beans were selected in the trials of task 5.1 and are described in BRESOV D5.1. Their production was tested under local organic production conditions during two seasons in different European location. The one-year prolongation of the project allowed the addition of a season of trials in Portugal (P4-UTAD) and Romania (P11-VRDS). P14-ZAAS and P13-BAAFS tested varieties from their own breeding programs in China. Their trials are not included in this report.

Varieties cultivated at each trial location are listed in BRESOV D5.1. These varieties originate from organic seed producers' breeding programs, BRESOV partners breeding trials, or from partners previous experiments or tests with other tasks of BRESOV. In the second year of trials, minor changes of varieties were made in some locations to adapt to the result of the first year.

In this deliverable, we describe the performance of the main common varieties tested, in terms of yield, health and appreciation by the farmers. We also include the analysis of soil sample from the different trial locations.

2. Description of Activities

Material from the three main crops of BRESOV, Tomato (greenhouse GH and open field OF), beans and broccoli were tested by up to seven partners in collaboration with regional organic farmers in 2020 and 2021, as well as in 2022 for partners P4-UTAD and P11-VRDS (table 1). The farm locations and usual production practices can be found in BRESOV D5.1.

Partner	Country	GH Tomato	OF Tomato	Broccoli	Bean
P4-UTAD[1]	PT			X	
P5-VURV	CZ			X	
P6-FiBL	CH	X		X	X
P9-UNILIV	UK			X	
P11-VRDS[1,2]	RO		X	X	X
P12-CREA[2]	IT		X		
P16-SERIDA	ES				X
P18-ITAKA[3]	IT	X	X	X	X
P21-SECL	FR	X		X	X

Table 1: Crops for which each partner performed variety trials. [1]three years of variety trials. [2]trials were carried in two locations, except for the 2023 trials of P11-VRDS. [3]One GH tomato trial, and one OF tomato trial were carried in the 2 years.

The main material tested is presented in the annex of BRESOV D5.1 and consist of the following lines:

- Greenhouse tomato
  - FiBL2-298X
  - FiBL7-TZ24
  - FiBL3-236X
  - FiBL4-TZ32
- Open field tomato
  - FiBL8_To65_Mauro Rosso
  - FiBL9_PVB8(Ti03)
  - FiBL10_PVB67(Ti08)
  - FiBL 12_ PL-10 Bacau

- Broccoli
  - Rasmus
  - CN-BRO-09
- Bean
  - La Victoire
  - Slenderwax

For the first year of trials, the seeds of tomato and broccoli were procured from the seed producers and distributed by P6-FiBL to partners. Seeds of beans (the two commonly tested varieties la Victoire and Slenderwax) were multiplied by P18-ITAKA and distributed to partners. In the first year, P11-VRDS and P21-SECL used bean seeds directly from the seed producers, due to the particular requirements of their trials (timing, and farm regulations, resp.). For the second (and third) year of trials, seeds of the commonly tested material of bean and tomato were multiplied by P18-ITAKA.
The following tomato varieties were added after the first year and provided by P10-UPV from the Breeding set (GH)

- Rosa de Barbastro (BT04150): large sized pink variety, appreciated for its flavour and carnosity
- Uco Plata (BT00900): old variety from Argentina, tolerance to TSWV, very good yield and fruit quality, medium sized fruit, harvested green
- Valenciana d'el Perelló (BT04260): cultivated by a cooperative of farmers from Valencia. Very similar, if not identical to Breeding Set accession BT04060. Heart shaped tomato, with large fruit and very fleshy
- Benissoda (BT04250): local variety used by several farmers with very good results. Pink flat tomato with very good flavour and performance. It is incorporated in the crosses of the breeding programme (Task 3.4);

from partner P17-PSR

- Brad's Atomic Grape (heirloom variety): interesting fruit, turning from lavender and purple to green with other shades when ripe, and great taste;

and from organic seed producer Sativa Rheinau (OF)

- FiBL13-PVB66: advanced breeding line for industrial tomato production
- FiBL14- PVB82: advanced breeding line for industrial tomato production;

and are therefore not listed in BRESOV D5.1.

The experimental designs of the variety trials followed recommendations of Koller et al. 2016 and Lindner& Billmann, 2006. The evaluation of the varieties of each crop was made using the tables (i.e. evaluation table and farmer questionnaire) developed in WP5 and included in BRESOV D5.2. Prior to the trials, partners sampled the farm soil following a common protocol (annexed to BRESOV D5.2) of 12 sub-samples per field, pooled them and sent the sample for soil analysis. Some partners repeated the procedure during the 2 years trials.

In this deliverable, we report the overall performance of each of the commonly tested material of tomato (GH and OF), broccoli and beans and their appreciation by the local farmer hosting the trial. We also include the soil analysis result and the evolution of the soil during the experimental period whenever available.

3. Results

While partners used the same evaluation tables to acquire data on their trials, the particular conditions of an on-farm production trial and the different expertise of each partner resulted in heterogeneous exhaustivity and therefore large complexity of the data. This data was homogenised as much as possible by P6-FiBL and was uploaded to the project database on Kibana. The detailed results will be used by task 5.2 partners to write up to three manuscripts for peer-reviewed publications.
In this public deliverable, a summary of the performance of the varieties in each location is reported.

Greenhouse tomato

Greenhouse tomato variety trials were carried out in Switzerland, Italy, and France by P6-FiBL, P18-ITAKA, and P21-SECL, respectively. The commonly tested material was selected in task 5.1 and consists of FiBL2-298X, FiBL7-TZ24, FiBL3-236X, FiBL4-TZ32, brad's atomic grape and BT04150, BT00900, BT04260 and BT04250. Overall, not one of the tested materials gained the unanimity of partners and farmers. They all performed below the commercial variety references that can currently be found on the market. FiBL3-236x and FiBL7-TZ24 were even excluded from P6-FiBL and P21-SECL's second year of trial due to poor marketable yield and fruit quality (fruits' heterogeneity and waste). Only for Brad's atomic grape, which was tested by P6-FiBL and P21-SECL, an interest in its cultivation was found, despite a susceptibility to bursting as well as to pests and diseases. In France, a potential was also found in Valenciana d'el Perelló and FiBL-TZ32 (only in direct marketing), for their interesting quality and special type of fruits, respectively.

In table 2., we describe the performance of each variety in the different trials based on the results of the production at this site.

	P6- FiBL		P18-ITAKA	P21-SECL	
	2020	2021	2021	2020	2021
GENERAL	No clear variety differences regarding diseases detected.	Year with high proportion of waste due to late blight *Phytophthora infestans*.	All varieties in the trial performed worse than reference Tiepolo EZ. Fruit cracking and BER were the main reasons for an extremely high proportion of rejects.	All varieties in trial out-performed by the commercial reference. All were more subject to powdery mildew. Limited interest for commercialization except in small quantity (direct marketing).	Among the five varieties tested, only 'El Perello's Valenciana' and 'Brad Atomic grape' were found of interest.
FiBL2-298X	Average Fruit Weight: 37 g 80-85% of the right calibre, 2-3 Fruit Chambers Good yield and good taste properties. Nice aerated plant architecture Work intensive (a lot of pruning necessary) Produced small, un-tasty fruits. K deficiency symptoms observed (but lower than FiBL4-Tz32 and F1 reference).	Best in term of growth strength, uniformity of stock and good resistance to *Phytophthora infestans* (highest tolerance in trial). Aerated architecture. FiBL2-x298 produced a high proportion of fruits outside the regular calibre.	Best marketable yield among tested (75% of the reference). Not attractive for commercialization due to fruit deformation and cracking. Needs a better management of irrigation. Not recommended.	Commercial yield on the highest (ca. 75% of the reference Codino) Less sensitive to bursting than FiBL3 Colour more attractive than FiBL3 (more intense, more brilliant, less golden spots) Very good not excessive firmness. Heterogenous size (18-20 g up to 50g, not conform with cherry). Susceptibility to powdery mildew. In tasting, thick and crunchy skin but good balance of acidic sugar. To review despite a calibre on the larger side.	Highest commercial yield among tested varieties in the trial with 14.1 kg.m-2. Could be of little commercial interest with a smaller fruit calibre.
FiBL3-236X	Average Fruit Weight: 34 g	Excluded.	Low % rejects (18%) similar to reference. Highest BRIX 6.2 >	Very sensitive to bursting even after harvest.	Excluded.

	P6- FiBL		P18-ITAKA	P21-SECL	
	2020	2021	2021	2020	2021
	60-70% of the right calibre, 2-3 fruit chambers. Easy to harvest. sensitive to bursting, produces small, non-tasty fruits with a bland taste.		ref. Low yield, easy to harvest, sweeter fruits than reference with full pulp. Fruits are cracked and deformed. Needs better irrigation management.	Unattractive colour, lacks shine with many golden spots. Heterogeneous size from 25-50gr, not fitting a commercial category. Insufficient firmness Susceptibility to powdery mildew. In terms of taste, thinner skin than Fibl2 but less acidic juice. No commercial interest given the productivity and sensitivity to bursting! (with FiBL7 obtained farmer's lowest rating of 2/9).	
FiBL4-TZ32	Average Fruit Weight: 255 g Right size category: estimated 80-85% 5 Fruit Chambers Good yield and uniform plant development. Late start of harvest with irregular maturing of fruit (yellow, green spots) Very dense plant architecture (Pruning important) Showed the strongest	Good vigour, compact and dense architecture (can increase probability of fungal diseases if not pruned enough), absence of rolled leaves. Better tolerance to *Phytophthora infestans* (still responsible of over third of rejects) than others in test. Highest yield. Lowest rate of fruit bursting in the trial. Not appreciated for its taste in our trial.	50.75% waste, bad quality of fruits. Skin cracking, Blossom End Rot, and sunburn. Variety not adapted to hot summer cycles. Better management of irrigation and monitoring of calcium are needed. One of the worst varieties in the trial (Farmer rating 3/9).	Highest commercial yield among tested (ca. 75% of the reference). Intense and pretty pink colour. Very heterogeneous shape. Some fruits with yellow collars. Very limited firmness and very large disparity in calibre. Very susceptible to Blossom End Rot. Very limited commercial interest, size of the bouquet needs to be specified. BER is a major	Intermediate yields 9.8 $kg.m^{-2}$. Highest susceptibility to Blossom end rot (17.2%) and yellow collar (3.7%) in the trial.

	P6- FiBL		P18-ITAKA	P21-SECL	
	2020	2021	2021	2020	2021
	symptoms of K-deficiency Irregular fruit size.			handicap. Could be of interest only in direct marketing because of its type of fruits.	
FiBL7-TZ24	Average Fruit Weight: 394 g 90% in the right size category. Undeterminable number of chambers Good yield and regular fruit shape and size, but big. Displays yellow collar, less uniform plant development, dense plant architecture and a higher susceptibility to diseases. Displays symptoms of K-deficiency.	Excluded.	53,72% rejects. Low production and unsuitability for market due to low shelf life and high commercial waste. Cracking of thin skin, subject to Blossom End rot and sunburn. Small structure, difficult management of irrigation. Variety not adapted to summer cycles at high temperature.	Very heterogeneous shape and large display of yellow collars and Blossom End Rot. Cracked and burst fruits make for the rest of the rejects. Very insufficient firmness. No commercial interest. (lowest rating with FiBL3 2/9).	Excluded.
Rosa de Barbastro (BT04150)	Not tested.	High susceptibility to Phytophthora, strong growth, good vigour. Susceptibility to late blight responsible of over third of rejects. Tastiest varieties after Brad's Atomics in a panel degustation. It has a good quality of yield but inferior to FiBL4. It has beautiful fruits and a good taste.	62,73% waste. Skin cracking. Variety not adapted to hot summer cycles. Better management of irrigation and monitoring of calcium. One of the worst varieties in the trial (Note 3/9).	Not tested.	Not tested.

	P6- FiBL		P18-ITAKA	P21-SECL	
	2020	2021	2021	2020	2021
Uco Plata (BT00900)	Not tested.	Not tested.	Higher yield than other varieties but lower than reference and 30% waste. Susceptible to cracking, BER and sunburn. Only variety in the trial where farmer see a potential for IT market but not possible today due fruits deformity.	Not tested.	Not tested.
Valenciana d'el Perelló (BT04260)	Not tested.	Extremely susceptible to *Phytophthora infestans*, and bursting which are responsible of around a third of the rejects, each.	Low yield. Brix 5.82. Smaller plant, difficult irrigation management, not suitable for summer cultivation. Production not suitable to IT market place.	Not tested	Intermediate commercial yields 9.8 kg.m-2. With Brad's atomic grape, only varieties with some commercial interest. Interesting fruit quality with a good percentage of first choice quality (81%). Size somehow limiting for a 'beef' tomato type. The variety is sensitive to blossom end rot and bursting.
Benissoda (BT04250)	Not tested.	High susceptibility to *Phytophthora infestans.* High tendency to roll leaves. Small, compact plant. Susceptibility to late blight responsible of over third of rejects and fruit bursting responsible of up to third of rejects. Taste not appreciated in our trial, low note in tasting. No interest in the variety due to its	Highest yield (80% of reference, but 43% rejects). Subject to cracking, BER and yellow collar (blotchy). Better management of irrigation and Ca needed. One of the worst varieties in the trial (Note 3/9).	Not tested.	Lowest yield in trial of 8.9 $kg.m^{-2}$. Only 58% in first quality. Not recommended.

	P6- FiBL		P18-ITAKA	P21-SECL	
	2020	2021	2021	2020	2021
		taste and susceptibility to *Phytophthora*.			
Brad's atomic	Not tested.	Fruit bursting was responsible of up to third of rejects. Brads atomic grape was found better than FiBL2 because of its beautiful fruits, taste and attractiveness to the consumers. It is however susceptible to pests and diseases. In a tasting, Brads atomic grape followed by Rosa de Barbastro were found the tastiest of all varieties. It has beautiful fruits, great taste and attractiveness.	No tested.	Not tested.	Intermediate commercial yield 11.9 $kg.m^{-2}$. With Valenciana del Perello, only varieties with some commercial interest. Attractive and original fruit, may fit for a niche market. Good agronomic potential, 99% of the first choice with less than 6% of waste.

Table 2. Performance of tested tomato varieties in greenhouse on-farm production trial

Open Field tomato

Open field tomato trials were carried out by P11-VRDS, P12-CREA and P18-ITAKA. In both trial years, varieties performed differently depending on the location and low or high inputs in the production. FiBL10-PVB67 was excluded from P12-CREA's second year of trial due to its bad performance in the trial. P12-CREA performed trials in two location: The Battaglia farm with low input and an agroecological approach, and the Concetti farm with higher input. P11-VRDS also conducted the trials in two locations in 2020 and 2021. P11-VRDS conducted a third year of tests in one location.
Two new advanced breeding materials were procured and were evaluated by P12-CREA and P11-VRDS in the second year (and third year for P11-VRDS).
At P12-CREA, in the Concetti trial, the Malareto local variety showed the highest Brix, and HF1-17 the highest yield (significantly higher than all others in test). From the commonly tested varieties, a good potential was found for FiBL9_PVB8 (Ti03), and under low input conditions for FiBL13-PVB66 and FiBL14- PVB82 (highest yield at the Battaglia farm), as well as for FiBL8_To65_Mauro Rosso and FiBL12-PL10 Bacau which might be interesting for some markets. In 2020, P11-VRDS obtained similar performances for tested varieties and found that local line T6-Buzau47, T9-Inima de bou Musca, T10-Maremano and T11-PL 15 BACAU gave a better performance than the reference. In 2021 and 2022, however, T9-Inima de bou Musca and T10-Maremano did not perform well and are therefore not recommended. Similarly, T11-PL15 Bacau gave a lower performance in 2022 and is also not recommended. In general, FiBL12 performed differently in every location. In all three trial years, the four commonly tested varieties had an acceptable performance and are therefore recommended for organic production in Romania.
The third year of trials carried by P11-VRDS showed that seeds from the same varieties but resulting from two different seed multiplications (Sativa Rheinau vs. P18-ITAKA BRESOV multiplication) resulted in plants with very different performance in the production trial. FiBL8, FiBL10 and FiBL12 resulting from seeds multiplied by P18-ITAKA performed much worse than the same variety with the seeds provided by Sativa Rheinau via P6-FiBL.
In all trials, there was no breakthrough discovery of a consistently excellent tomato variety. Diseases and bad performance of the reference variety in certain cases requires that the results are handled with care.

In table 3, we describe the performance of each variety in the different trials based on the results of the production at these sites.

	P12-CREA		P18-ITAKA	P11-VRDS		
	2020	2021	2020	2020	2021	2022
General	Varieties selected by P12-CREA showed a higher adaptability to the environmental conditions. All varieties, in both farms and both years, presented the following waste classes in order of importance: undersize, rot and burns (physiological alterations), pest attack (*Tuta absoluta, Heliotis armigera*) and fungal attack.	Battaglia farm obtained 3.919 Kg/plant and a total yield of 60.582 t, while Concetti produced lower Kg/plant (2.608) and higher total yield (65.198 t). *See 2020 for waste categories.*	Bad production in this trial with very high rates of rejects due to BER (Blossom end rot) and sunburn. Bad performance of the reference variety does not allow for conclusive results.	Difference in variety performance was observed in the two farms (production and experimental), with large yield differences between locations. FiBL8,9,10&12 performed similarly. All trial varieties showed severe symptoms from the green aphid *Myzus persicae.*	Local lines T8-Leana Mare, T11-PL15 Bacau, FiBL8, T12-FiBL8, T15-FiBL12 obtained highest yield at the production farm, while T10-PL Mare and T13-FIBL9 yielded the most at the experimental station. Most varieties outperformed the reference Bacuni. It is hard to draw conclusions. A higher yield of tomato was obtained in the production farm with high rotation and diversity.	This additional trial was only conducted on the experimental farm. Growth strength was medium for all varieties, weaker than reference. All stocks were uniform, assessed as strong to very strong. The best varieties overall were FiBL8, FiBL 13 and FiBL 14.
FiBL8_To65_Mauro Rosso	At the lower end of yield in both farms. Only at Concetti farm a very limited market potential was found as it performed worse than the reference	Obtained intermediate to high yield in both farms. At Battaglia, it was much better than reference in terms of resistance to diseases and	Despite a high rate of rejects due to BER and sunburn, the variety performed better than the reference and can work for summer cycles under better	Best yield on the production farm. Better yield than the reference but lower tolerance to diseases. Low susceptibility to Alternaria.	With FiBL12, obtained the highest yield at the production farm. Compact architecture. Better yield quality than reference. Overall,	Similar to 2021 when using seeds from the same lot. Alternaria was detected here despite a low susceptibility described in the first year of trial.

	P12-CREA		P18-ITAKA	P11-VRDS		
	2020	2021	2020	2020	2021	2022
	in terms of yield, quality, and susceptibility to pests and diseases.	better in terms of taste, yield quality and ease of harvest. It was appreciated by farmer there. It was, however, not recommended in the Concetti due to lower yield and overall performance compared to reference and despite being less labour intensive.	irrigation and calcium management.		obtained the best appreciation by farmers.	Homogeneous fruits. Third highest marketable yield after FiBL13 and FiBL10. One of the best 3 varieties in the trial.
FiBL9_PVB8 (Ti03)	Only variety next to local lines (Cream sausage, Malareto and Hf1-17) which was appreciated at Battaglia low input farm for its highest yield, taste and overall performance compared to the reference. It obtained the highest Brix at Battaglia. Under high input, it gave	Highest Brix in the Battaglia trial the variety and better performance than standard. The results obtained in Concetti farm confirmed the agronomic performances of the two varieties Malareto and FiBL9-t103 with the highest yield. Under low input at Battaglia farm it	Despite a high rate of rejects due to BER and sunburn, the variety performed better than the reference and can work for summer cycles under better irrigation and calcium management.	Better yield than the reference but lower tolerance to diseases. A slight impact of the pest Gryllotalpa was observed. High susceptibility to Alternaria.	Produced the highest yield at the experimental farm. Compact architecture	Similar to 2021. Homogeneous fruits.

	P12-CREA		P18-ITAKA	P11-VRDS		
	2020	2021	2020	2020	2021	2022
	an intermediate yield Recommended under both low and high input production.	obtained the lowest yield. Its acceptance by consumers and taste was better than the reference and is therefore recommended.				
FiBL10_PVB67(Ti08)	Taste better than the reference at Battaglia but lower performance overall. Low yield in both farms, lowest yield and high rate of rejects in high input farms.	Excluded due to bad performance in 2020.	Despite a high rate of rejects due to BER and sunburn, the variety performed better than the reference and can work for summer cycles under better irrigation and calcium management.	Second best yield behind FiBL 8 on the production farm and better yield than the reference. Lower tolerance to diseases and acceptance by the customers. Lower homogeneity of fruits compared to other varieties.	Aerated architecture. Good yield, quality, tolerance to diseases and acceptance by consumers compared to the reference.	Similar to 2021 when using seeds from the same lot. Highest marketable yield after FiBL 13, followed by FiBL8.
FiBL 12_ PL-10 Bacau	Yield, taste and acceptance by consumers less good than reference at the Battaglia farm. But still among the highest yielding under low input. Under high input at the Concetti farm, it gave an	At Battaglia, perceived as slightly better than standard variety. Comparable intermediate yield under both low and high input. Lower performance than standards in Concetti, but might	Lowest marketable yield, and highest proportion of waste. Largest fruit calibre of varieties in test (175g compared to 77-87g on average for other three). Lack of firmness and bad shelf life of fruits makes it unsuitable for an	Best yield at P11-VRDS experimental farm. Overall best performance and appreciation by farmers, despite a lower tolerance to diseases and highest maintenance needs than reference. Low susceptibility to	With FiBL8, obtained the highest yield at the production farm. However, it has overall a lower yield than the reference. Aerated architecture. Best taste in the trial.	Similar to 2021 when using seeds from the same lot. Homogeneous fruits.

	P12-CREA		P18-ITAKA	P11-VRDS		
	2020	2021	2020	2020	2021	2022
	intermediate yield like all others in test and better taste than the standards.	have a potential market somewhere.	industrial production. It has an unbalanced structure with slightly long internodes, sweet but watery fruits. Not recommended.	Alternaria. Largest fruits (>100g) in trial compared to others with 40-55g.		
FiBL13-PVB66	Not tested.	Good yield, taste and performance at Battaglia, recommended. Under high input, despite a good yield, yield quality and overall performance, these were worse than standard varieties, and is therefore not recommended.	Not tested.	Not tested.	Heterogeneous architecture and low yield produced. Average fruit weight of 75g	Highest marketable yield obtained. Overall, one of the best 3 varieties in the trial.
FiBL14- PVB82	Not tested.	Highest yield at Battaglia farm under low input and good high yield in Concetti but lowest Brix 3.98. Normal Brix and difficult to harvest in Battaglia, inconclusive farmer's evaluation. In Concetti, lower	Not tested.	Not tested.	Heterogeneous architecture and low yield. Average fruit weight 55g. Better yield, quality, overall performance and acceptance by consumers compared than	Similar to previous year. One of the best 3 varieties in the trial.

	P12-CREA		P18-ITAKA	P11-VRDS		
	2020	2021	2020	2020	2021	2022
		performance, yield and quality than reference. Not recommended.			reference. Slightly better rated than FiBL13. Like FiBL8 has good potential.	

Table 3. Performance of tested tomato varieties in open field on-farm production trials

Broccoli

Two broccoli varieties, Rasmus and CN-Bro-09 were tested by P4-UTAD1, P5-VURV, P6-FiBL, P9-UNILIV, P11-VRDS, P18-ITAKA3 and P21-SECL.
The non-CMS variety CN-Bro-09 performed well in most trials and obtained results similar to F1 references. It is a good alternative to CMS varieties. The open pollinated variety Rasmus was also appreciated in several locations, with high yields (sometimes similar or higher to CN-bro-09) and yield in general exceeding other tested lines (other than F1 references). It was appreciated in Portugal for its ability to produce secondary heads. Under certain conditions, Rasmus had less homogeneous heads and a higher proportion of unmarketable yield compared to CN-Bro-09. Both test varieties are recommendable for organic production of broccoli. Rasmus and CN-bro-09 performed differently depending on location. In Italy and France, these varieties were evaluated as less good than available standard varieties in their market. In 2020, the trial in Romania unfortunately failed due to late sowing. Broccoli production suffered in many locations in the wet spring and summer of 2021. In general, CN-Bro-09 was the most appreciated. The status of CN-Bro-09 needs clarification at the moment. We know that it is free of cytoplasmic male sterility but have no additional information from the seed provider.

In tables 4.a and 4.b, we describe the performance of each variety in the different trials based on the results of the production at these sites.

	P4-UTAD			P5-VURV		P6-FiBL	
	2020	2021	2022	2020	2021	2020	2021
General		CN-Bro-09 and Rasmus obtained a similar good performance, also similar reference Naxos. Reference Marathon was more productive with bigger and well-developed main heads	The farmer reported that the test varieties Rasmus and CN-BRO-09 were well accepted in the market and are recommended for organic production.	Broccoli cultivation is not very common in Czech Republic. Rasmus and CN-bro-09 gave comparable yields with a 10% lower yield than reference Limba			Loss of certain repetition blocks due to floods in the field. Rasmus and CN-bro-09 had no yellowing heads contrary to the F1 references. KSB-BRO-CHE-BALB a tested variety which didn't make the selection in Task 5.1 (see deliverable 5.1) outperformed Rasmus in this trial.
Rasmus	Highest percentage of 1st quality heads, outperforming the references. Smaller heads than CN-Bro-09 and references. The farmer recommends this variety.	Lowest yield. Appreciated for its secondary sprouts. Head diameter comparable to reference Marathon, but smaller than CMS varieties. Slightly higher rate of rejects. Smaller heads (80% of their size) than the 3 F1 references. In general, preferred	Smaller heads than CN-Bro-09 and references (around 25% smaller). Thinner stalk. Marketable yield similar to CN-BRO-09 but lower than references. High proportion of non-marketable heads Re-emission ability very appreciated by farmer as secondary sprouts	Yield similar to reference Limba except, except for a small proportion of rejects and a slightly lower marketable yield	Higher total yield than reference, but lower yield of first quality and second quality heads Reasons for rejection, were mainly yellowing or lack of compactness	Lower yield than the F1 and CN-bro-09, higher proportion of 2nd quality heads. More regular heads than CN-Bro-09 but higher branching. Smaller heads compared to CN-bro-09 and references.	Lower yield with a large proportion of rejects, mainly due. to head rot, uncommon, misshapen heads, smaller heads or lack of compactness.

	P4-UTAD			P5-VURV		P6-FiBL	
	2020	2021	2022	2020	2021	2020	2021
		to Naxos. Has a potential for market but not under these conditions due to a verified sensitivity to excess water and heterogeneity of main heads.	are commercially valorised by organic vegetables consumers, recommended for certain markets.				
CN-Bro-09	Large heads, similar to reference Naxos. High marketable yield compared to reference. The farmer recommends this variety.	Head diameter comparable to reference Marathon, but smaller than CMS varieties. Smaller heads (80% of their size) than the 3 F1 references. Recommended by the farmer for its rigorous plants and overall good performance.	80% of heads are of first quality. Similar yield to Rasmus in terms of number of 1st quality marketable heads and total marketable yield in weight. Lower yield than references Heraklion and Naxos. Recommended.	Yield similar to reference Limba except, except for a small proportion of rejects and a slightly lower marketable yield	Latest variety to ripen, with a harvest two weeks later than Rasmus and reference Limba. Highest total yield followed by Rasmus. Lowest yield of first quality heads. The main reason for rejection was the lack of compactness	Yields similar to F1 reference Batavia. Comparable head sizes with the F1 references. Less regular heads than Rasmus.	High marketable yield similar to non-CMS and CMS F1 references, Batavia and Ironman, respectively. The few rejected heads were either small or had an uncommon shape

Table 4.a Performance of tested broccoli varieties in on-farm production trials in Portugal, Czech Republic and Switzerland

	P9-UNILIV		P11-VRDS			P18-ITAKA		P21-SECL	
	2020	2021	2020	2021	2022	2020	2021	2020	2021
General			Due to late planting when temperatures had dropped, the trial failed to produce marketable heads.	Next to several local reference varieties and a sprouting variety, both Rasmus and CN-Bro-09 gave the best performance in terms of yield and quality.	Farmer assessed both Rasmus and CN-Bro-09 as excellent, and better than the reference Calabrese and the rest of tested material.		The reference variety produced the highest proportion of rejects (26%).	Yields impacted by water deficit during the 1st stage of crop development and bird damages. The trial was later aborted.	Despite good performance of both varieties, the reference Steel was still preferred for the production.
Rasmus	Despite highest yield, most heads not marketable due to a susceptibility to spear rot. Variety more adapted to spring-summer cultivation.	Highest marketable yield followed by CN-Bro-09 despite highest proportion of rejects in terms of weight (similar to Waltham reference in term of number of heads) due to grow out buds, shape and lack of uniformity. Taste less	Experienced a higher attack of *Pieris albae* compared to the other varieties.	More regular head shape and smaller branching compared to CN-Bro-01. However, less homogeneous than CN-bro-09. Equally good performance in both locations with the highest marketable yield, especially on the production	Better yield, quality, appearance, number of 1st quality commercial heads than reference. Good general performance in organic agriculture, recommended .	Less productive Than CN-Bro-09 and reference. 27% rejects. Not recommended because of smaller heads and higher need of Nitrogen.	Higher proportion of rejects compared to CN-bro-09 (24%). Produced the most secondary heads. Lower yield and smaller heads than reference. Rated better than CN-Bro-09 by the farmer but	Did not meet the strict criteria of P11-SECL's market requirements (irregular and small buds). Higher branching, less regular shape, smaller heads and more buds than reference Steel. Higher head weigh than CN-Bro-09.	Less regular head shape than CN-Bro-09 and reference. Branching similar to the reference. Shape rather transfer medium elliptic. Lowest marketable yield, 7.5t/ha compared to the reference with 9.5t/ha.

		good than Waltham and susceptibility to spear rot makes it not recommended by farmer.		farm. On the experimental farm, obtained higher 1st quality heads than CN-Bro-09 but similar total marketable yield. Recommended by farmer for its better yield, quality and appearance compared to reference Calabrese.			worse than the reference.		
CN-Bro-09	Best variety (20% more yield than Rasmus), much less diseases than Rasmus and reference Waltham. Higher susceptibility to hollow stems.	Outperformed Rasmus and Waltham in terms of yield, quality, ease of harvest and maintenance, resistance to pest and diseases. Only the taste was slightly less good than Waltham. It is also more	Slightly or not affected by CAMV virus.	Irregular head shape but very homogenous heads. Outperformed by Rasmus, especially in the Romanian farm. Recommended by farmer for its better yield, quality and appearance compared to	Similar to Rasmus, a better yield, quality and appearance compared to the reference and a general suitability to organic agriculture, makes it recommended.	Highest marketable yield (despite 18% rejects) followed closely by reference Naxos. Recommended for its yield and ease of agricultural management.	Out-performed Rasmus. Higher marketable yield than Rasmus but lower than reference. Lowest proportion of rejects (15%). Easy to manage agronomically,	Did not meet the strict criteria of P11-SECL's market requirements (irregular and small buds). Higher branching, less regular shape, smaller heads and more buds than reference Steel. Least	Highly regular head shape, and branching just like the reference. Same transverse narrow elliptic shape as reference. Marketable yield comparable to reference Steel (9t/Ha).

		susceptible to hollow stem. Recommended by the farmer.		reference Calabrese.			good yield and better taste than reference Naxos makes it appreciated by farmer.	regular heads in trial.	Earlier harvest but more harvest days than reference.

Table 4.b Performance of tested broccoli varieties in on-farm production trials in England. Romania, Italy and France

Beans

Slenderwax and la Victoire, the two bean varieties selected in task 5.1 (see deliverable 5.1), were tested by P6-FiBL, P11-VRDS, P16-SERIDA, P18-ITAKA3 andP21-SECL. Both performed in general very well in the trials. During the production, it was not always easy to identify the disease when evaluating the varieties. Also, in the second year, both commonly tested varieties, Slenderwax and La Victoire, gave good results and high yields, comparable or better to standard references. Both varieties are therefore recommended for organic cultivation in all regions. Depending on the location, one or the other variety was preferred. In some trials, Slenderwax outperformed La Victoire. In others, it was the opposite. Regional visual appreciation of the varieties also differed, such as for Slenderwax's whose yellow pods were not appreciated in Italy. Other tested BRESOV lines gave good result, in particularly SPB240-Prennel in Romania and Spain. These trials confirm the good performance of Slenderwax and La Victoire under most organic production of beans.

In tables 5.a and 5.b, we describe the performance of each variety in the different trials based on the results of the production at these sites.

	P6-FiBL		P18-ITAKA		P21-SECL	
	2020	2021	2020	2021	2020	2021
General	Slenderwax, Maxi and la Victoire gave better results than P17-PSR-varieties included in the trial.	Compared to 2020, yield of reference Maxi decreased by 22%, La Victoire by 13% and Slenderwax by 30%. For all varieties, rejects mostly due to fat spots (Pseudomonas). Symptoms of aphids, snails and other pests were equally present on both varieties and reference. Similar performance for all varieties. All three had quite straight pods.	This trial was performed under greenhouse. Both gave comparable, even slightly higher yield than reference Ferrari. They were however found less easy to manage in GH and less tasty than the reference.	In 2021, beans were cultivated in 2 rotations, one in GH and one in OF. Both tested varieties are recommended by farmers for their vigorous plants, earliness and high yield in both systems.		Tested varieties obtained a good satisfying yield, but slightly lower than the reference Maxi, which was therefore preferred by the farmer. Yield, yield quality, ease of harvest and overall performance were found slightly better with the reference Maxi.
La Victoire	High yield slightly lower than the reference Maxi. Very good overall performance.	Highest yield but also highest proportion of rejects, mainly due to fat spots. Pods slightly narrower than Slenderwax and Maxi, but longer than slenderwax.	Good yield, slightly higher than reference, comparable to Slenderwax.	Similar slightly lower yield than reference Ferrari. Performance found as good as reference.	Only variety tested. Gave 12% lower yield than reference Maxi. Less easy to harvest than Maxi whose pods are above to foliage. The reference is therefore preferred.	Yield comparable but slightly lower than Slenderwax and lower than reference. On average across harvest dates, 81% of pods of marketable quality, just like the reference. Two sets of seeds from two different multiplication of La Victoire were tested, with a lower (but

	P6-FiBL		P18-ITAKA		P21-SECL	
	2020	2021	2020	2021	2020	2021
						acceptable) performance of plants from seeds multiplied within the project.
Slenderwax	Highest yield followed by reference Maxi and la Victoire. Lower susceptibility to diseases.	Higher susceptibility to Botrytis compared to La Victoire and Maxi, but higher resistance to Ascophyta. Fast manual harvest, similar to Maxi because of its easy to spot yellow pods. Seeds were more marked than La Victoire and Maxi.	Despite a very good performance, wasn't attractive due to its yellow pods. Therefore, not yet suitable for this market.	Yellow pods not appreciated. Obtained highest marketable yield in trials. Received a lower assessment compared to the reference.	Not tested as necessary sanitary tests on seeds could not be carried on time.	Yield comparable but slightly higher than La Victoire and lower than reference. Slenderwax needed less harvest days than Maxi and La Victoire. On average across harvest dates, slightly lower proportion of marketable pods (71%) compared to reference and La Victoire.

Table 5.a Performance of tested bean varieties in on-farm production trials in Switzerland, Italy and France

	P16-SERIDA		P11-VRDS		
	2020	2021	2020	2021	2022
General	Several additional lines were tested. Many obtained a good performance. One of the best varieties was SPB-240 followed by Slenderwax.	Four lines: SBP_240 Prennel, SBP_237, Slenderwax (SBP_355), and SBP_049 obtained a production > 4.5 kg /plot and high pod quality.	Additional local lines and material from P16-SERIDA tested with a great performance of SPB240-Prennel followed by the two varieties Slenderwax and La Victoire.	Good yield obtained by SPB240-Prennel in both locations. This line combines several resistances according to WP2 tasks. Similar good performance of Slenderwax. Both Slenderwax and La Victoire rated excellent by farmer.	This additional trial year confirmed previous performances of Slenderwax, La Victoire and SPB240-Prennel. All were found excellent and recommended by farmer. Agronomical assessment of La Victoire and Slenderwax slightly better than for Prennel.
La Victoire	Lower yields than Slenderwax. Great taste.	La Victoire obtained a lower yield than in the first year.	High yield and good overall performance but lower than SBP240-Prennel and Slenderwax. Rated excellent by farmer.	Good steadfastness of the plant. Better tolerance to anthracnose compared to other tested materials, except Slenderwax and Perlata Straight pods, longer than Slenderwax.	Very good yield, quality and overall performance. Better than local reference Miruna. Surprisingly, no anthracnose detected contrary to other varieties. Pod weight similar to Slenderwax but lower than Prennel.
Slenderwax	Highest yield and lower susceptibility to diseases.	Top yielding variety among 12 determinate beans in test and very good pod quality.	Highest yield and lower susceptibility to diseases. Rated excellent by farmer.	Best plant steadfastness. Least susceptible to anthracnose in test. Straight pods. With SBP240-Prennel, least affected by common blight. Highest marketable yield behind SBP240-Prennel in both farms.	Very good yield, quality and overall performance. Better than local reference Miruna. Pod weigh similar to La Victoire but lower than Prennel.

Table 5.b Performance of tested bean varieties in on-farm production trials in Spain and Romania

At the beginning and during production trials of the three crops, soil samples from the farm were analysed. The results allowed to adapt fertilization and irrigation when needed during crop cultivation. For tomato and other crops such as broccoli in the UK, the sampling and analysis were repeated during the trial. The results of the soil analysis of samples from the different farms where the variety trials were conducted are reported in tables 6.a for tomato, 6.b for broccoli and 6.c for beans. This data would complete the discussion of the detailed result of each crop and each trial in prospective papers. Ideally, up to three peer-reviewed publications based on these trials can be developed with the trials' partners.

Partner, Country	**P6-FiBL, CH**	**P6-FiBL, CH**	**P6-FiBL, CH**	**P11-VRDS, RO**	**P12-CREA, IT - Battaglia**	**P12-CREA, IT - Concetti**	**P18-ITAKA, IT - Sicily**	**P18-ITAKA, IT**	**P21-SECL, FR**
Year /date	2020	2021 pre-plant.	2021 post-harv.	2020, 2021	2020	2020	2020	2021	2020, 2021
Crop	GH Tomato	Tomato GH	Tomato GH	Tomato OF, Bean, Broccoli	OF Tomato	OF Tomato	GH Tomato, Bean	Tomato OF	Tomato GH
Soil type	sandy loam	sandy loam	sandy loam	chernozem cambic	clay	39.5% sandy, 39.6% clay	sandy	sandy	silt & clay
pH	7.1	7.1	7.4	6.7	7.82	7.7	7.95	7.87	7.04
Soil salinity- electrical conductivity (dS/m)	95.3 (µS/cm)	95.3 (µS/cm)	95.3 (µS/cm)		479 (ds/m)	421	0,46 dS/m	1.78	0.53 mS/cm
Organic matter (% or g/100g)	3	3	2.5	2.6	1.13%	0.63	1.17%	1.68%	4.2
Macronutrient									
Total nitrogen (g/kg)	5.4 mg/kg	5.4 mg/kg	10.6	0.15%	1.15	0.51	0.6	0.9	31.58 mg/kg
Assimilable phosphorus (mg/kg)	2.5	2.5	24.1	138 ppm	4.8	5	20.4	7.5	6.7
Exchangeable potassium (mg/kg)	16			185			183.38	120.62	195.6
Exchangeable calcium (mg/kg)	103.3	103.3	87.8	1170			1903.39	2083.29	194.3
Exchangeable magnesium (mg/kg)	10.5	10.5	18.8	4640			93.47	89.67	61.3
Micronutrient									
Assimilable iron (mg/kg)	802	802	802	2.66%			11.2		
Assimilable manganese (mg/kg)	375	375	347	823			1.1		
Assimilable rame (mg/kg)	6.1	6.1	105	32.4			0.2		
Assimilable zink (mg/kg)				75.34			0.6		
Soluble boron (mg/kg)	0	0	0.7				0.6		

Table 6.a Reported soil analysis in tomato production

Partner, Country	P4-UTAD, PT	P6-FiBL, CH	P6-FiBL, CH	P6-FiBL, CH	P9-UNILIV, UK	P9-UNILIV, UK	P9-UNILIV, UK	P9-UNILIV, UK	P11-VRDS, RO	P18-ITAKA, IT
Year /date	2020	2020	2021 pre-plant.	2021 post-harv.	2020 pre-plant.	2020 post-harv.	2021 pre-plant.	2021 post-harv.	2020, 2021	2020
Crop	Broccoli	Broccoli	Broccoli	Broccoli	Broccoli	Broccoli	Broccoli	Broccoli	Tomato OF, Bean, Broccoli	Broccoli OF
Soil type	loamy		sandy loam	sandy loam	sandy loam	sandy loam	sandy loam	sandy loam	chernozem cambic	sandy
pH	pH H2O5.15; pH KCl 4.05	7.1	7.1	7.2	5.77	6.06	5.6	5.63	6.7	7.78
Soil salinity- electrical conductivity (dS/m)		121.1	95.3 (µS/cm)		30mg KCl/100	15mg KCl/100	37.5mg KCl/100	48.75mg KCl/100		2.4
Organic matter (% or g/100g)	4.915	1	3	3	3.45	4.17	5.18	4.71	2.6	0.30%
Macronutrient										
Total nitrogen (g/kg)		20.5 mg/Kg avail. N	20.5 mg/kg	14.5 mg/kg	83.9	34.6	122.1	106.8	0.15%	0.8
Assimilable phosphorus (mg/kg)	51	4	4	9	66	68	60	62	138 ppm	20.7
Exchangeable potassium (mg/kg)	113.5	12.8			131	82	71	83	185	101.2
Exchangeable calcium (mg/kg)		93	93	62.3	659	1201	736	1010	1170	2503.79
Exchangeable magnesium (mg/kg)		162	10.2	9.9	90	126	88	99	4640	192.35
Micronutrient										
Assimilable iron (mg/kg)		291	291	262	505	493	400	482	2.66%	7.3
Assimilable manganese (mg/kg)		346	346	252	2.4	1.3	3	2.7	823	2.8
Assimilable rame (mg/kg)		6.9	6.9	8.3	18	17.9	22.6	18.6	32.4	1.9
Assimilable zink (mg/kg)					5.3	5.5	6.1	6.4	75.34	1.1
Soluble boron (mg/kg)		0.1	0.10	0.30	0.39	0.31	0.39	0.38		1.3

Table 6.b Reported soil analysis in broccoli production

Partner, Country	**P6-FiBL, CH**	**P6-FiBL, CH**	**P11-VRDS, RO**	**P16-SERIDA, ES**	**P18-ITAKA, IT**	**P18-ITAKA, IT**
Year /date	2021 pre-sow.	2021 post-harv.	2020, 2021	2020, 2021	2020	2021
Crop	Bean	Bean	Tomato OF, Bean, Broccoli	Bean	GH Tomato, Bean	Bean OF
Soil type	sandy loam	sandy loam	chernozem cambic	62% sandy-22% loam-	sandy	sandy
pH	7.1	7.2	6.7	6	7.95	7.81
Soil salinity- electrical conductivity (dS/m)	95.3 (µS/cm)	(µS/cm)		0.43 mS/cm	0,46 dS/m	1.46
Organic matter (% or g/100g)	3	3	2.6	0.0324	1.17%	1.31%
Macronutrient						
Total nitrogen (g/kg)	20.5 mg/kg	12.2 mg/kg	0.15%	90.7 mg/kg	0.6	0.7
Assimilable phosphorus (mg/kg)	4	12.5	138 ppm	99.3	20.4	21.6
Exchangeable potassium (mg/kg)			185	157	183.38	83.38
Exchangeable calcium (mg/kg)	93	65.7	1170	1480	1903.39	2301
Exchangeable magnesium (mg/kg)	10.2	10.7	4640	128	93.47	113.49
Micronutrient						
Assimilable iron (mg/kg)	291	304	2.66%	74.5	11.2	5
Assimilable manganese (mg/kg)	346	277	823	8.56	1.1	1.2
Assimilable rame (mg/kg)	6.9	11.5	32.4	24.9	0.2	1.3
Assimilable zink (mg/kg)			75.34	7.92	0.6	0.8
Soluble boron (mg/kg)	0.10	0.40		0.727	0.6	0.9

Table 6.c Reported soil analysis in bean production

4. Deviations

Since the project was prolongated by one year due to the delays cause by the Covid pandemic in other work packages, partners who had the capacity, namely P4-UTAD and P11-VRDS, added a third year of on-farm trial, which brings added value to the results.

Impossible timely exchange of seeds with China prevented partners P13-ZAAS and P14-BAAFS of testing the same varieties as in Europe. They tested their own breeding material instead.

5. Conclusions

These on-farm trials allowed new or less widespread varieties as well as advanced breeding lines to be tested under usual organic production conditions on-farm in several European locations. They presented new crop material to the farmers but also to their customers, therefore the objective of WP5.

The results show that tomato material tested for greenhouse cultivation could not compete with commercially available varieties. However, it allowed the identification of varieties interesting for alternative markets such as direct marketing. Tested material for open field tomato cultivation performed differently according to location and inputs and were in general out-performed by local lines. Broccoli trials showed the great potential of the new open pollinated variety Rasmus (registered in 2018) and the CMS-free variety CN-bro-09. These trials showed that good alternatives to CMS varieties exist and that other open pollinated varieties in the pipeline could be of interest. Bean trials confirmed the good performance of Slenderwax and La Victoire and allowed the discovery of other interesting bean material such as SPB240-Prennel.

Planning for these multi-location on-farm trials resulted in the development of evaluation and farmer assessment tables for each crop (available in D5.2) that can be used by future variety trials. The extensive data collected on these trials can be used by the partners of task 5.2 for peer-reviewed publications and exploitation beyond the project's lifetime.

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