BRESOV

Breeding for Resilient, Efficient and Sustainable Organic Vegetable production

Civil Dialogue Group on Organic Farming

BRESOV H2020 project for increasing the resilience of the agroecosystems by exploiting agrobiodiversity

- [redacted]
- University of Catania

- 24.10.2023

Università di Catania

The BRESOV project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 774244.

The BRESOV H2020 project

Exploitation of **genetic resources**, in terms of formulating **climate- resilient** cultivars addressed to **vegetable organic production** systems under current and future scenarios of climate change

- **Three crops: broccoli, snap bean and tomato**
- **5** years *(1 May 2018 - 30 April 2023)*
- **22** partners
- **9** EU28 countries *(IT, BE, ES, PT, CZ, FR, UK, RO, GER)*
- **2** Associated countries *(Switzerland, Tunisia)*
- **2** Third countries *(China, South Korea)*

Approach and Anticipated Outputs

Multi-crop

Multi-actor

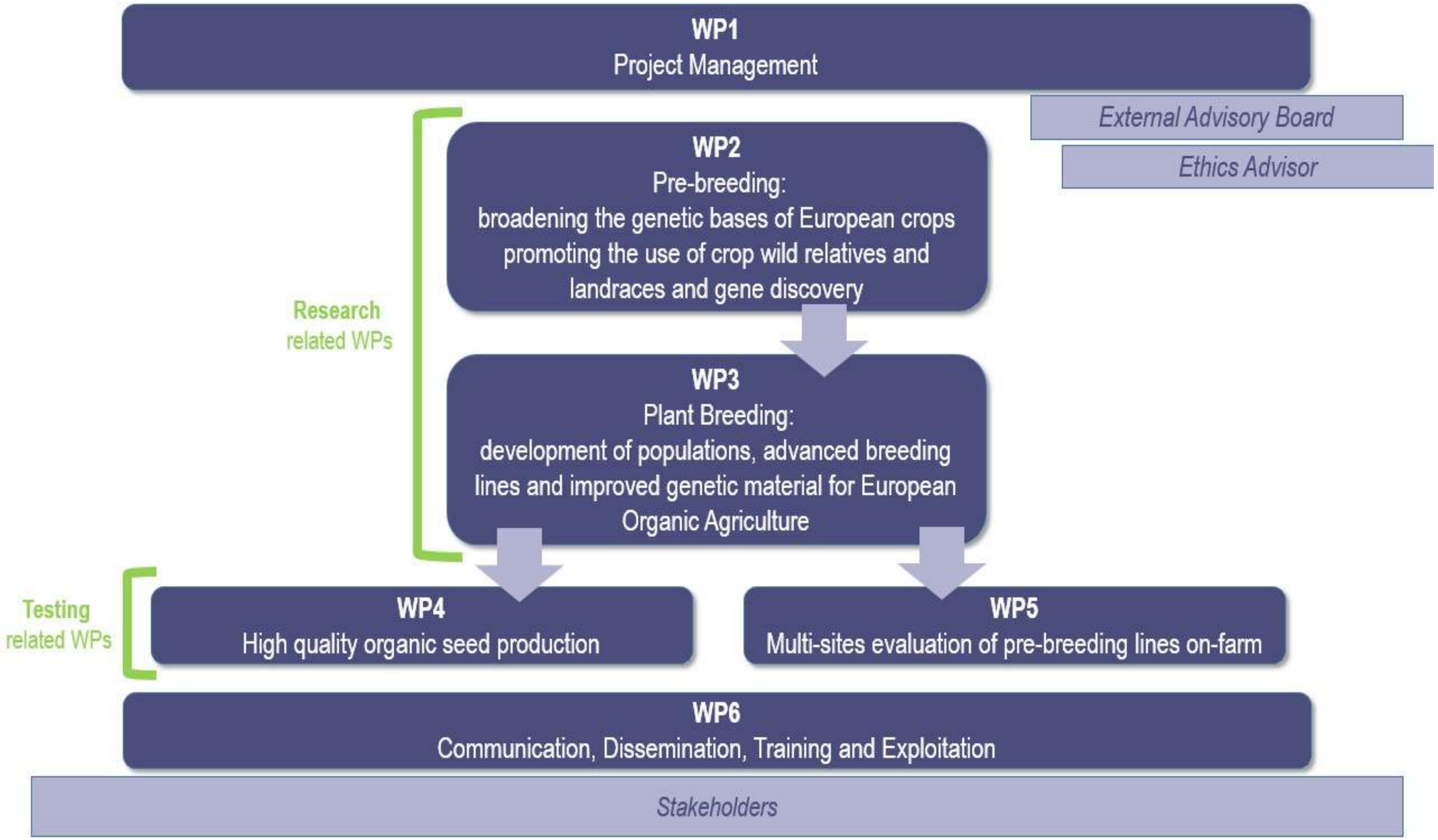
Multi-climatic

Improving competiveness of three important vegetable crops in organic production

Extending the genetic basis of organic breeding for broccoli, snap bean and tomato

Enhancing existing and newly developed varieties for organic vegetable production

Increasing the plants' tolerance to biotic and abiotic stress

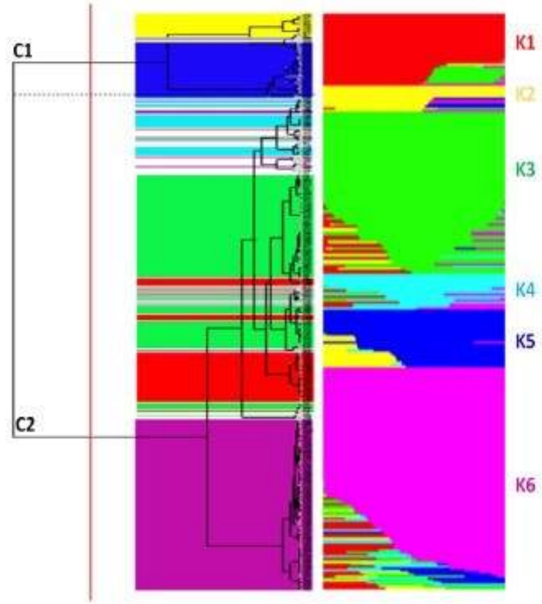

WP1
Project Management
External Advisory Board
Ethics Advisor
Research related WPs
WP2
Pre-breeding:
broadening the genetic bases of European crops promoting the use of crop wild relatives and landraces and gene discovery
WP3
Plant Breeding:
development of populations, advanced breeding lines and improved genetic material for European Organic Agriculture
Testing related WPs
WP4
High quality organic seed production
WP5
Multi-sites evaluation of pre-breeding lines on-farm
WP6
Communication, Dissemination, Training and Exploitation
Stakeholders

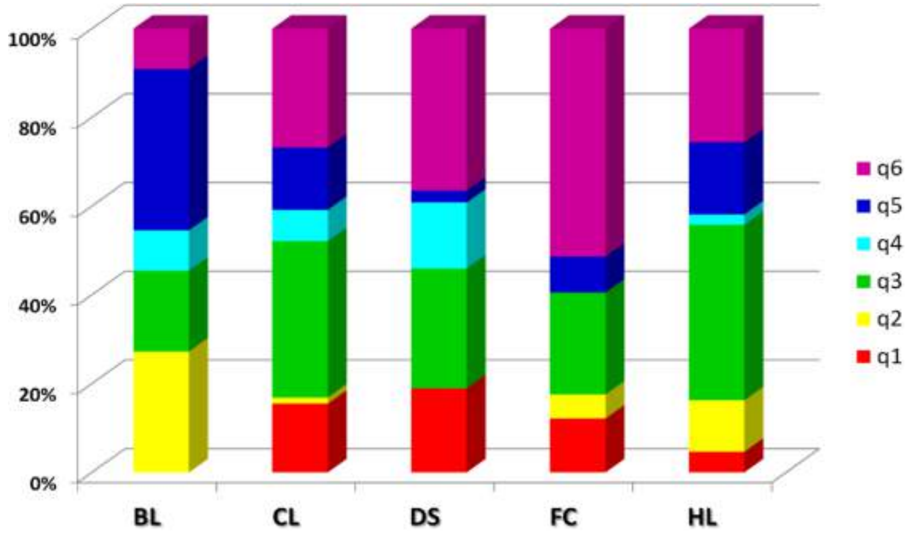
Achievement: Establish core collections for each species

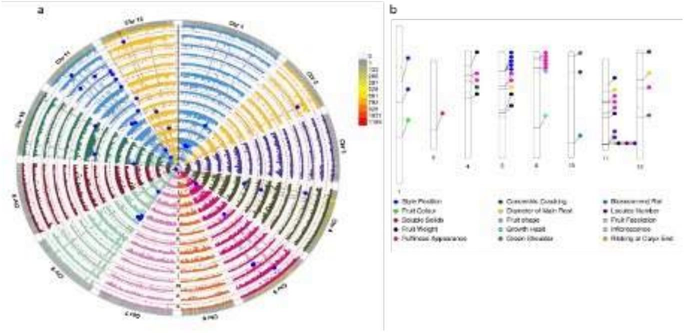
Crop Wild Relatives	58 [1]	41 [1]	11 [9]
Landraces	193 [1,2]	495 [1,6,7]	173 [4,8,9,13,14,15]
Improved lines	232 [1,2,3,4]	51 [1,6]	253[4,8,9,10,11,12,13,14,15]
Breeding lines	273 [2,3,4]	238 [1,4,5]	282[4,8,9,13]
Mapping population		148[7]	
Unknown			3 [9]
Total	**756**	**973**	**722**

Providers : [1] Universitat Politecnica de Valencia, [2] Consiglio per la ricerca in agricoltura e l'analisi dell'economia Agraria, [3] Universidad de Almeria, [4] Zhejiang Academy of Agricultural Sciences, [5] Chungnam National University, [6] Crop Reseach Institute VURV, [7] University of Liverpool, [8] Serida, [9] Università Politecnica delle Marche, [10] Vilmorin, [11] Institut National de la Recherche Agronomique, [12] Gautier semences, [13] Vegetable Research and Development Station Bacau, [14] Agricultural Institute of Slovenia, [15] ProSpecieRara

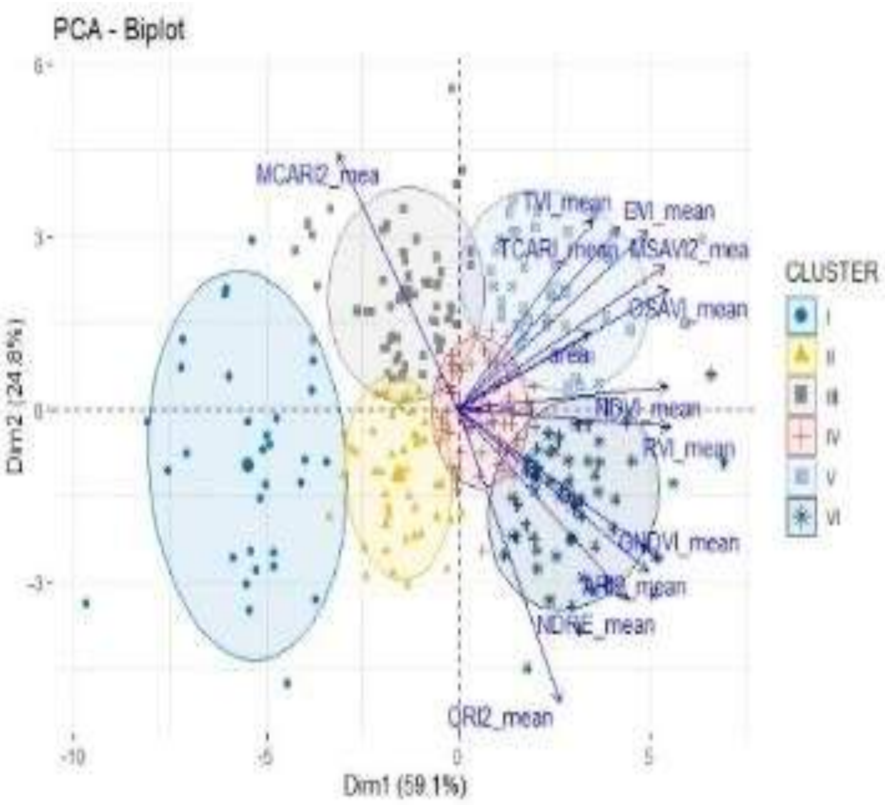
Achievement: Established and genotyped the core collections for each species

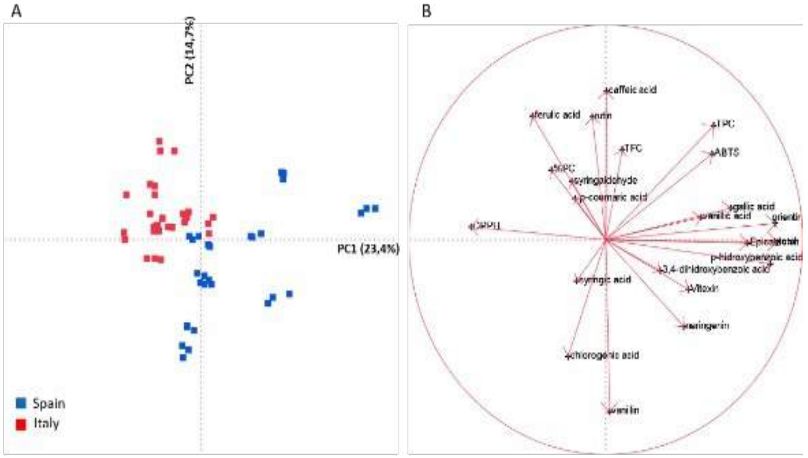


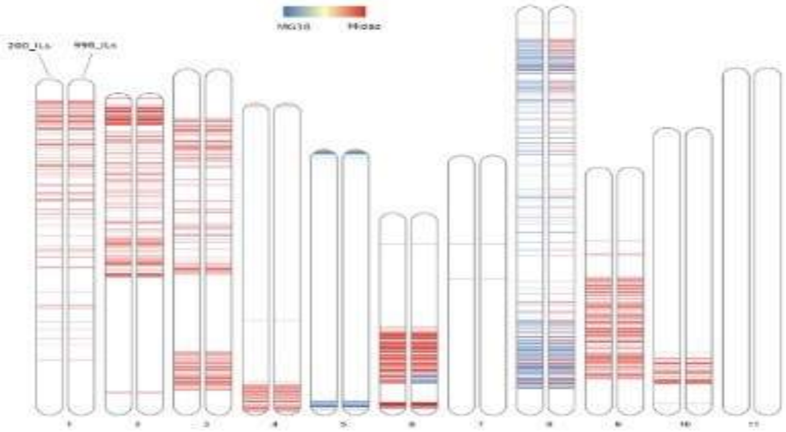




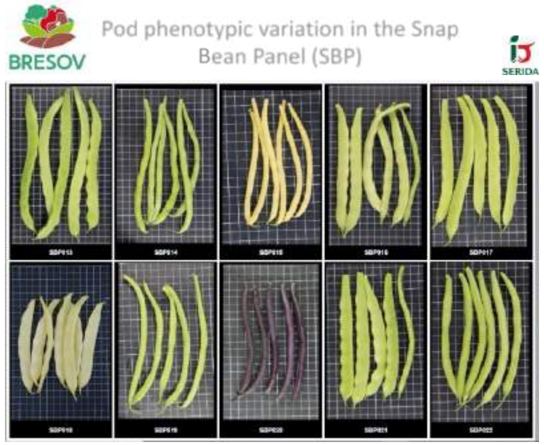
Achievement: Established and genotyped the core collections for each species







Achievement: Establish core collections for each species



Seed phenotypic variation in the Snap Bean Panel (SBP)

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Breeding for Resilient, Efficient and Sustainable Organic Vegetable production

WP2 - Pre-breeding: broadening the genetic bases of European crops promoting the use of crop wild relatives and landraces and gene discovery

The BRESOV project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 774244.

WP2 - Pre-breeding: broadening the genetic bases of European crops promoting the use of crop wild relatives and landraces and gene discovery

Objectives

Number	Description
O2.1	**Characterize genetically and phenotypically genetic resources** (CWRs, LRs and improved varieties) and use this information **by specific core collections, association panels and mapping populations**
O2.2	**Provide high-throughput genomic data** of associations panels and mapping populations, **along with phenotypic data** related to organic farming-related traits
O2.3	**Identify genes and/ or QTLs controlling organic farming related traits by using GWAS, linkage mapping and population genomics**, and exploit this information to **identify interesting lines/ genotypes** and to **develop molecular markers** to be used in future breeding for organic farming environments
O2.4	**Integrate all data** (genotypic and phenotypic information) from WP2 and WP3 in a **common database for each crop**

Morphotyping of the BRESOV *Brassica oleracea* core collection

Materials and methods

182 accessions of different morphotypes of *Brassica oleracea* complex species (n=9) provided by the genebank of UNICT, UNILIV and VURV were sowing in October 2018.

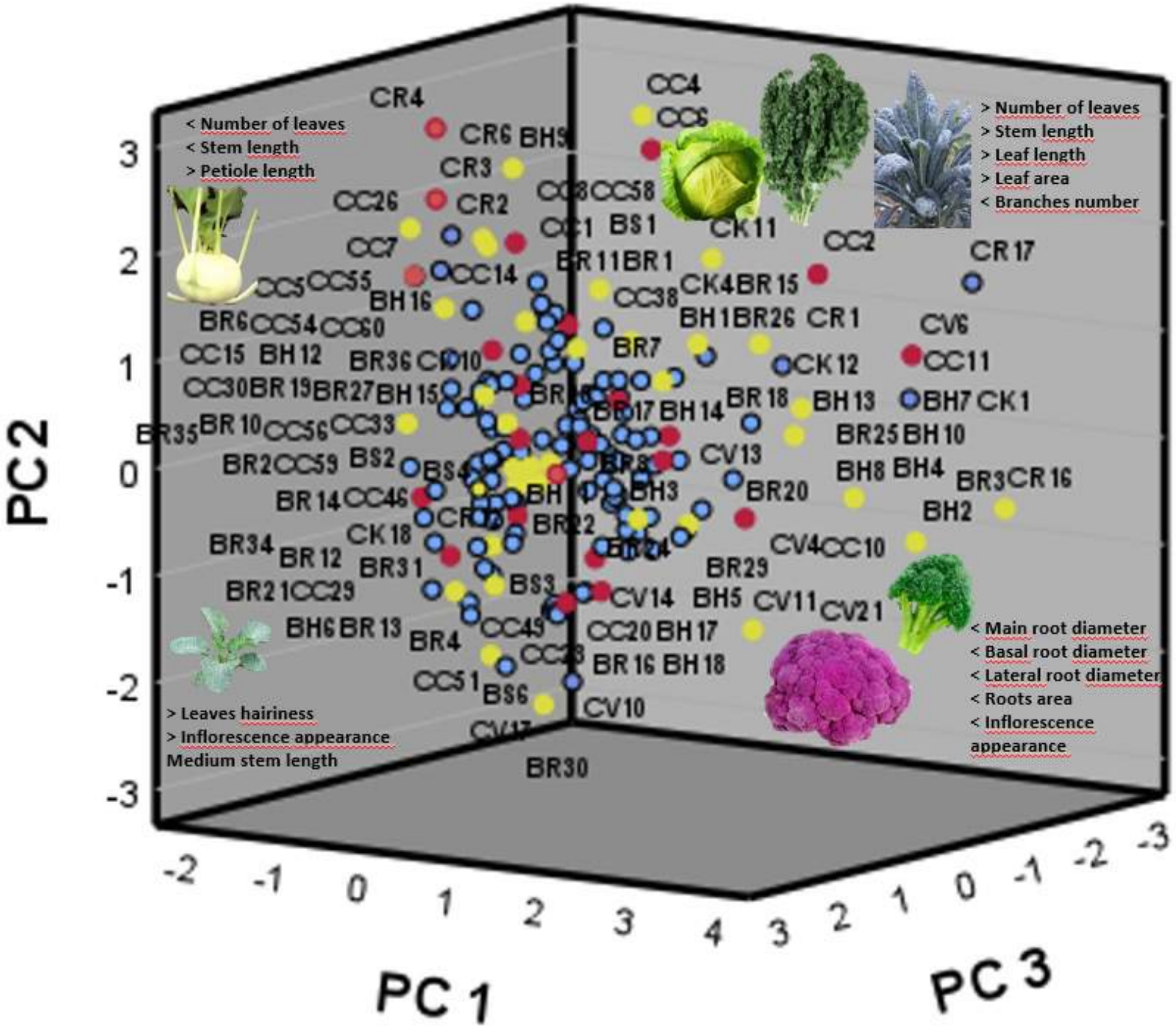
The experimental field
(Contrada Randello, Ragusa).

B. oleracea crops and CWRs accessions used for morphological characterization and morphological traits studied.

Crop name	Common name	Number of accessions	Provider
B. oleracea var italica	Broccoli	37	21 from UNILIV
			12 from UNICT
			4 from VURV
B. oleracea var botrytis	Cauliflower	26	15 from UNILIV
			7 from UNICT
			4 from VURV
B. oleracea var capitata	Cabbage	60	29 from VURV
			27 from UNILIV
			4 from UNICT
B. oleracea var acephala	Kale	18	12 from UNICT
			6 from UNILIV
B. oleracea var alboglabra	Chinese kale	18	18 from UNILIV
B. oleracea var gongylodes	Kohlrabi	17	10 from UNILIV
			5 from VURV
			2 from UNICT
B. villosa	CWR	2	UNICT
B. drepanensis	CWR	2	UNICT
B. incana	CWR	2	UNICT
Total number		182	182

The majority of the accessions studied were provided by Liverpool University germplasm with 97 accessions, while 43 accessions were provided by UNICT and 42 accessions by VURV.

Index	Descriptors
IA	Inflorescence appearance (d)
PB	Plant branches (n)
PLS	Plant leaf shape (1-7)
PGH	Plant growth habit (1-9)
PLN	Plant leaves number (n)
PSL	Plant stem length (cm)
LHR	Leaf hairiness (0-7)
LA	Leaf area (cm^2)
LL	Leaf length (cm)
LW	Leaf width (cm)
LD	Leaf division (incision)
LPL	Leaf petiole length (cm)
LPW	Leaf petiole width (cm)
RLA	Root left angle (°)
RRA	Root right angle (°)
BRD	Basal root diameter (mm)
MRD	Main root diameter (mm)
MRL	Main root length (cm)
LRD	Lateral root diameter (mm)
RA	Roots area (cm^2)
RFW	Roots Fresh weight (g)
RDM	Roots dry matter (g)



Spatial distribution of the different accessions characterized in the experiment in relation to the main three principal components (PCs).

UNICT
UNILIV
VURV

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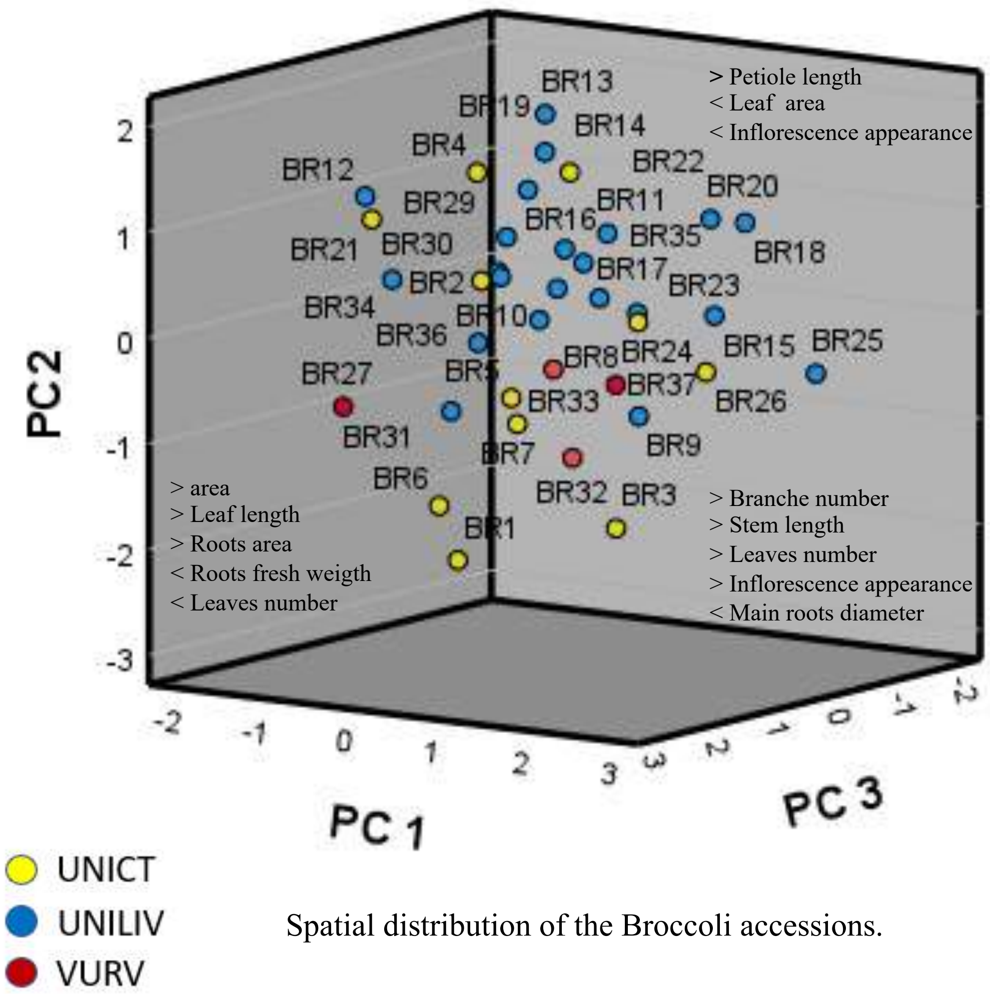
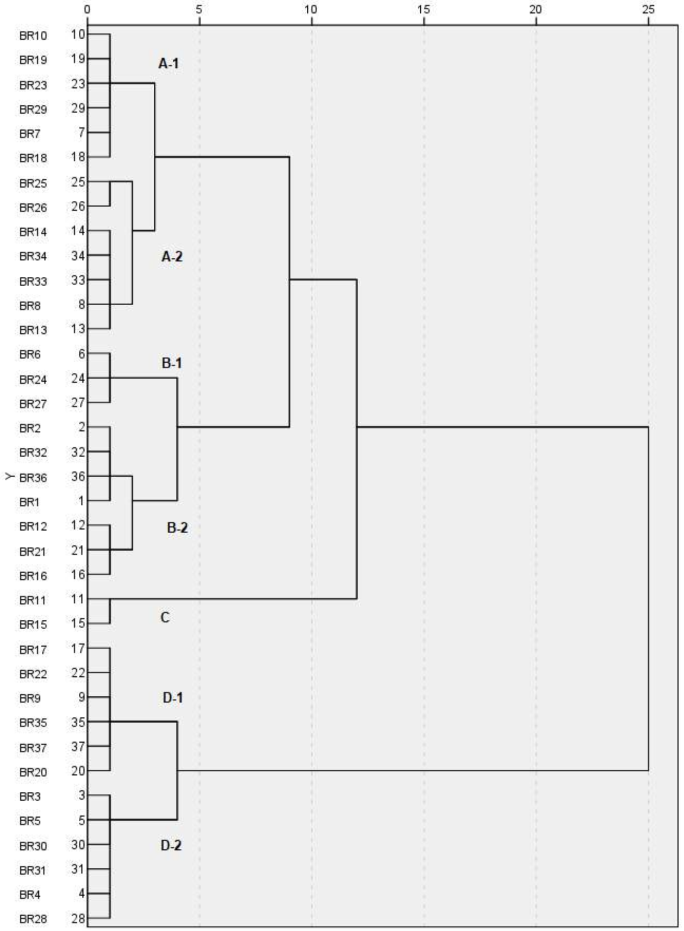
Diversity of BROCCOLI

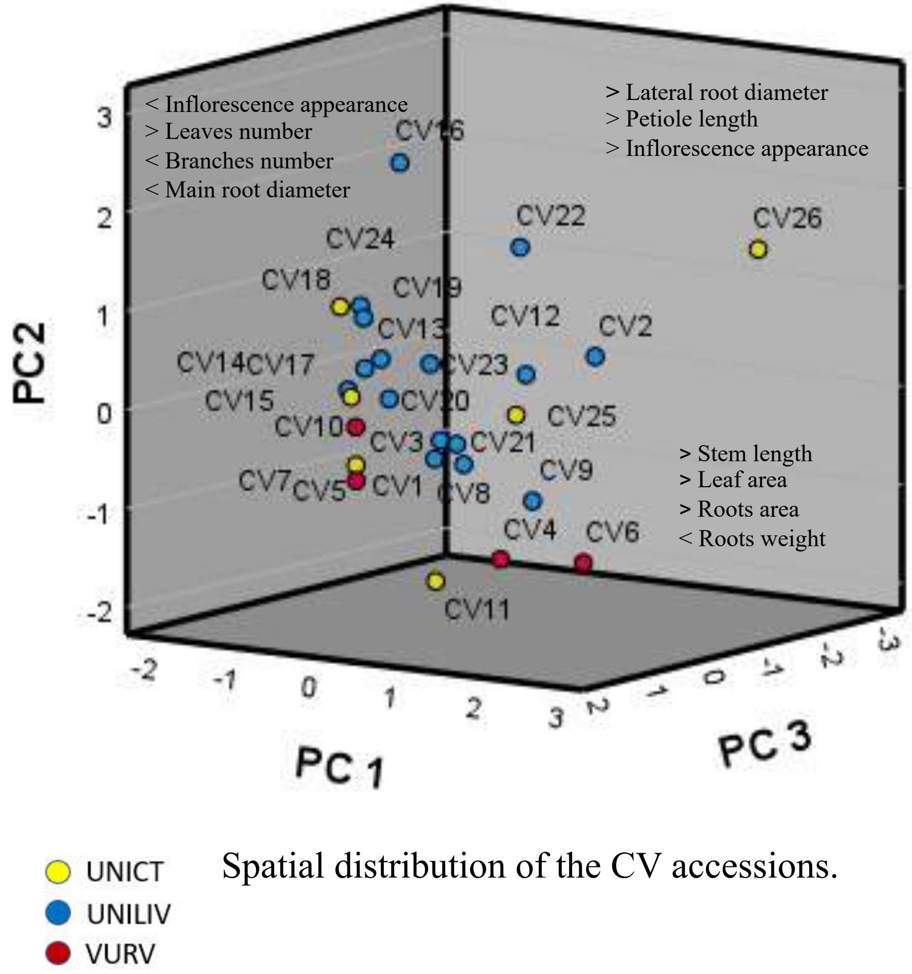


Spatial distribution of the Broccoli accessions.

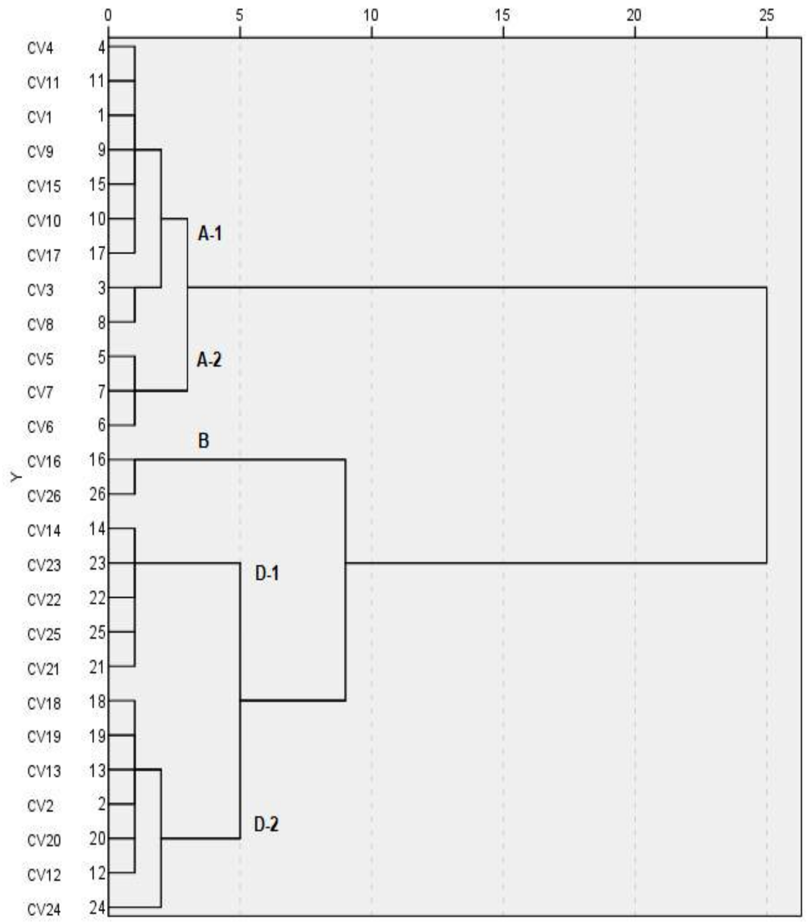


Dendrogram based on the genetic similarity matrix of Broccoli accessions.

Diversity of CAULIFLOWER



Spatial distribution of the CV accessions.



Dendrogram based on the genetic similarity matrix of CV accessions.

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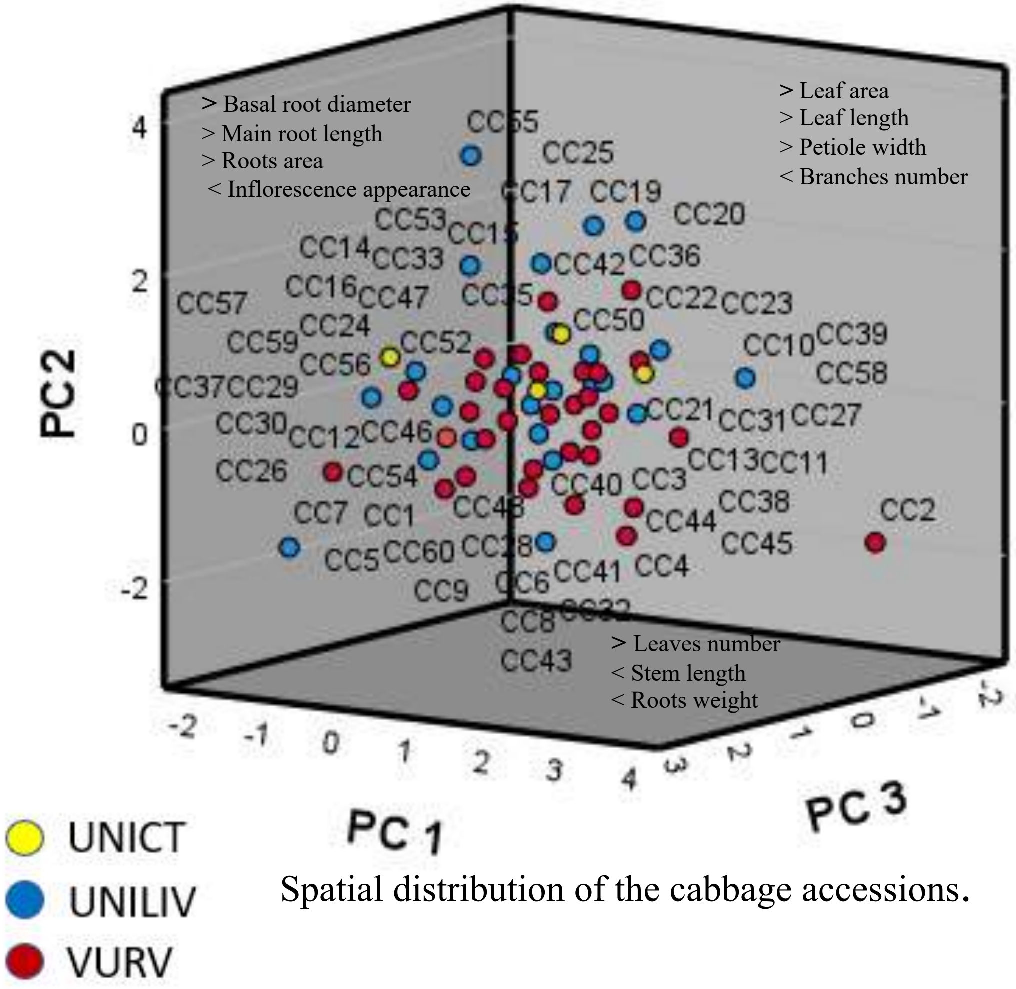
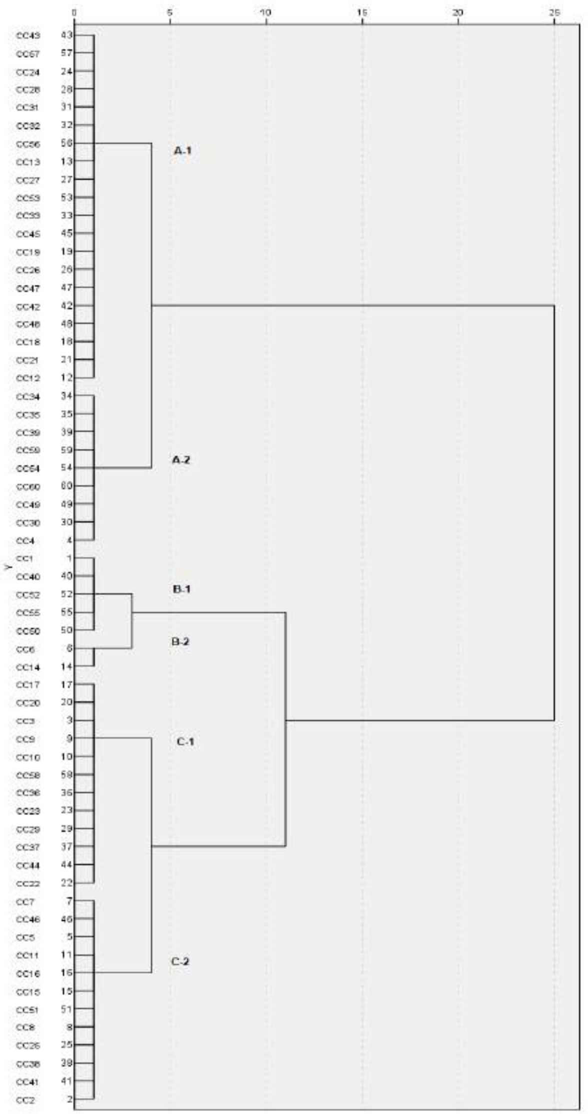
Diversity of CABBAGE

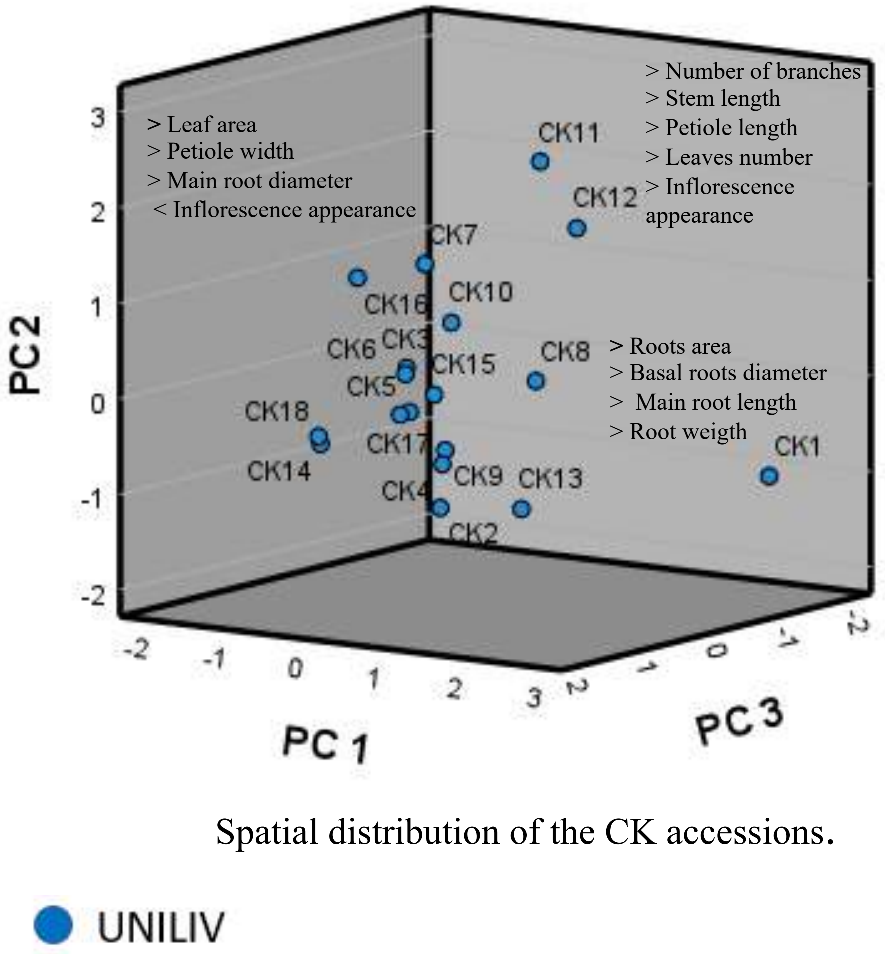


Spatial distribution of the cabbage accessions.

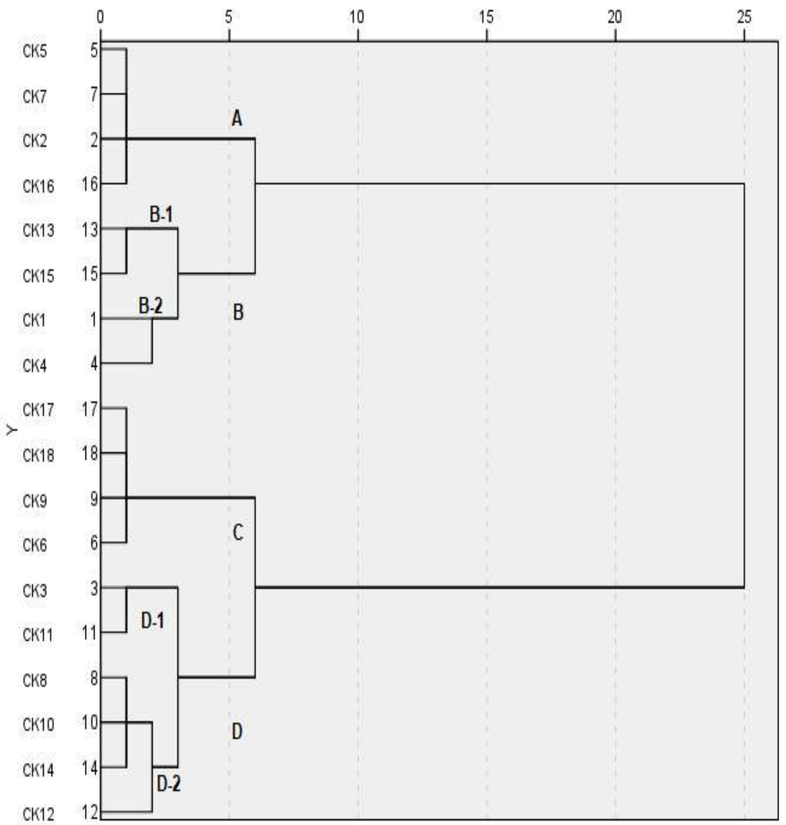


Dendrogram based on the genetic similarity matrix of CC accessions.

Diversity of CHINESE KALE

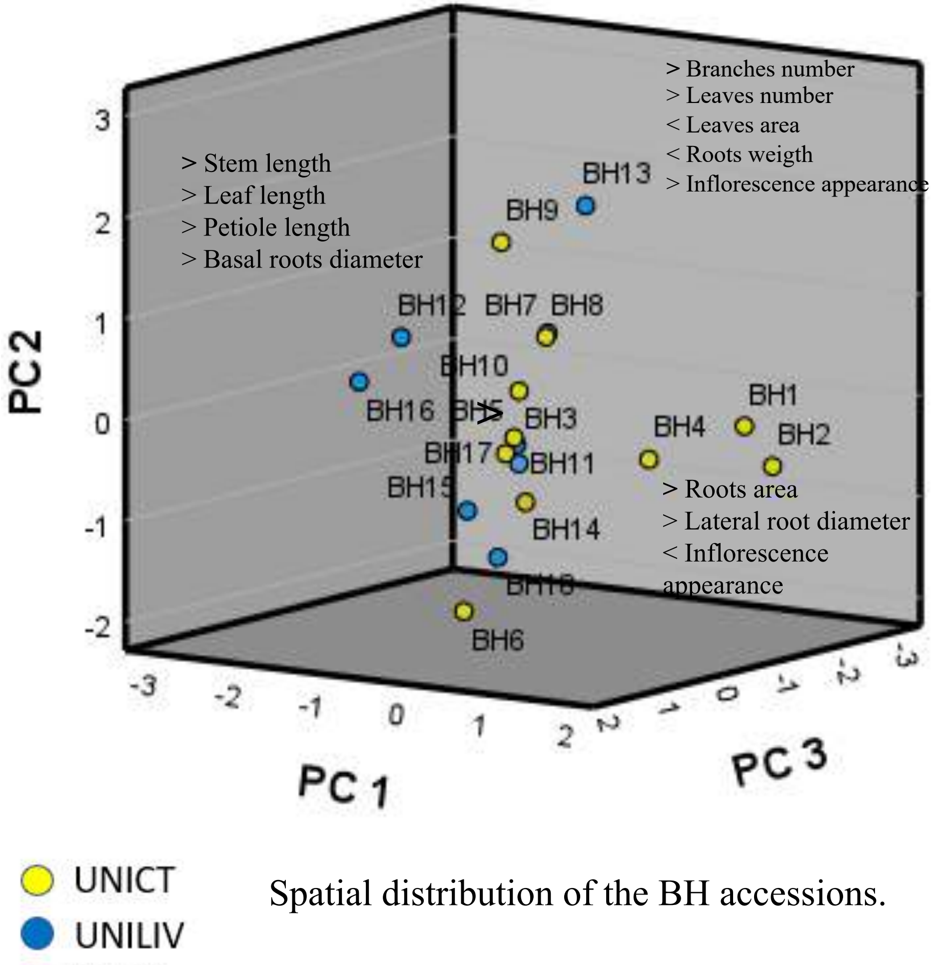


Spatial distribution of the CK accessions.

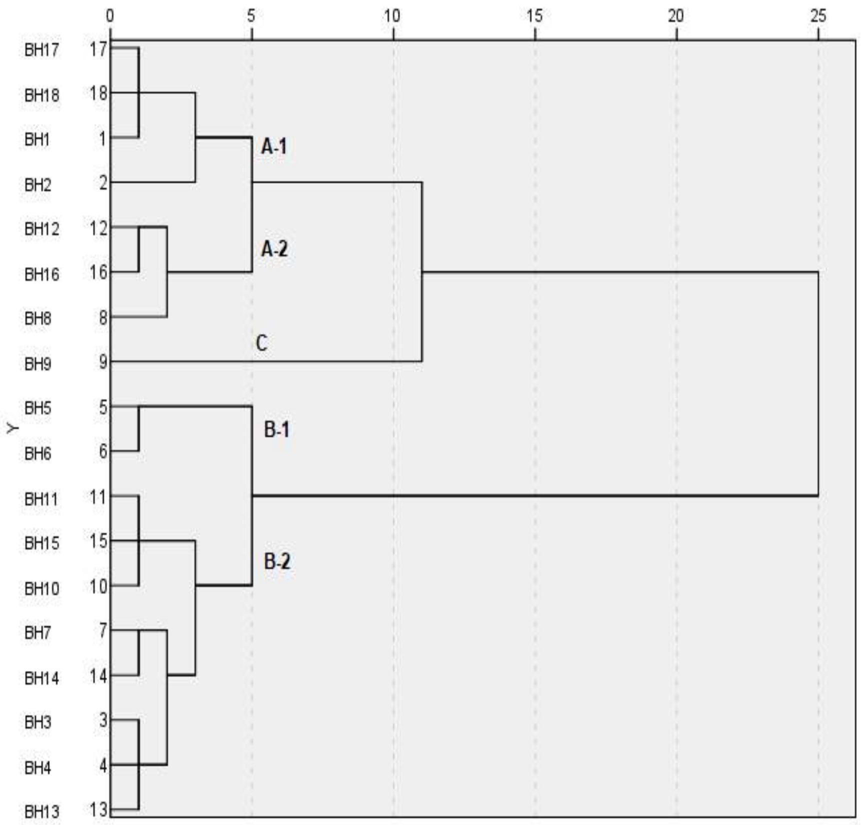


Dendrogram based on the genetic similarity matrix of CK accessions.

Diversity of KALE

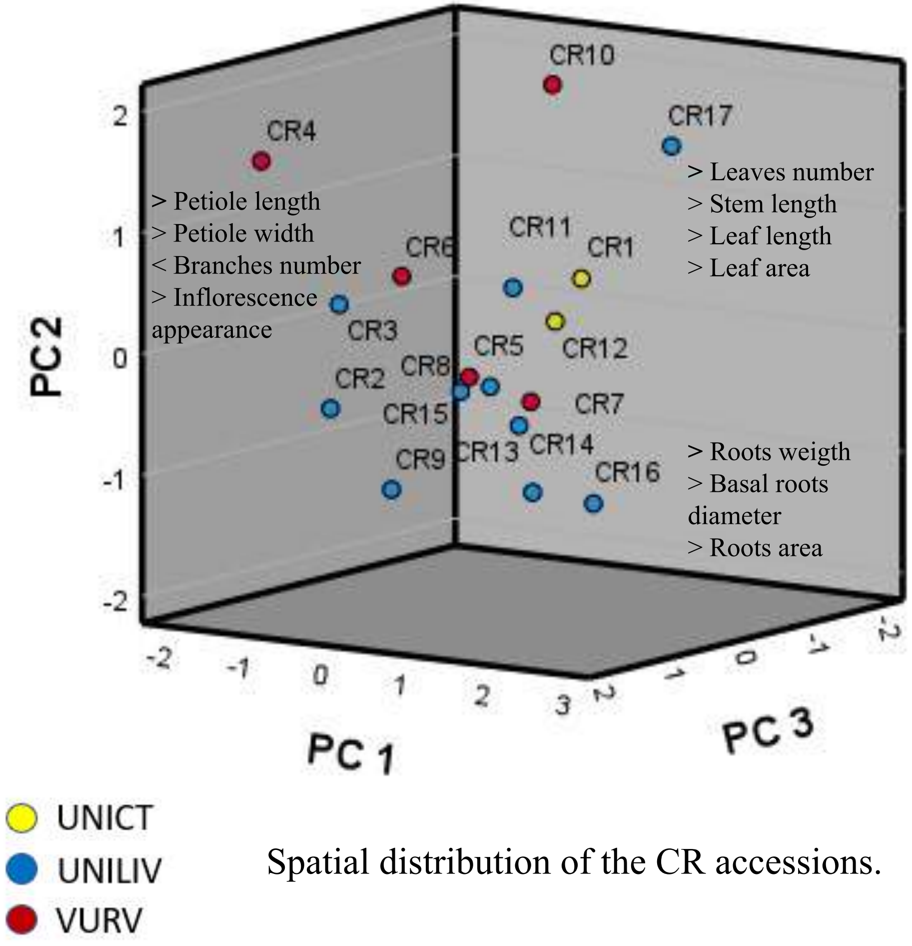


Spatial distribution of the BH accessions.

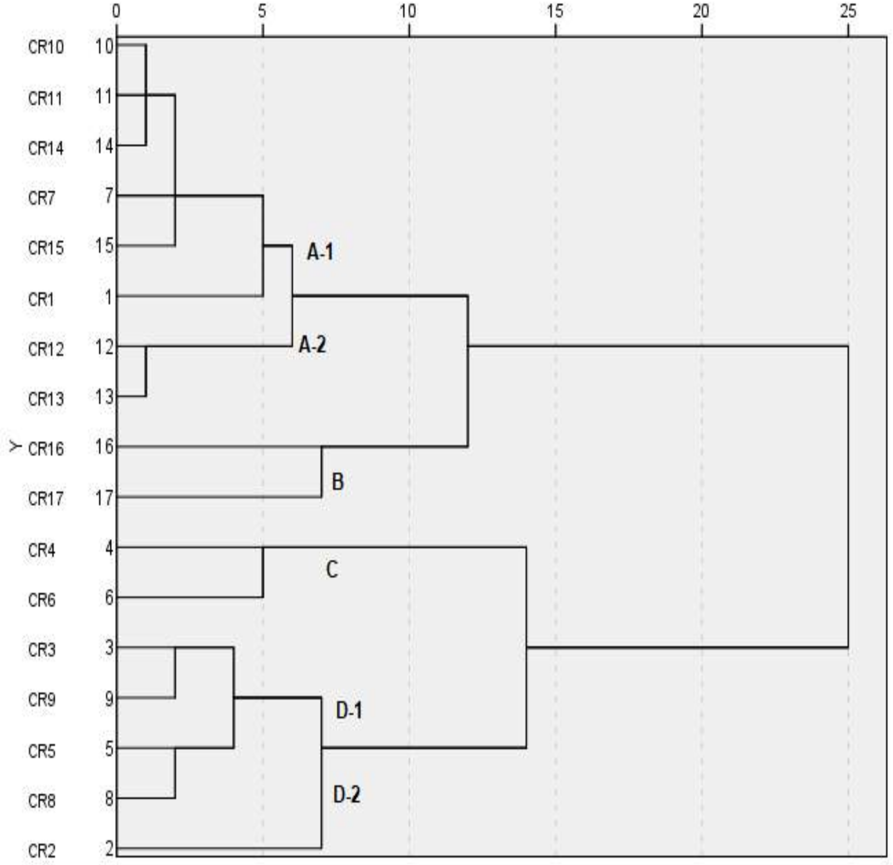


Dendrogram based on the genetic similarity matrix of BH accessions.

Diversity of KOHLRABI

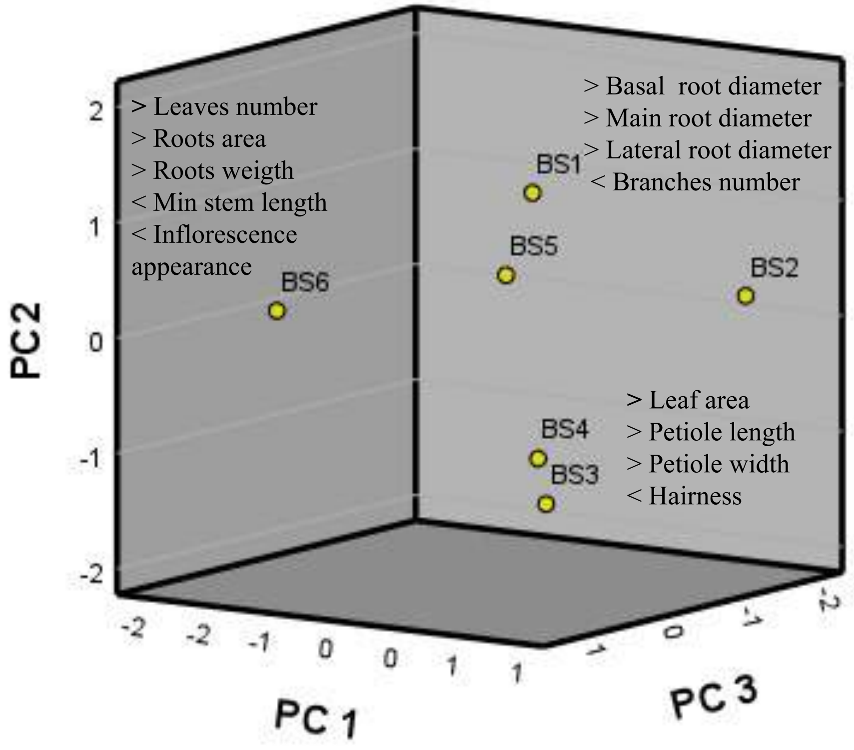


Spatial distribution of the CR accessions.

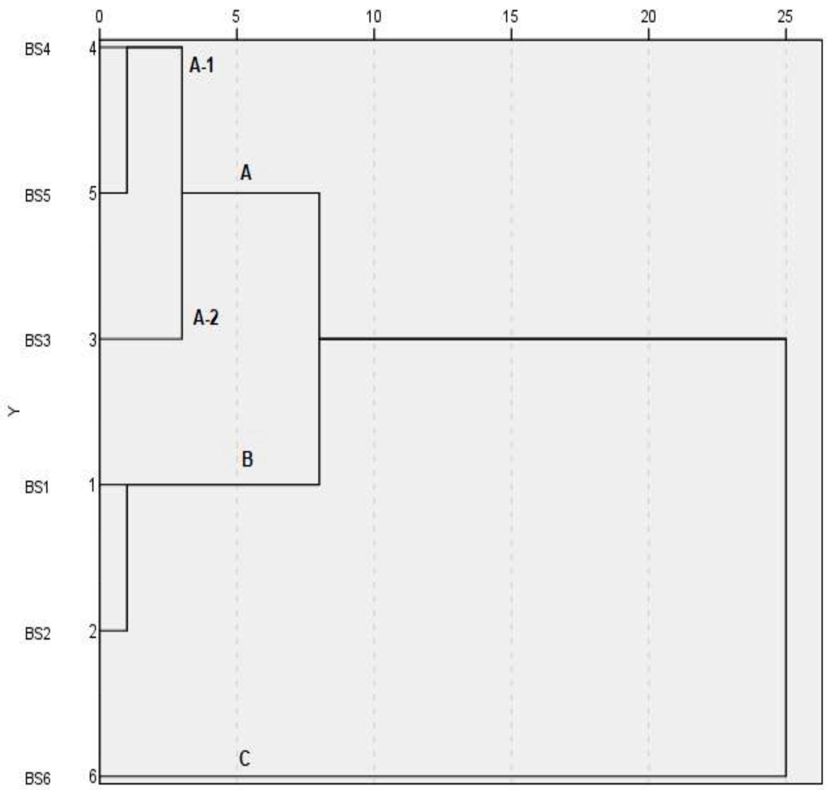


Dendrogram based on the genetic similarity matrix of CR accessions.

Diversity of CWRs



Spatial distribution of the CWRs accessions.



Dendrogram based on the genetic similarity matrix of CWRs accessions.

UNICT

BS1: *B. drepanensis;* **BS2**: *B. rupestris;* **BS3**: *B. incana;* **BS4**: *B. incana;* **BS5**: *B. villosa;* **BS6**: *B. villosa*.

Results/ (Key) Achievements

- *Genetic and phenotypic characterization of genetic resources, association panels and segregant populations* *(O2.1 & O2.2)*

ACTIVITIES RELATED TO:

T2.2 High quality genotyping and phenotyping

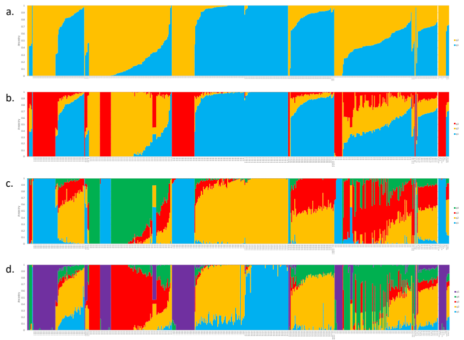
RESULTS REPORTED IN:

SUBMITTED

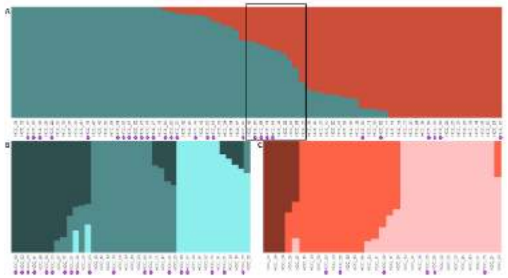
D2.2 - *M48, Apr 2022*

D2.3 - *M48, Apr 2022*

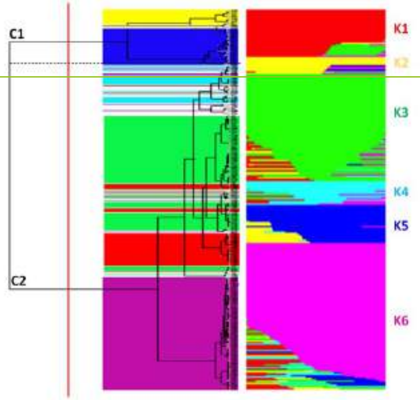
Genotypic characterization of BRESOV sets of materials



Brassica core collection
> Genotyping by Sequencing (GBS)



Snap bean Hyper Core Collection
> Genotyping by Sequencing (GBS)



Tomato Core Collection & Breeding set > ddRADseq

Results/ (Key) Achievements

- *Genetic and phenotypic characterization of genetic resources, association panels and segregant populations (O2.1 & O2.2)*

Phenotypic characterization of BRESOV sets of materials

Artificial inoculation system of *Alternaria brassicicola* in broccoli

Snap bean Panel - MLFTs

Nursery screening under combined heat and drought stress conditions - EMS tomato mutant families

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Results/ (Key) Achievements

Data analysis and results (O2.3)

- **275 new genetic tools (genes and/ or QTLs - *bean 133, broccoli 84 and tomato 58)*** controlling organic farming related traits by using GWAS, linkage mapping and population genomics
- Exploitation of obtained information to **identify interesting lines/ genotypes and to develop molecular markers** to be used in future breeding for organic farming environments
- Validation of markers

ACTIVITIES RELATED TO:

T2.3 ***Identification of genes and QTLs*** *for specific needs in organic farming*

T2.4 ***Validation of markers/ genes identified*** *as controlling important traits for organic farming*

RESULTS REPORTED IN:

SUBMITTED

D2.4 – *M54, Oct 2022*

D2.5 – *M60, Apr 2023*

D2.6 – *M60, Apr 2023*

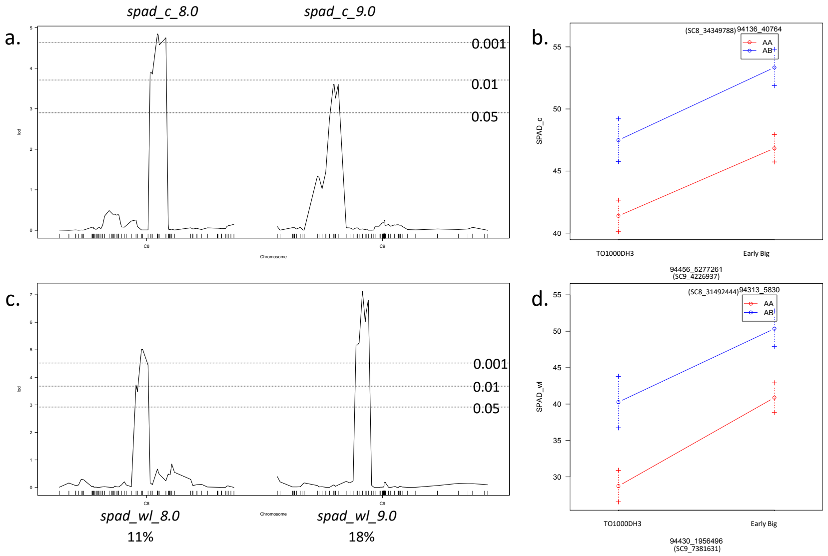
D2.7 – *M60, Apr 2023*

Results/ (Key) Achievements

Identification of genes and/ or QTLs controlling organic farming related traits by using GWAS, linkage mapping and population genomics

Waterlogging tolerance in BolTBDH mapping population

- BolTBDH bi-parental mapping population (*Iniquez-Luy et al. 2019*)
- Genotypic data available
- Controlled condition trial (waterlogged plants displayed stress and premature leaf senescence > trait data for chlorophyll reflectance in SPAD units (SPD) was chosen as a good indicator of waterlogging tolerance)



- **Four QTL** were identified for chlorophyll reflectance
- QTL spad_wl_9.0 > **5 potential candidate genes**, for of which associated with the formation of ariel roots

D2.4 – *M54, Oct 2022*

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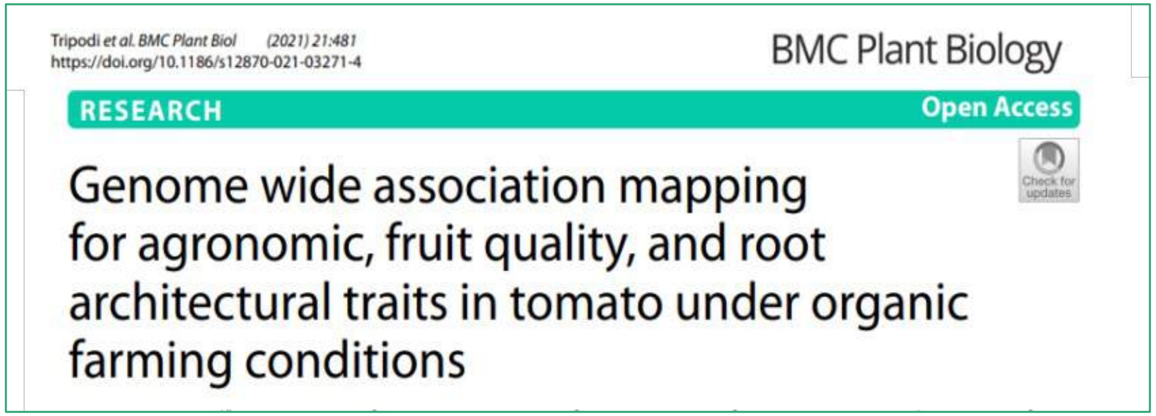
Results/ (Key) Achievements

Identification of genes and/ or QTLs controlling organic farming related traits by using GWAS, linkage mapping and population genomics



Tripodi et al. BMC Plant Biol (2021) 21:481
https://doi.org/10.1186/s12870-021-03271-4

BMC Plant Biology

RESEARCH — Open Access

Genome wide association mapping for agronomic, fruit quality, and root architectural traits in tomato under organic farming conditions

- Tomato Core Collection
- dd-RADseq data
- Field trials under organic farming conditions
- GWAS to map loci controlling the variation of agronomic, fruit quality, and root architecture

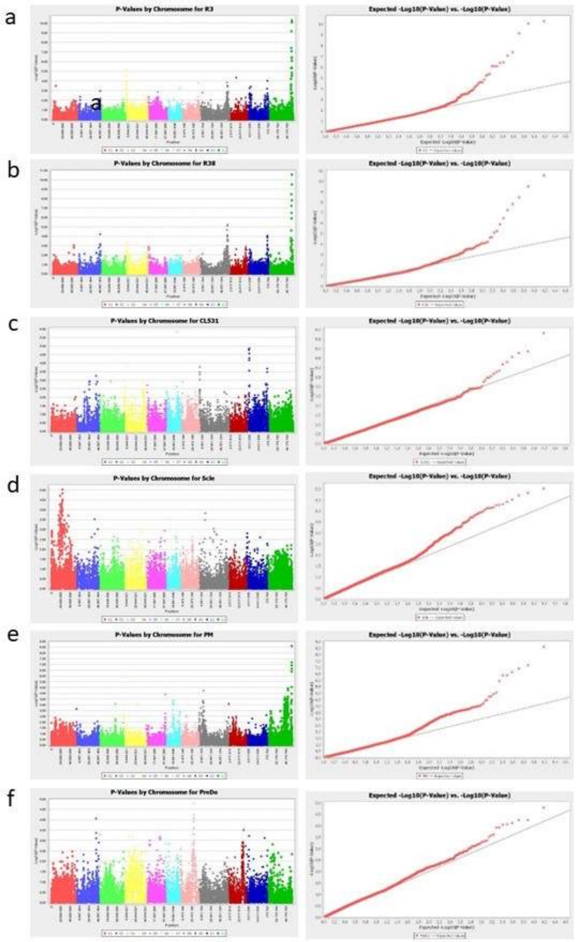
- **59 significantly associated loci** were identified, allowing the identification of novel genes **related to flower and fruit characteristics**
- Most genomic associations fell into the region surrounding *SUN, OVATE*, and *MYB* gene families
- **Six flower and fruit traits** were associated with a single member of the *SUN* family (*SLSUN31*) on chromosome 11, in a region involved in the increase of fruit weight, locules number, and fruit fasciation
- additional candidate genes for soluble solids content, fruit colour and shape were found

D2.4 – *M54, Oct 2022*

Results/ (Key) Achievements

Identification of genes and/ or QTLs controlling organic farming related traits by using GWAS, linkage mapping and population genomics

Association mapping of genomic regions involved in the control of resistances using the Snap Bean Panel



- Snap Bean Panel (SBP)/ GBS data
- Resistance tests in controlled conditions for **4 diseases causes by fungus: anthracnose, powdery mildew, white mold and *Pythium ultimun***
- GWAS to map loci controlling resistance/ tolerance

- Significant associations located on chromosomes Pv01, Pv02, Pv04, Pv05, Pv07, Pv10, and Pv11, mainly
- Involvement of the known regions in the reaction to these fungi, but also, of **new regions** as a region located **on chromosome Pv10** in the reaction to anthracnose

D2.4 – *M54, Oct 2022*

Results/ (Key) Achievements

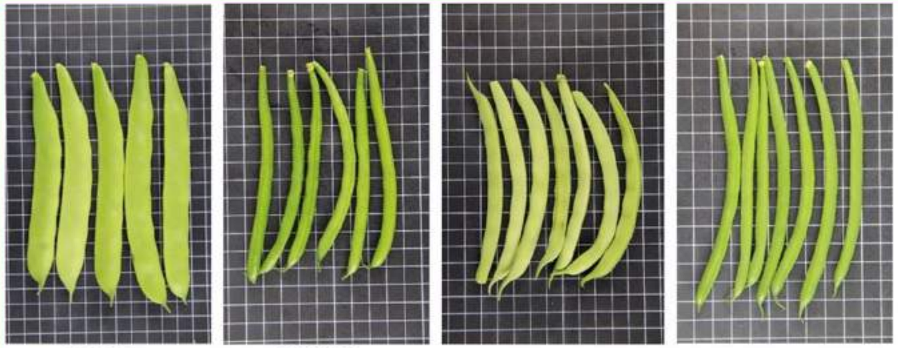
Exploitation of obtained information to identify interesting lines/ genotypes to be used in future breeding for organic farming environments

D2.5 – *M60, Apr 2023*

Seed coat color:
White

Growth habit:
Determinate

Susceptible to:
Pythium and antracnose (100)



SBP005 SBP145 SBP240 SBP302

	SBP005	SBP145	SBP240	SBP302
Powdery mildew	R	R	R	R
White mold	S	S	I	-
Anthracnose (CL18)	R	R	R	R
Anthracnose (CL123)	R	R	R	R
Anthracnose (C531)	S	R	R	S

S, susceptible; R, resistant

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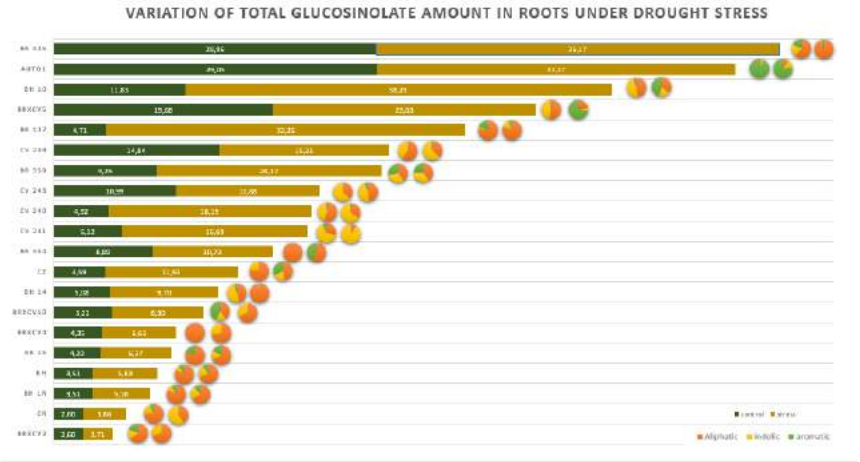
WP 3 – Plant Breeding: development of populations, advanced breeding lines and improved genetic material for European organic agriculture

- Objectives

Number	Description
O3.1	**Select germplasm** in the BRESOV repository that are resilient, and **adapted to organic agriculture**
O3.2	**Identify sources of tolerance or resistance to** prevalent **pests and diseases** under organic conditions
O3.3	**Breed new elite resilient materials** for organic agriculture
O3.4	**Evaluate quality traits** for selecting **high-added value cultivars and materials** for organic agriculture

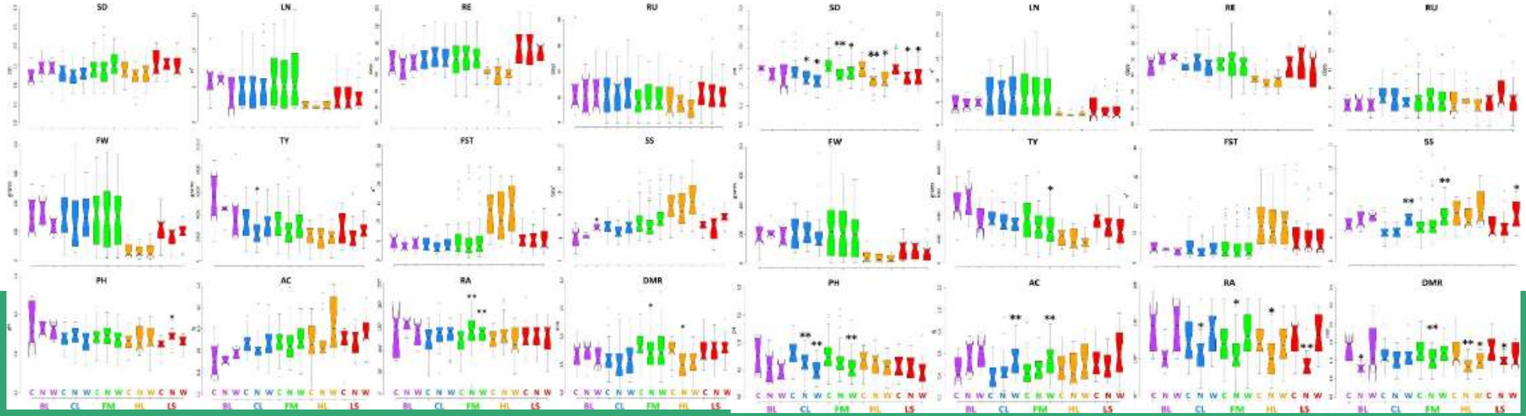
(Key) Achievements

- T3.1: **Screening of material for complex traits** related to resilience under organic agriculture (M1-M42)
  - Completion and validation of morphological and agronomic characterization trials of the BS under organic conditions, including evaluation in different sites → *Large genetic diversity and environmental effects assessed*



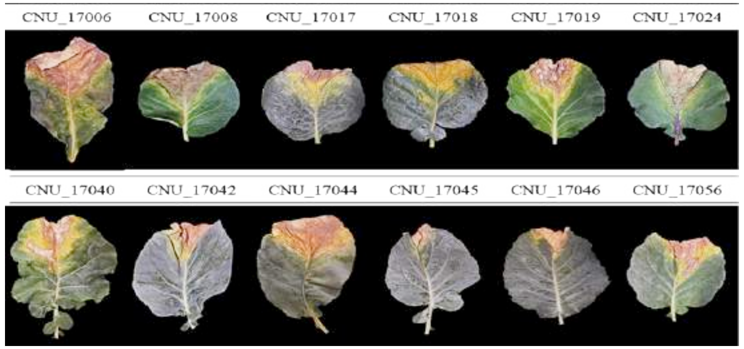
- T3.1: Screening of material for complex traits related to resilience under organic agriculture (M1-M42)
  - Evaluation of BS for **tolerance to stresses (water stress-related antioxidants and photosynthetic pigments in brassica; low N, deficit irrigation, heat tolerance in tomato**) → *Resilient materials detected*

Italy Spain

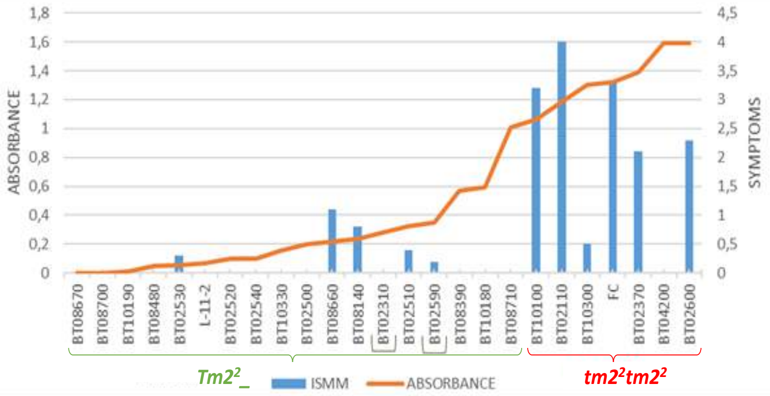


(Key) Achievement

- T3.1: Screening of material for complex traits related to resilience under organic agriculture (M1-M42)
  - **Regeneration and multiplication of materials** for further experiments → *Fresh seed produced for further experiments*
- T3.2: **Identification of sources of resistance to pests and diseases** (M1-M48)
  - Screening of BS and other materials **for fungal, bacterial and viral diseases** both under controlled and field conditions. For some diseases several strains were used → *New potential sources of resistance/tolerance found*
  - Validation of resistance/tolerance performed for selected diseases under controlled conditions → *Confirmed sources of tolerance*
  - Identification of pests and diseases affecting crops under organic conditions → *Main pests and pathogens affecting the three crops in field conditions identified*



Xcc in *Brassica*



Validation of TSWV resistance/tolerance in tomato

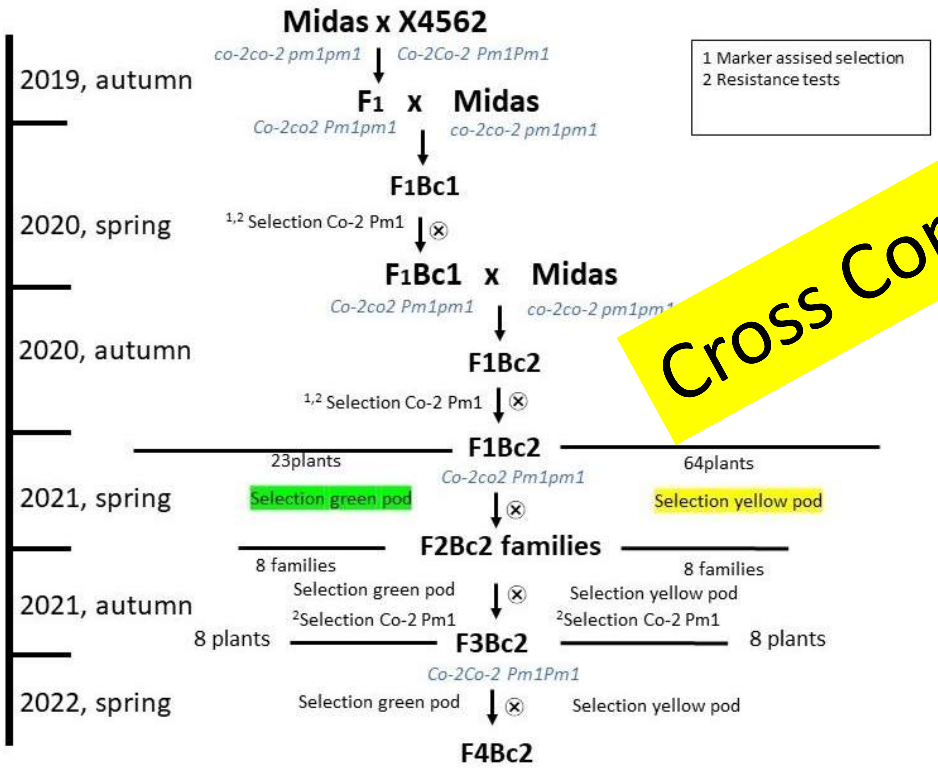
(Key) Achievements until now

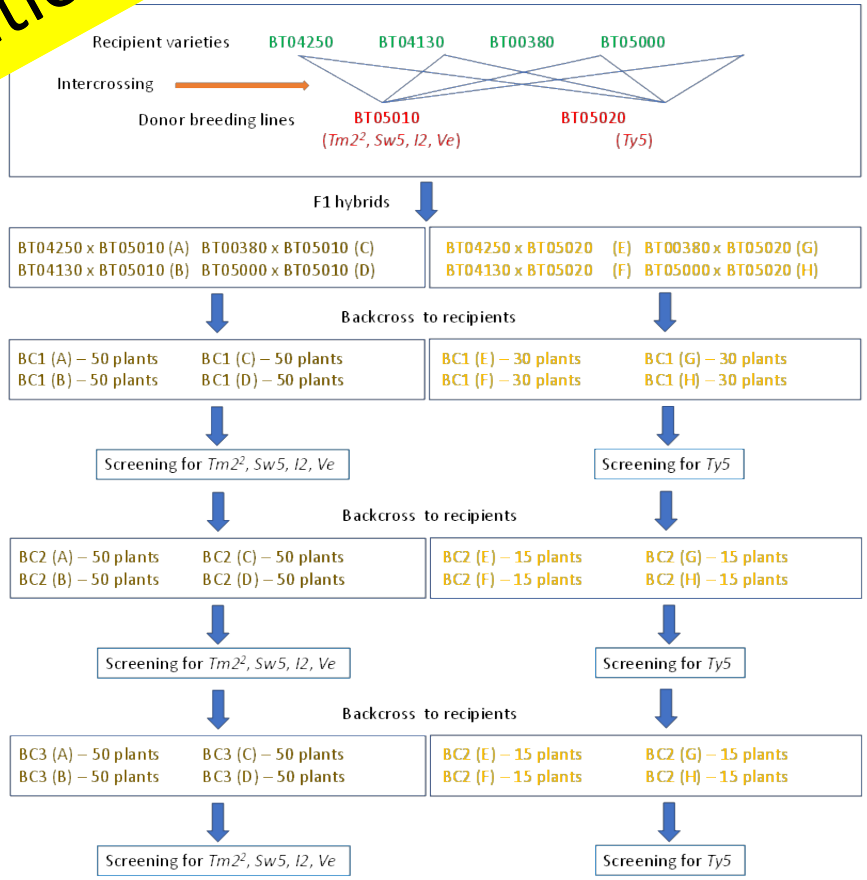
- T3.3: **Selection of resilient materials adapted to organic agriculture** (M24-M48)
  - ***179 genotypes/sources of important traits*** *to organic production (89 for brassica oleracea* L. crops and their crop wild relatives, 53 for bean and 37 for tomato)
  - → *Lists of selected materials (SS) for recommendation for organic cultivation* (D3.5. SELECTED SET of recommended materials for organic agriculture; M48)

- T3.4: Breeding and development of new resilient material for organic agriculture (M1-M60)
  - **Multiple breeding programmes** and strategies undertaken in the three crops (e.g., complementary and transgressive hybrids, diallels, backcrossing, pyramiding, selection in introgression lines) for agronomic, quality and resilience traits → *Breeding materials produced in different degrees of advancement*

T3.4: Breeding and development of new resilient material for organic agriculture (M1-M60)

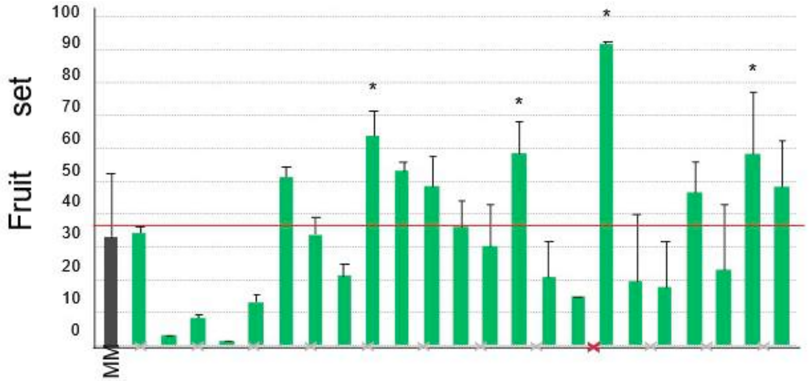
Cross Composite Populations





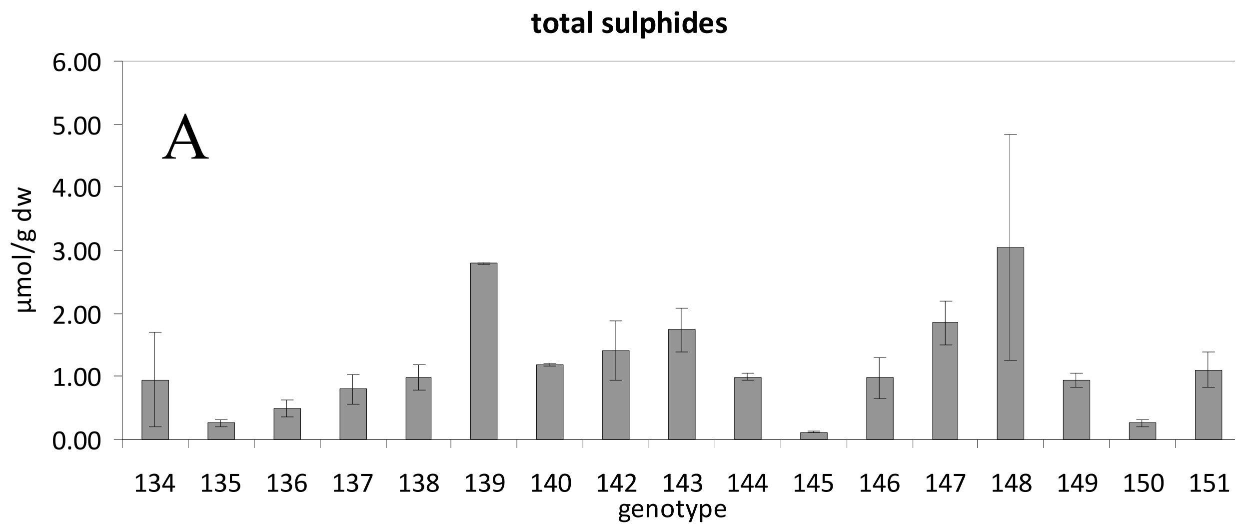
(Key) Achievements until now

- T3.4: Breeding and development of new resilient material for organic agriculture (M1-M60)
  - Development of hybrids to be used as **rootstocks in tomato** → *Interspecific and intraspecific hybrids developed under evaluation* (D3.6. Improved tomato rootstocks for organic agriculture; M40)



(Key) Achievements until now

- T3.5: **Identification of high added value materials for organic agriculture** (M1-M60)
  - High added value traits evaluated in the three crops (**postharvest evolution and multiple metabolomic traits related to organoleptic, nutritional and bioactive properties and postharvest**) → *Large variation and identification of materials for high added value traits*



Phenotyping of the BRESOV *Brassica oleracea* core collection

Biochemical phenotyping

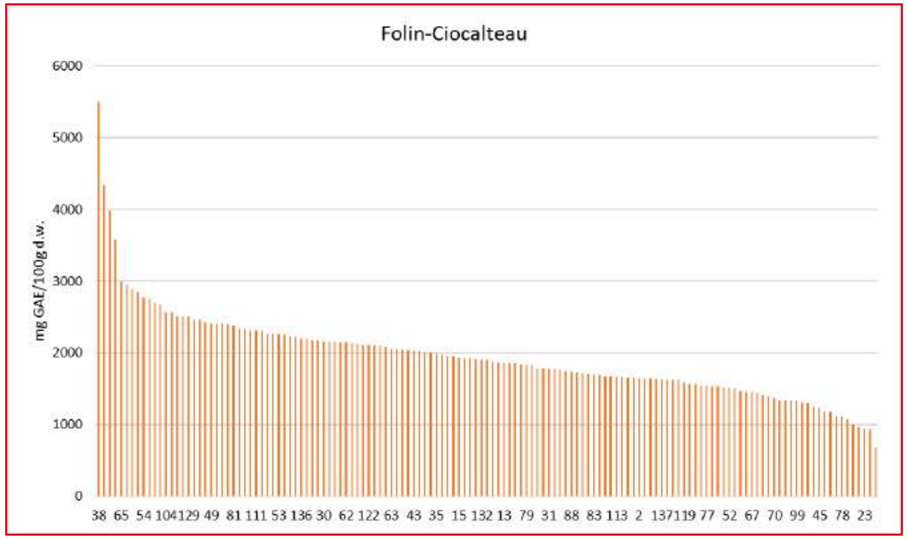
- **139 *Brassica oleracea* complex species (n=9) accessions** belonging to UNICT and UNLIV were screened for:
  - antioxidant capacity
  - ascorbic acid
  - glucosinolates profile and amount
  - polyphenols profile and amount

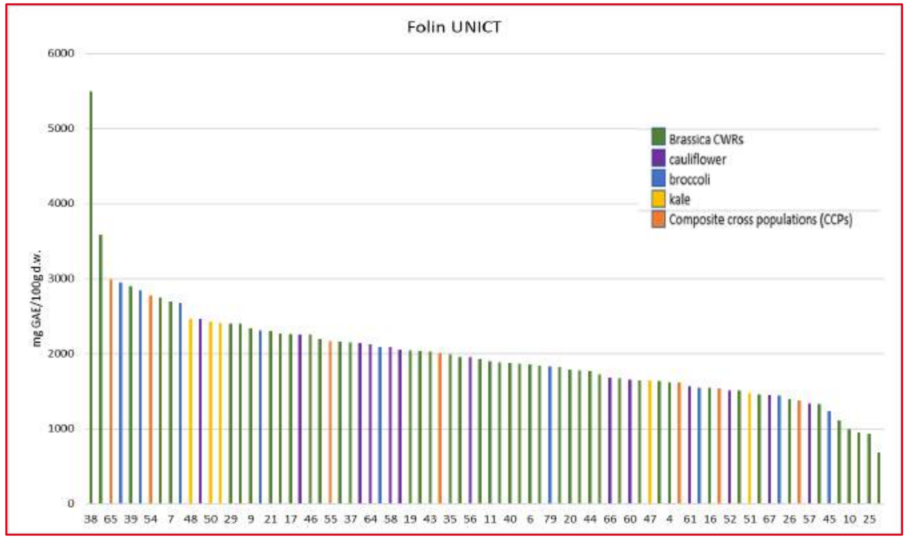
Crop name	Common name	Number of accessions	Provider
B. oleracea var. *acephala*	Kale	68	63 from UNILIV
			5 from UNICT
B. oleracea var. *botrytis*	Cauliflowers	18	18 from UNICT
B. oleracea var. *italica*	Broccoli	3	3 from UNICT
	Composite cross populations (CCPs)	8	8 from UNICT
B. oleracea var. *italica* x *B. oleracea* var. *botrytis*	CCPs		3 from UNICT
B. oleracea var. *botrytis* x *B. oleracea* var. *botrytis*	CCPs		3 from UNICT
B. rupestris x *B. oleracea* var. *botrytis*	CCPs		2 from UNICT
	Crop wild relatives (CWRs)	42	42 from UNICT
Brassica balearica Pers.	CWRs		2 from UNICT
Brassica barrelieri (L.) Janka	CWRs		2 from UNICT
Brassica bourgeaui (Webb ex Christ) Kuntze	CWRs		3 from UNICT
Brassica cretica Lam.	CWRs		2 from UNICT
Brassica desnottesii Emb & Maire	CWRs		1 from UNICT
Brassica drepanensis (Caruel) Ponzo	CWRs		2 from UNICT
Brassica hilarionis Post.	CWRs		1 from UNICT
Brassica incana Ten.	CWRs		7 from UNICT
Brassica macrocarpa Guss.	CWRs		3 from UNICT
Brassica montana Pourr.	CWRs		2 from UNICT
Brassica soulie (Batt.) Batt.	CWRs		1 from UNICT
Brassica rupestris Raf.	CWRs		7 from UNICT
Brassica tyrrhena Giotta, Piccitto & Arrigoni	CWRs		1 from UNICT
Brassica villosa Biv.	CWRs		7 from UNICT
Brassica villosa Biv. subsp. *tinei* Raimondo & Mazzola	CWRs		1 from UNICT
	Total number 139		

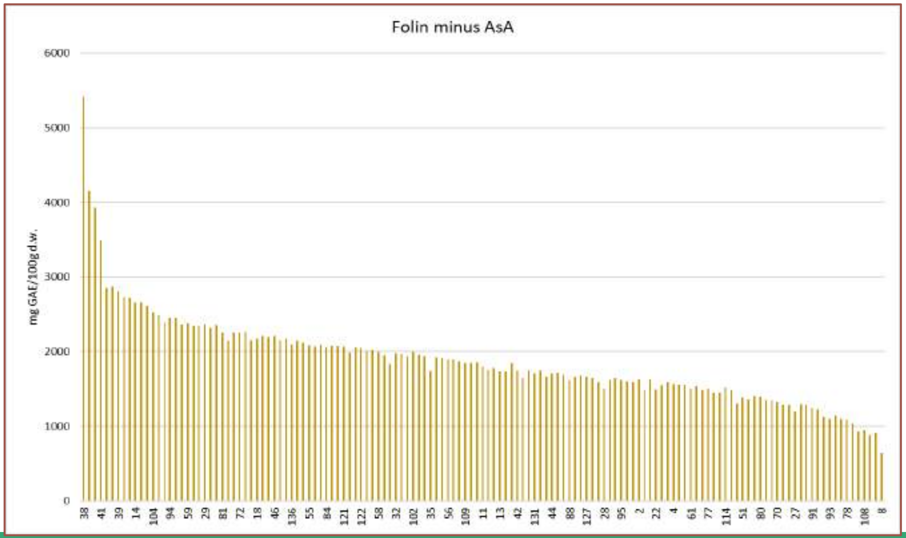
- Data showed several differences among the species.

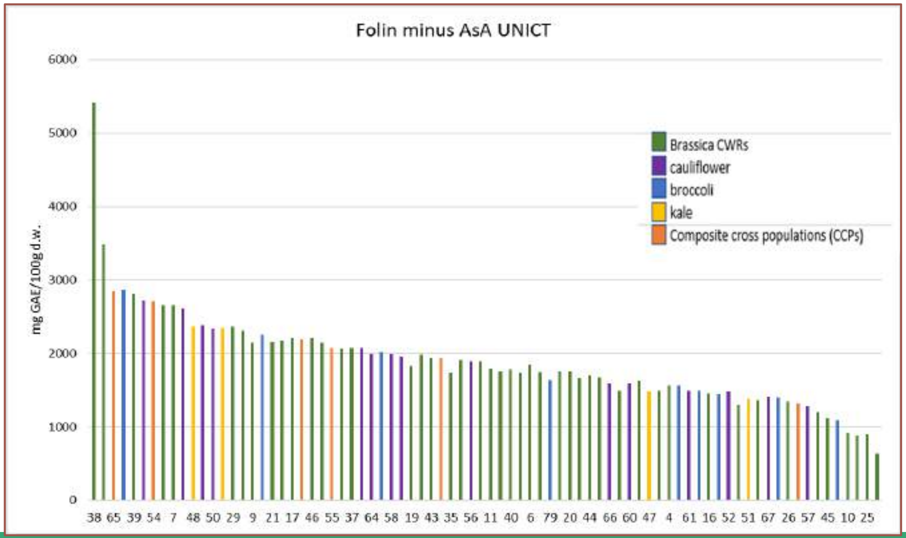
- ✓ 63 accessions by the Brassica collection of the University of Liverpool (UNILIV);
- ✓ 76 accessions by the Brassica collection of the University of Catania (UNICT).

- **Folin-Ciocalteau**
- **Folin minus AsA**

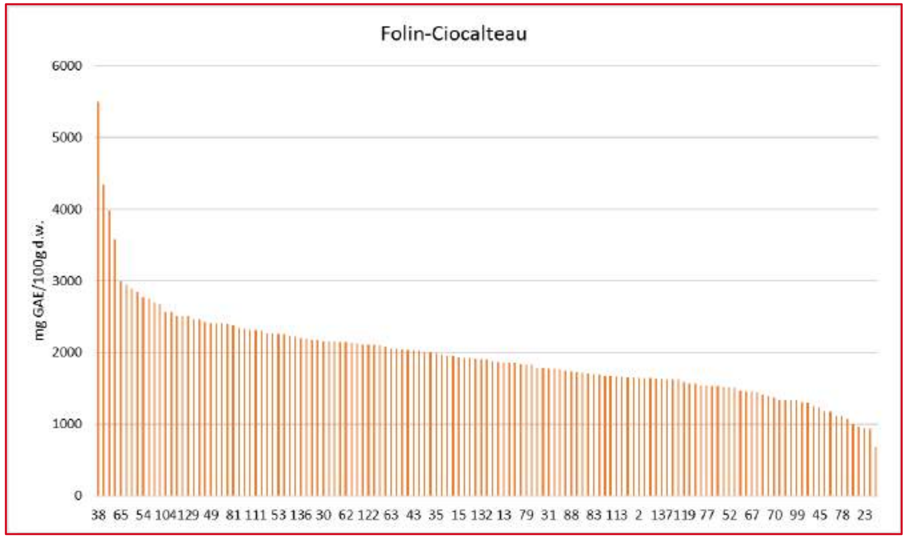


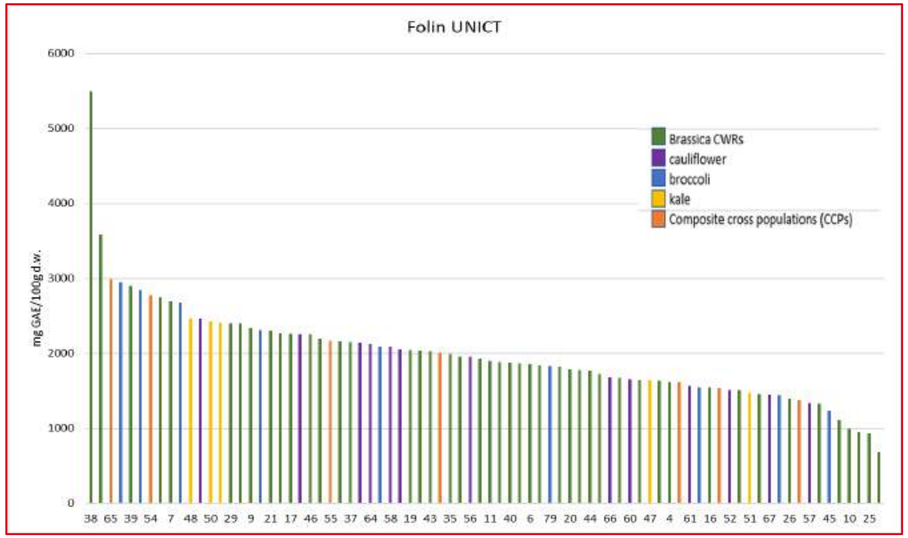


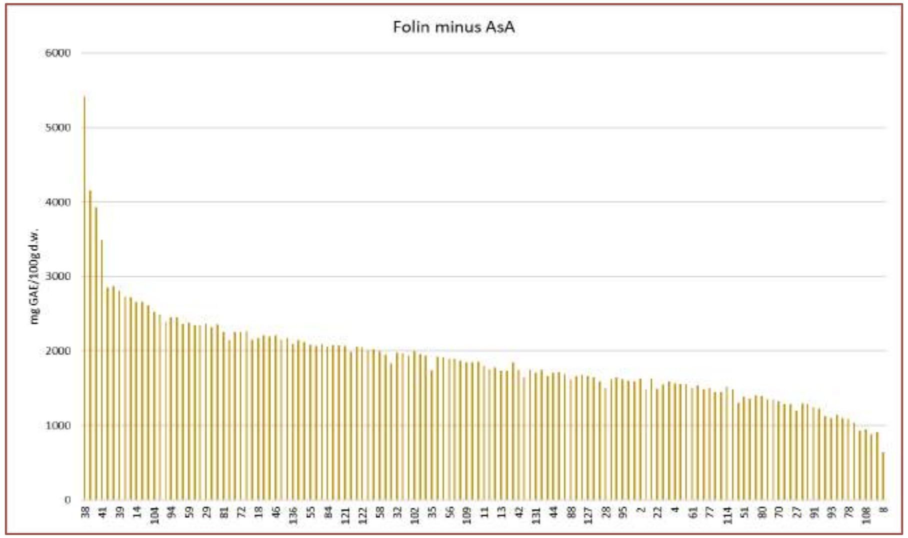


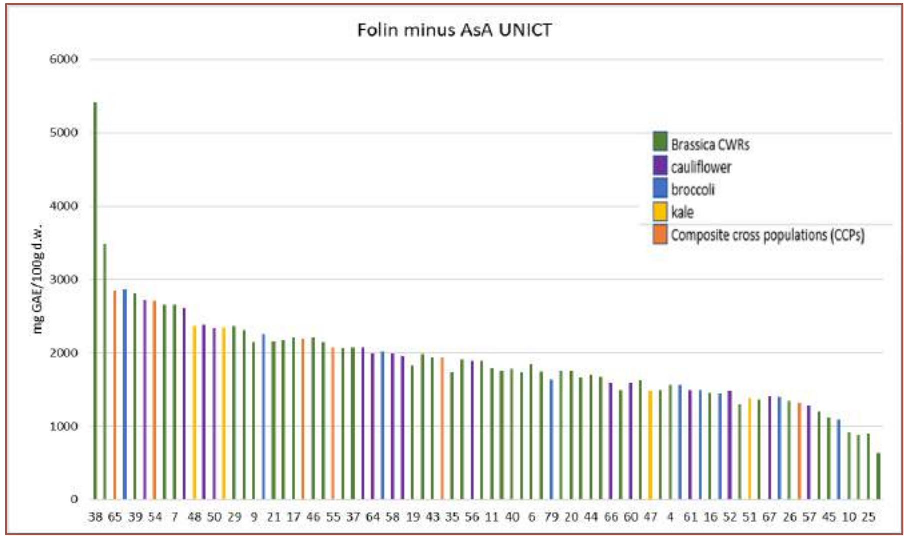


- **Folin-Ciocalteau**
- **Folin minus AsA**

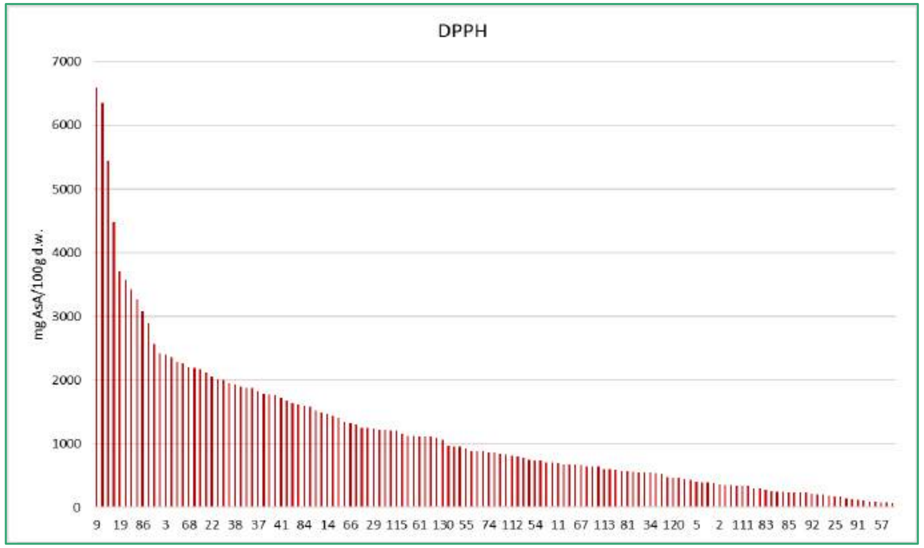


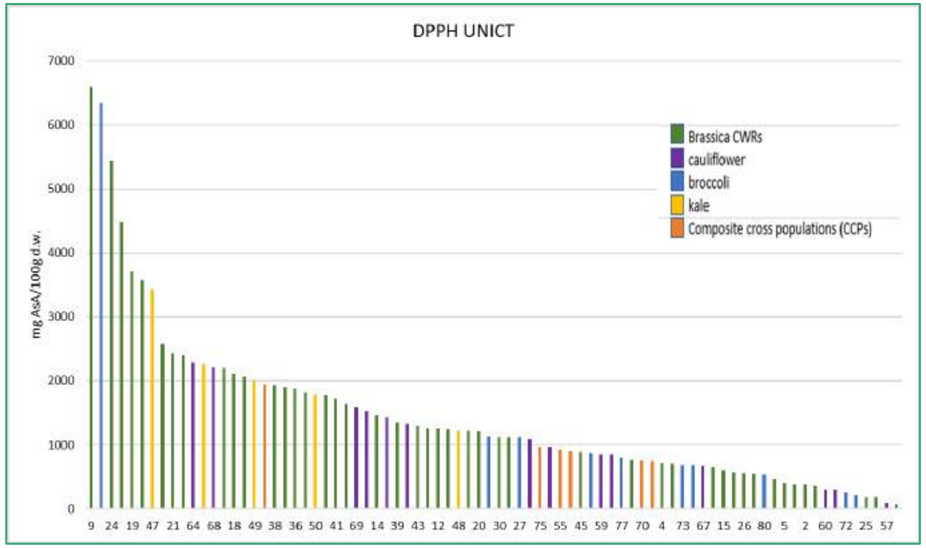


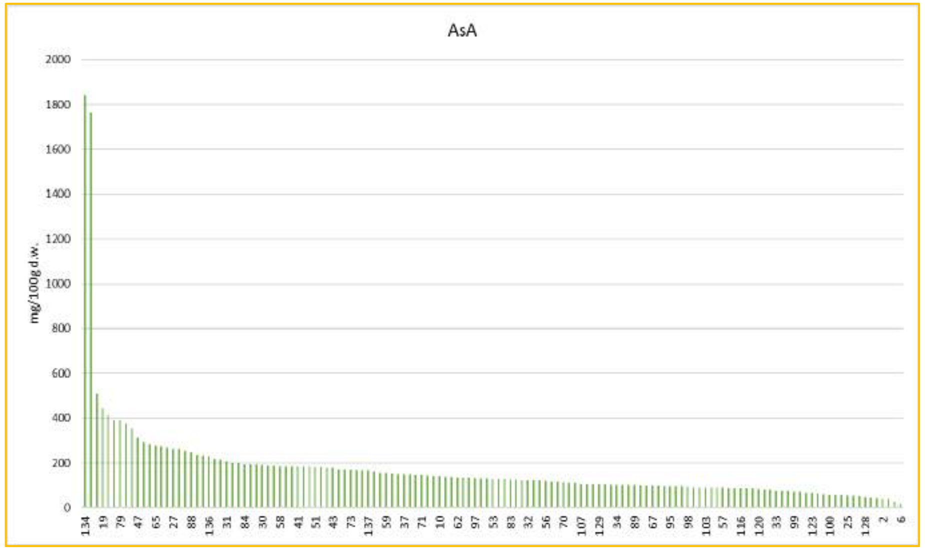


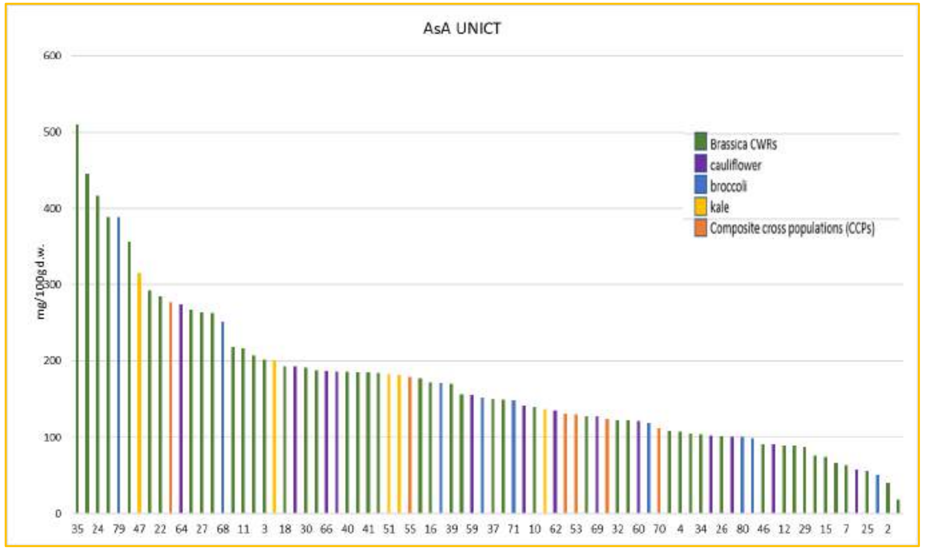


- **DPPH assay**
- **Ascorbic acid**

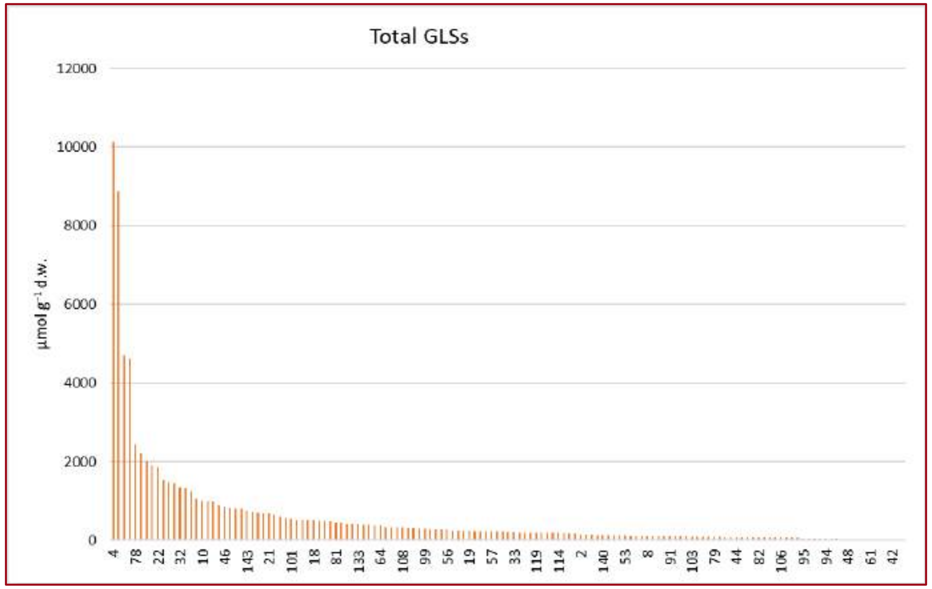


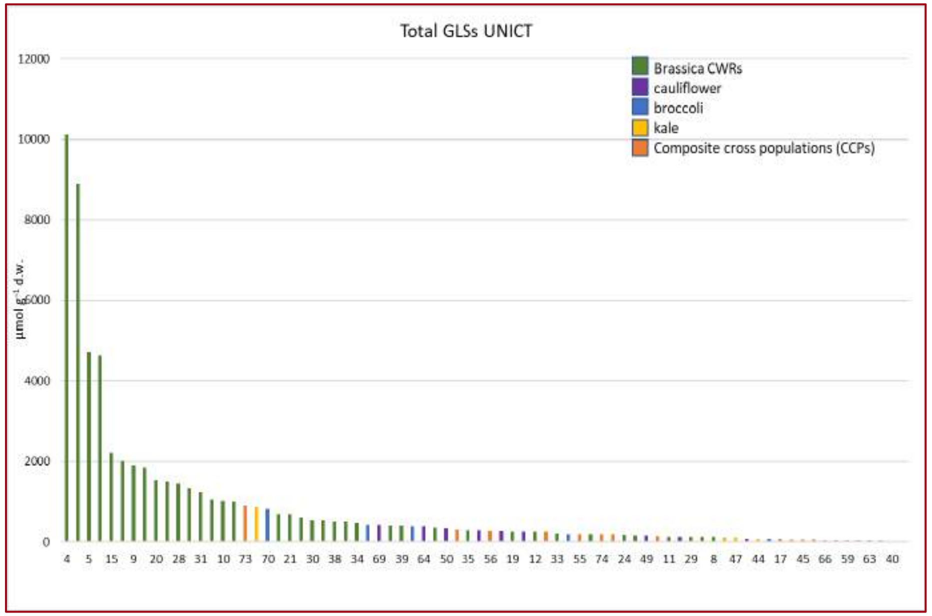


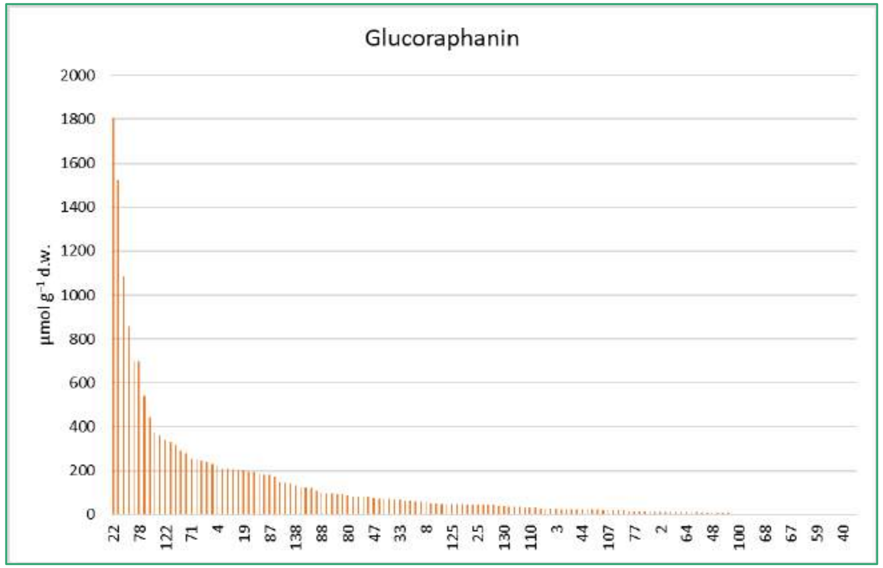


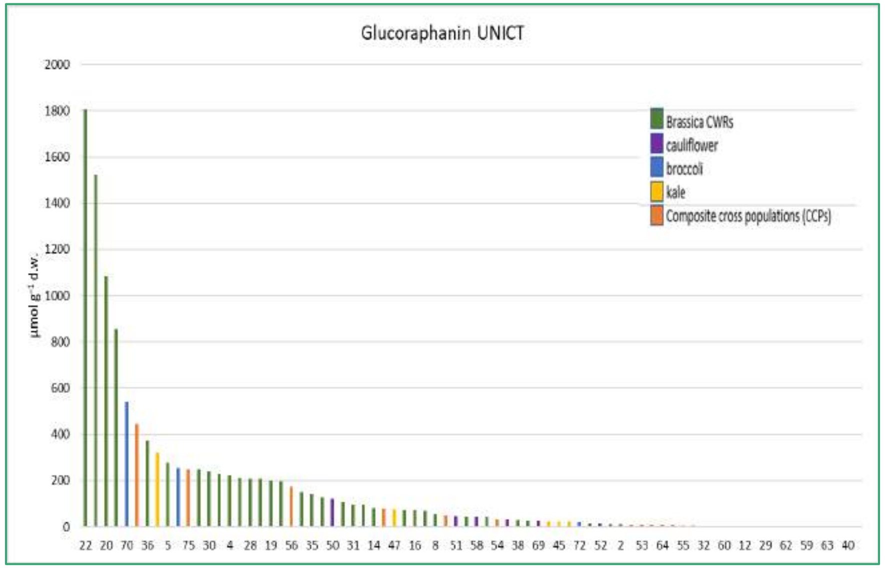


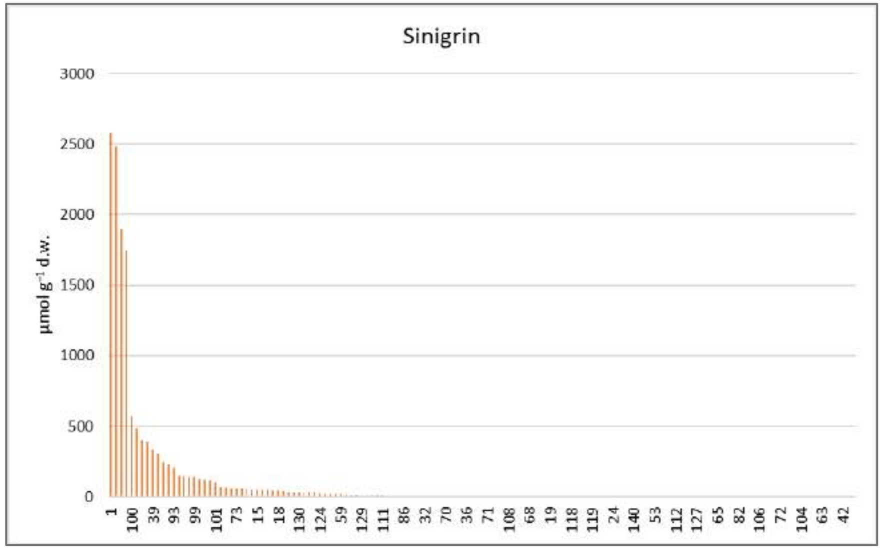
- **Glucosinolates analysis**

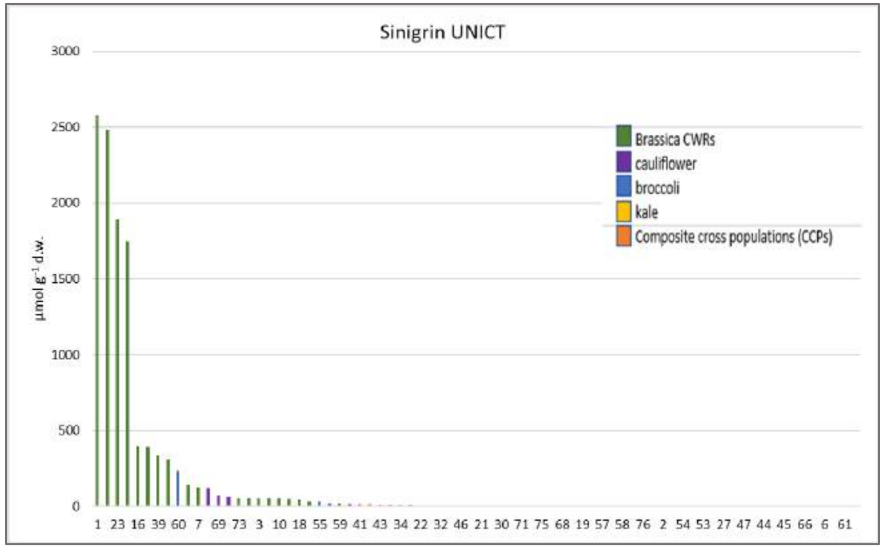





Glucoraphanin
µmol g-1 d.w.


Glucoraphanin UNICT
µmol g-1 d.w.
Brassica CWRs
cauliflower
broccoli
kale
Composite cross populations (CCPs)


Sinigrin
µmol g-1 d.w.


Sinigrin UNICT
µmol g-1 d.w.
Brassica CWRs
cauliflower
broccoli
kale
Composite cross populations (CCPs)

WP4 - High-quality organic seed production

Objectives

Number	Description
O4.1	Develop protocols adapted to the specific conditions of organic farming to **improve organic seed yield** (→ T4.1)
O4.2	Determine products and tools to control the **sanitary and genetic quality of organic seed lots** (→ T4.2 & T4.3)

WP4 partners and their contributions

WP4 leader : VEG

Partner	T4.1 Organic seed production	T4.2 Sanitary quality	T4.3 Genetic quality
UNICT	  	TL  	
EUROSEEDS	TL		
FiBL			
VEG		 	TL 
UPV			
ITAKA	  	  	
SECL			
OBS (sub-contractor)	 		

TL = Task Leader

Results / (Key) Achievements for T4.1

T4.1 - Determination of the optimal agronomic conditions for organic seed production

Evaluation of the effect of 6 agronomical parameters (ex: plant density, nutrition, etc.) on seed yield and seed germination > 4 trialling cycles across 5 sites > total of 32 trials for seed yield assessment

Agronomic factors tested in the BRESOV project:

- Plant density (tomato, *brassica* and snap bean)
- Use of microorganisms in combination with amino acids and foliar application (tomato, *brassica* and snap bean)
- Different harvesting regimes (tomato)
- Grafting on BRESOV rootstocks (tomato)
- *Rhizobium* symbiosis (snap bean)
- Different transplantation time-points (broccoli)


BRESOV
PRACTICE ABSTRACT 13
Soil based seed germination protocol for cauliflower and broccoli


BRESOV
PRACTICE ABSTRACT 5

Goal: High quality seed

- Increase the amount of seed production per sqm in organic conditions
- While maintaining high seed quality
  - Thousand Seed Weight (TSW)
  - High germination percentages

Results / (Key) Achievements for T4.1

Which factors can influence seed production?

- Location (e.g., climatic conditions, soil properties)
- Trial year
- Genotype
- Agronomic practices
- Interaction effects

Which data should be gathered during a seed production trial

- Farming practices (e.g., fertilization, soil preparation,sowing date, plant protection, watering) including date of application
- Plant health: occurence of biotic and abiotic stresses
- Number of lost plants (=missing values)
- Plant growth and fruit yield
- Seed production: seed number and thousand seed weight

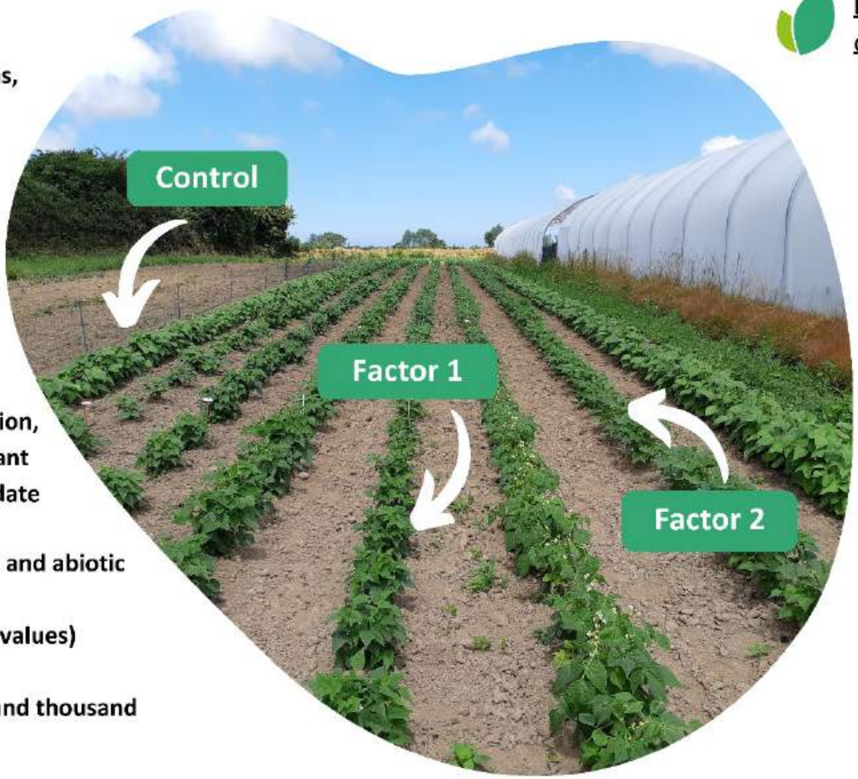


Photo credit: OBS - 2019 snap bean field trials

How to assess the effect of different factors on seed production?

- Experimental setup, e.g. slpit plot design
- Experimental factors to test: control plot, factor 1, factor 3
- At least 3 repetitions per plot

How to analysze the data identify relevant factors influencing seed production?

- To assess the different contriubtions of the different experimental factors to the total assessed variation , use e.g., ANOVA with posthoc test Tukey's HSD
- If you conducted field trials with different genotypes, in different locations and years you can also assess the variation introduced by these facotrs and their interaction effects

Results / (Key) Achievements for T4.1

Recommended agronomic practices – tomato

Recommended agronomic factor Tomato	Single-site (S)/multi-location (M)	Best results within BRESOV experiments
Plant density	M	Greenhouse, indeterminate production: 5 plants/sqm (distance between rows of 0.5 m and within rows of 0.2 m. Each plant was grown with a single stem)
Microorganism application in combination with amino acids/ and foliar nutrition	M	Sicily: D100%+F (3KO, ACE, ST02213, Micro7213, ITAKA srl)
Different harvesting regimes	S	Regular harvesting or bulk harvests every three weeks do not influence TSW or seed germination. Both can be used based on seed producer's needs.
Cooling fruit before seed extraction	S	Cooling tomato fruits for 2-3 weeks before seed extraction did not affect germination rate negatively and can save on number of extractions by pooling several harvests together.
Grafting	S	Grafting increases fruit production and with that seed production. Commercially available rootstock comparable to tested BRESOV rootstock

Results / (Key) Achievements for T4.1

Recommended agronomic practices– snap bean

Recommended agronomic factor Snap bean	Single-site (S)/ multi-location (M)	Best results within BRESOV experiments
Plant density	M	Brittany: 23.8 plants/sqm (5 plantlets per spot (bulk) with distance within rows of 0.30 m and distance between rows of 0.70 m) Sicily: 14.3 plants/sqm (5 plantlets are sown in bulks with a distance within rows of 0.5 m and between rows of 0.7 m) CAVE: Seed germination percentages (nutrition protocol and *Rhizobium* inoculation can have beneficial effect)
Microorganism application in combination with amino acids	M	Sicily: D50% (3KO, ACE, ITAKA srl)
***Rhizobium* symbiosis**	S	Seed treatment with RhizoFix® RF-60, Feldsaaten Freudenberger

Results / (Key) Achievements for T4.1

Recommended agronomic practices - *brassica*

Recommended agronomic factor *Brassica*	**Single-site (S)/ multi-location (M)**	**Best results within BRESOV experiments**
Plant density	M	6 plants/sqm (0.5 m distance between rows and 0.3 cm distance within rows)
Microorganism application in combination with amino acids and foliar nutrition	M	Sicily: D100%+F (3KO, ACE, ST02213, Micro7213, ITAKA srl)

Results / (Key) Achievements for T4.2

Seed treatments compatible with organic farming: main results in different crop-pathogen systems

1) Development/validation/application of detection methods for seed-borne pathogens

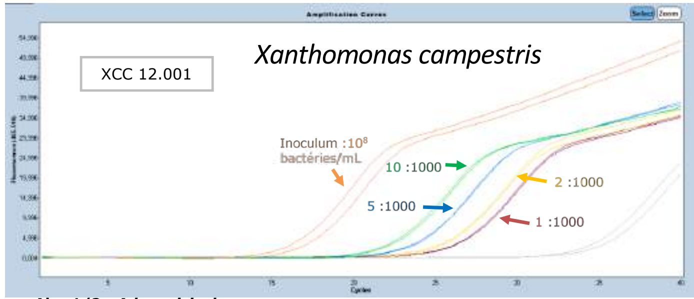
Tomato	*Clavibacter michiganensis* subsp. *michiganensis*	UNICT
	Xanthomonas spp pathogenic on tomato	UNICT
	Pseudomonas syringae pv *tomato*	UNICT
	ToMV	Vegenov
	Fusarium oxysporum f.sp. *radicis lycopersici*	ITAKA
Broccoli	*Xanthomonas campestris* pv. *campestris*	Vegenov
	Alternaria spp	Vegenov
	Phoma lingam (*Leptosphaeria maculans*)	ITAKA
Snap Bean	*Colletotricum lindemuthianum*	FiBL
	Pseudomonas savastanoi pv. *phaseolicola*	FiBL
	Fusarium solani f.sp *phaseoli*	ITAKA

Application on pathogen detection on seeds

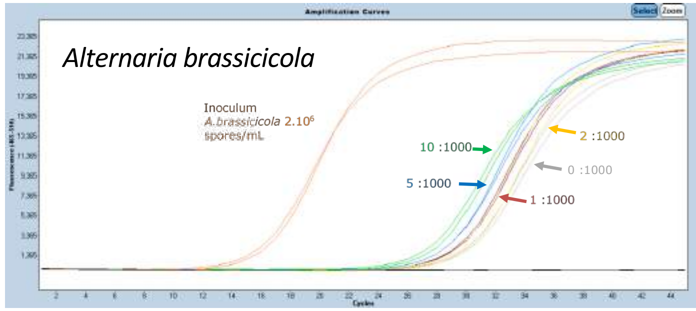
- ✓ International Seed Testing Association ISTA
- ✓ Seed Health Initiative-International Seed Federation ISF
- ✓ European and Mediterranean Plant Protection Organization EPPO
- ✓ Scientific papers

Detection of seed-borne pathogens in *Brassica* seeds

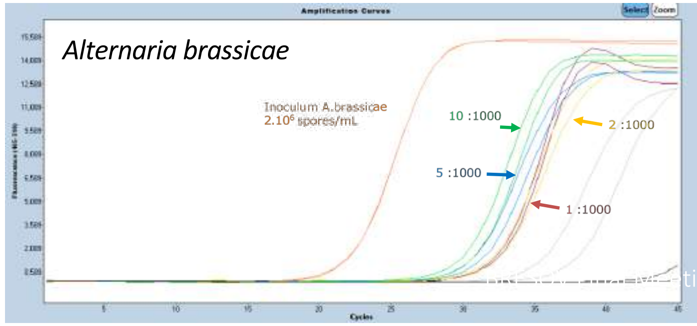
XCC F/R/Probe



mq Abra1/2 : *A.brassicicola*

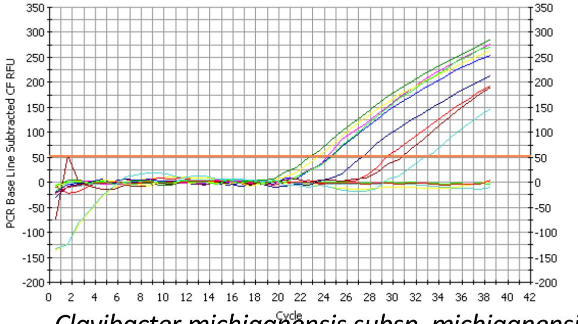


mq 115sens/rev : *A.brassicae*

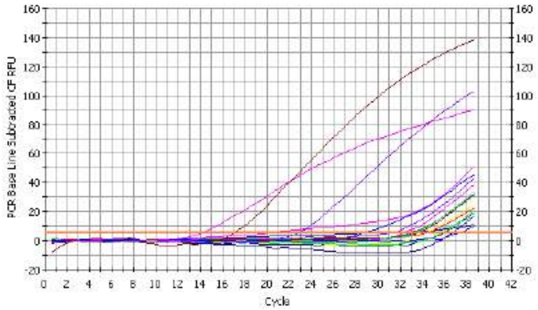


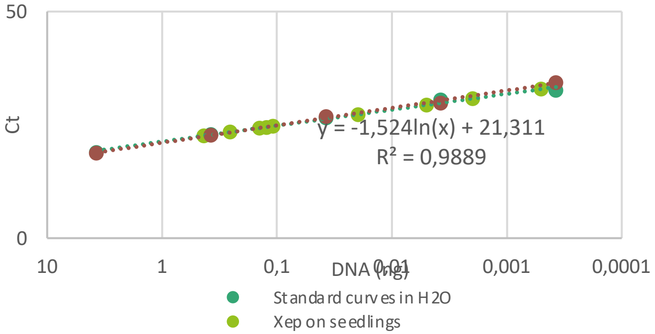
Detection of seed-borne bacteria in tomato seeds and seedlings

Xanthomonas perforans

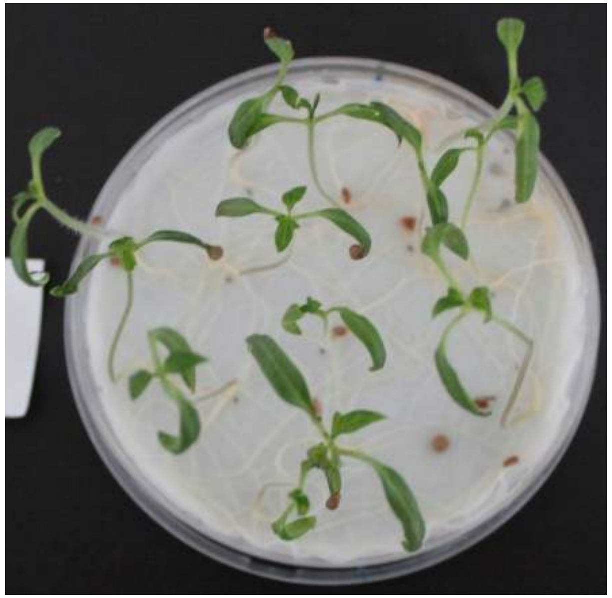


Clavibacter michiganensis subsp. michiganensis



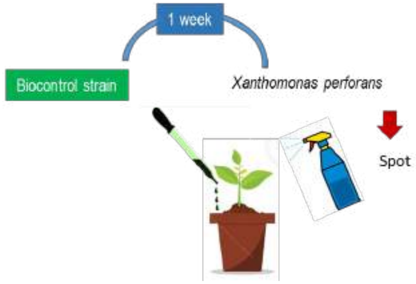


2) Establish inoculation methods of the pathogens



Seed inoculations

Biopriming effect (treatment and pathogen spatially separated)



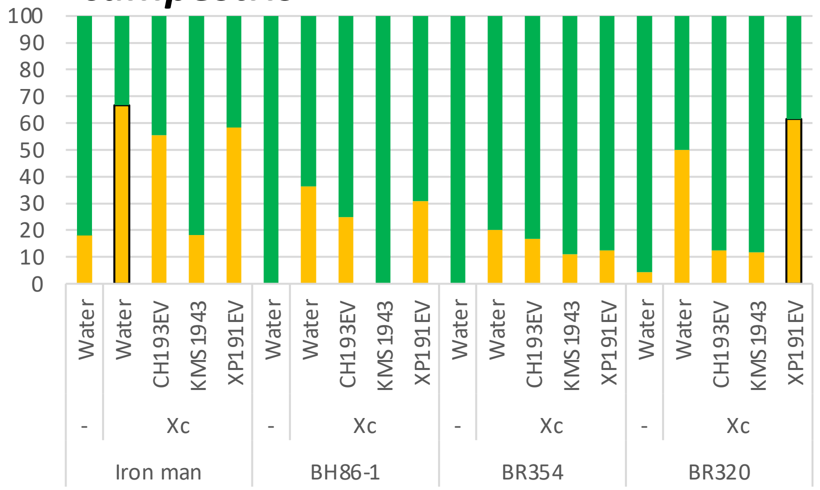
BRESOV

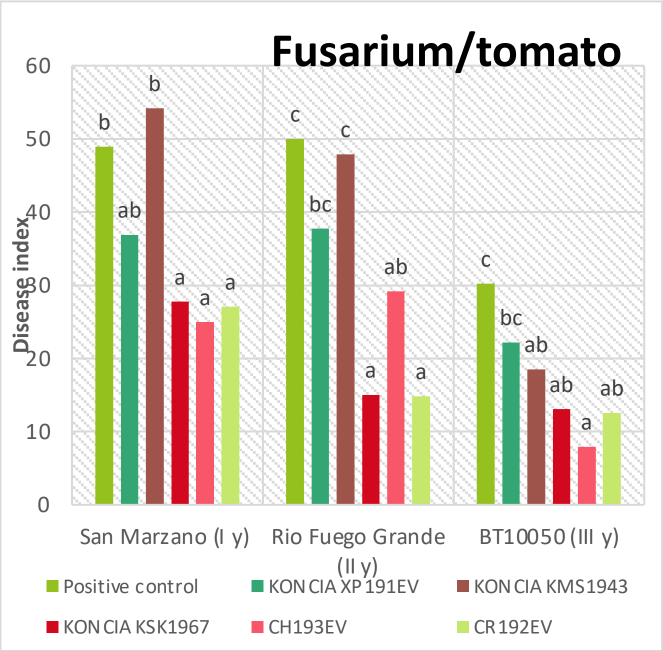
3) Evaluation of Microbial consortia (MC) and natural compounds (NC) for seed treatment (ITAKA)

Treatment	Composition	Diluition
KONCIA XP191EV	**MC** (bacteria-AM)	1:10
KONCIA KMS1943	**MC** (bacteria-fungi-AM)	1:10
KONCIA KSK1967	**MC** (bacteria-AM)	1:10
CH193EV	**NC**	1:100
CR192EV	**NC**	1:100

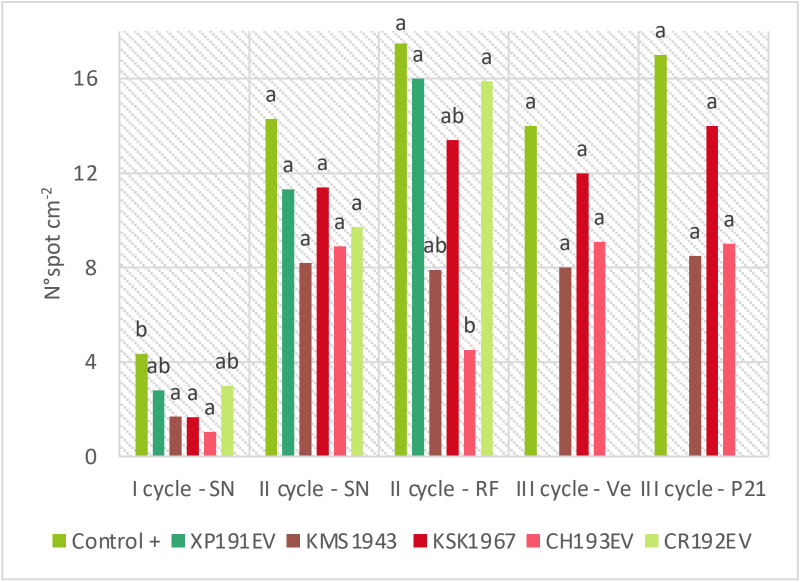
- ✓First cycle one cultivar with all products
- ✓Evaluation on germination
- ✓Subsequent two cycles different plant accessions were used (all or selected products)
- ✓Evaluation method according to the different pathosystem and inoculation protocol

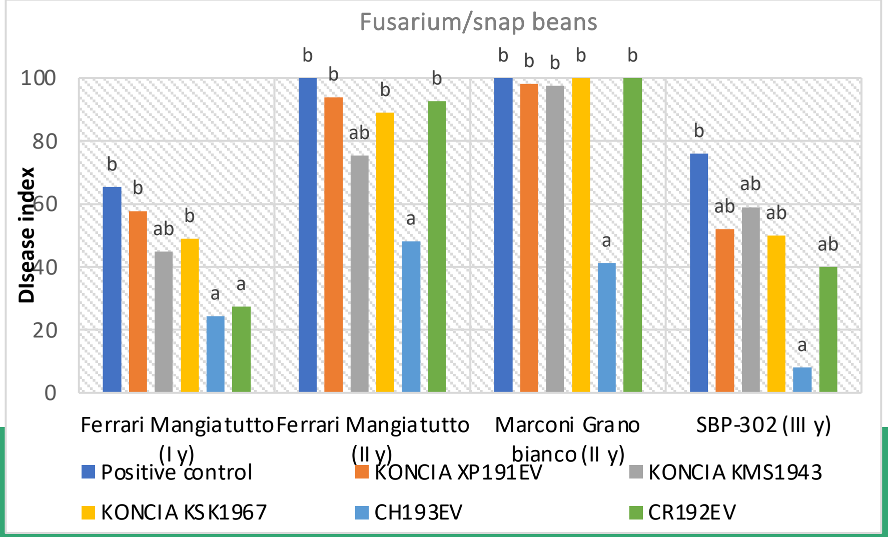
Broccoli/*X. campestris* pv. *campestris*





Biopriming assay - Bacterial spot.
Xanthomonas euvesicatoria pv. *perforans*.





- **Selected microbial consortia gave good results the mode of action in some pathosystems is worthy to be investigated (Gram positive- Gram negative bacteria or fungi)**
- **Inoculum reduction largely varied depending on the pathosystem and probably to the inoculation test**
- **A biopriming affect was demonstrated**

(Key) Achievements for T4.3

- T4.3 - Development of tools to control the genetic quality of seed lots

- Development of SSR marker sets for Brassica (UNICT), tomato (UPV) and snap bean (VEG)
  - Selection of the most polymorphic markers to detect genetic variations
  - Development of the DNA extraction protocol from seeds
  - Test of markers on artificial mixtures of seeds (2 varieties mixed in different proportions)
  - Validation of the optimal set of markers to detect seed contamination in line with the European regulation

Results summary for T4.3

- Snap bean:

Based on the genotyping results obtained for 33 diverse snap bean varieties, an optimal subset of **10 SSRs** was defined.

Artificial seed mixtures → detection of 10% down to 5% contamination

- Tomato:

6 SSRs generated a unique genetic profile for each variety tested.

Artificial seed mixtures → detection of 10% down to 5% contamination

- Brassica:

4 SSRs were selected for the **intraspecific contamination** detection.

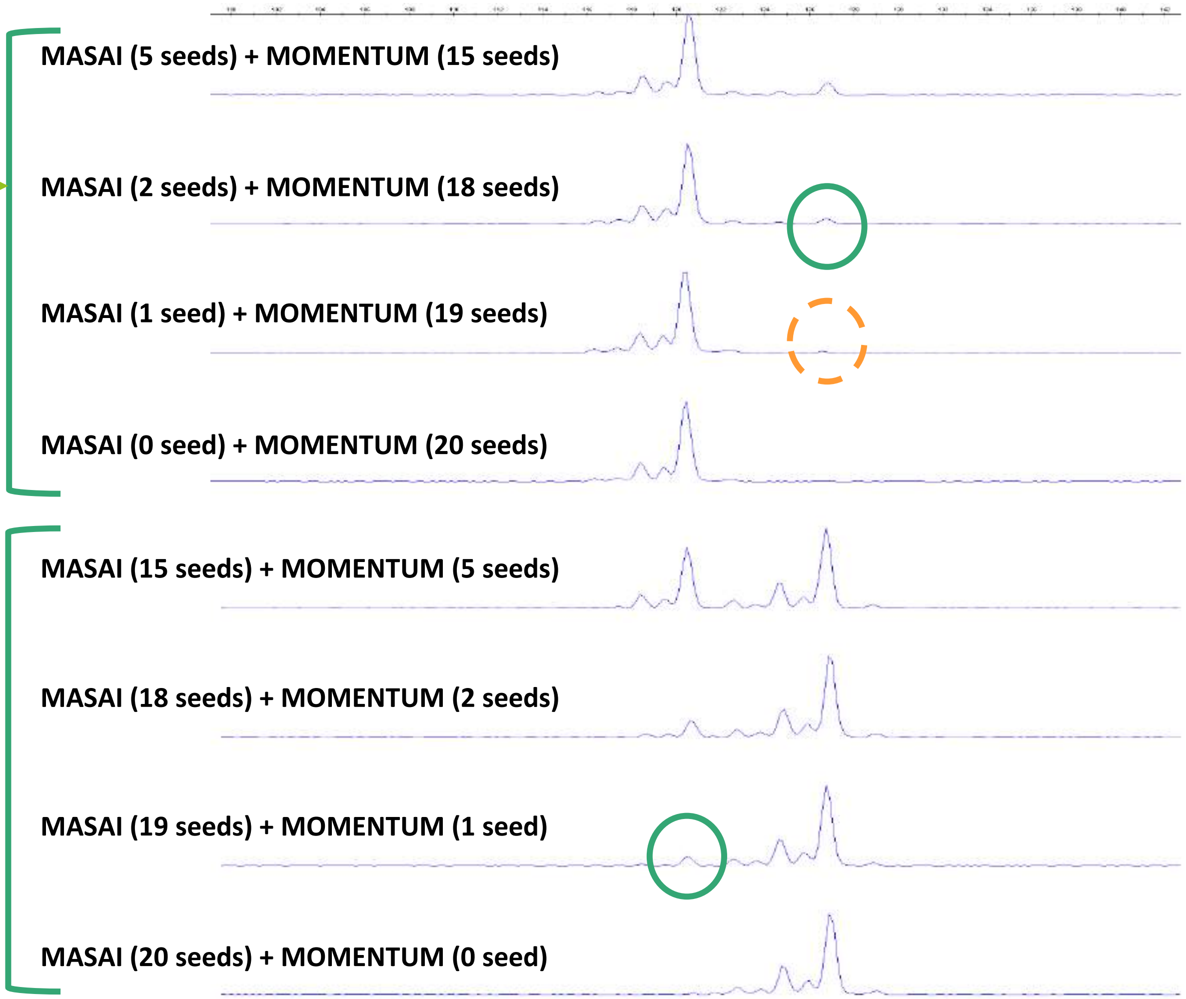
6 other SSRs were selected for the **interspecific contamination** detection.

Contamination ratios 1:2 and 1:3 are detected by the markers

Example of results obtained for one seed mixture with SSR 'BM 185'

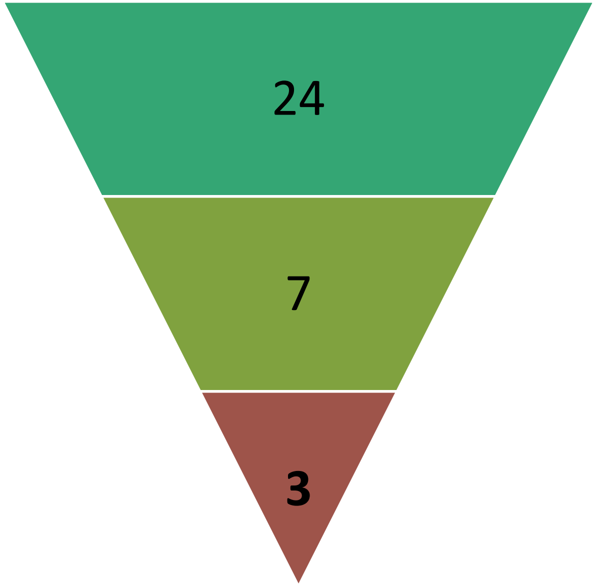
As for one of the seed mixtures tested, **10% contamination was the minimum that could be detected** (compared to 5% for the others), we should use **15 bulks of 10 seeds** to get the final size of sample of **150 seeds.**

If no contamination is detected in any of those bulks, we can **guarantee the genetic purity above the authorized ratio of 98%** with a 95% confidence level for the total sample of 150 seeds.

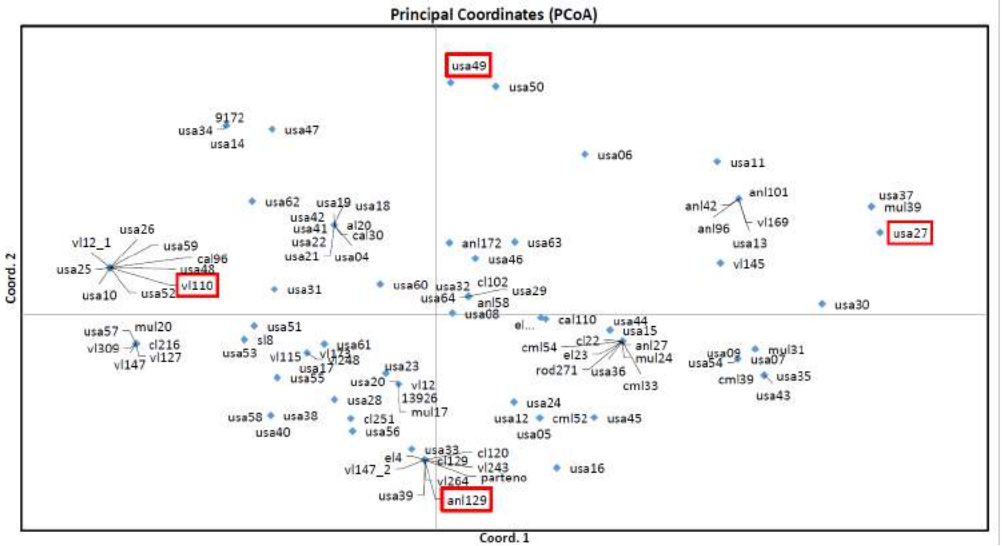


Tomato

SSR markers selection



Calculation of the **minimum number of seeds** to test to detect **3% of contamination** = 100 seeds



Materials

127 *in silico* accessions

Selection of 4+2 accessions for marker testing

5 dilutions

50/50, 75/25, 90/10, 95/5, and 99/1

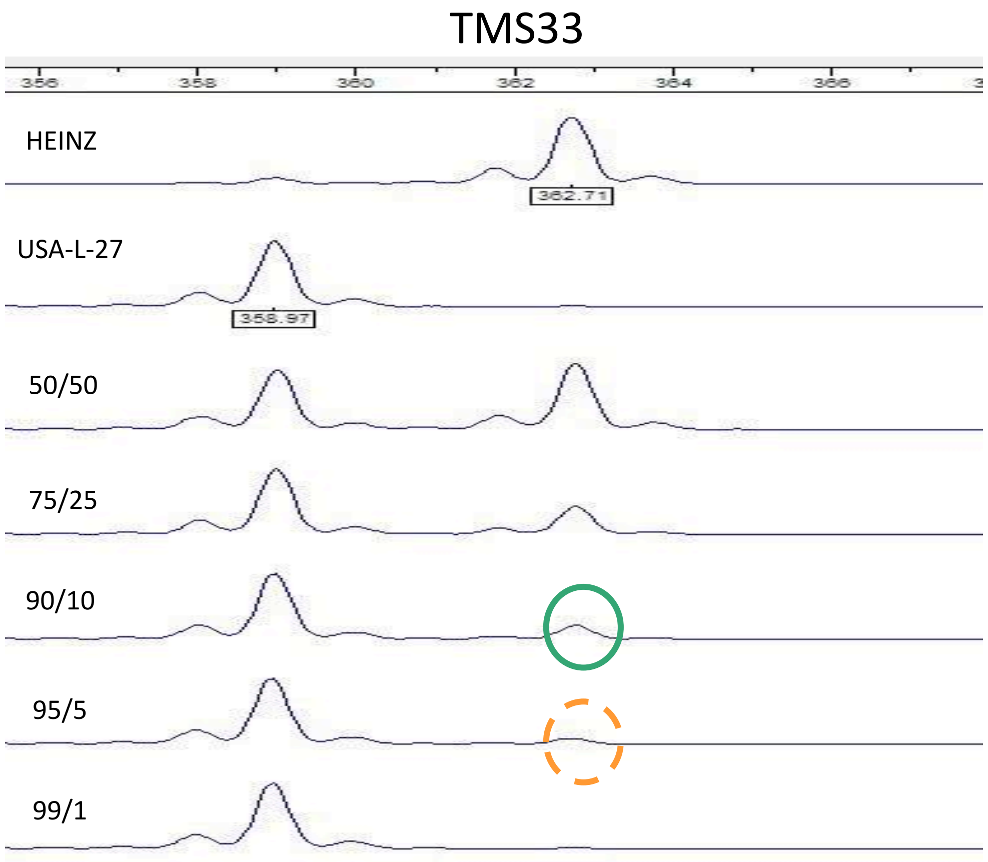
1) Tested 1 combination of 2 varieties (leaf)
2) Tested 1 combination of 2 varieties (seeds)

Example of results obtained for one seed mixture with SSR 'TMS33'

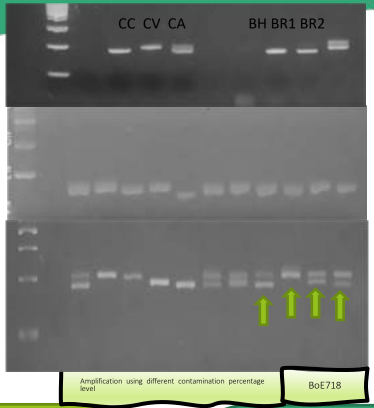
10 samples of 10 seeds need to be evaluated for markers able to detect contamination of up to **10%** (as for TMS33)

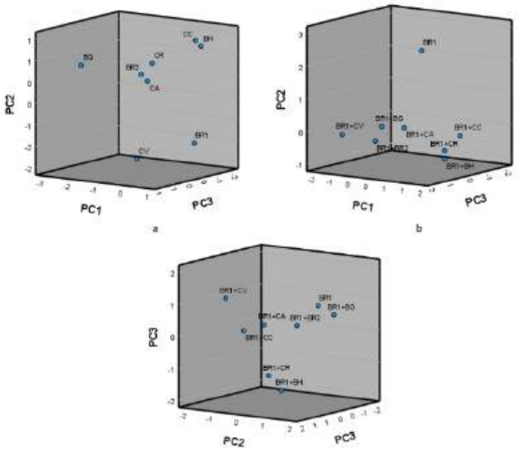
5 samples of 20 seeds need to be evaluated for markers able to detect contamination levels of up to **5%.**

If no contamination is detected in any of the samples, then it can be safely assumed with a 95% confidence level that the contamination of the initial sample of 100 seeds, if any, is below the 3% threshold.



Broccoli





PCA analysis to check the discriminative power of markers for intra-specific contamination

Intra-specific panel

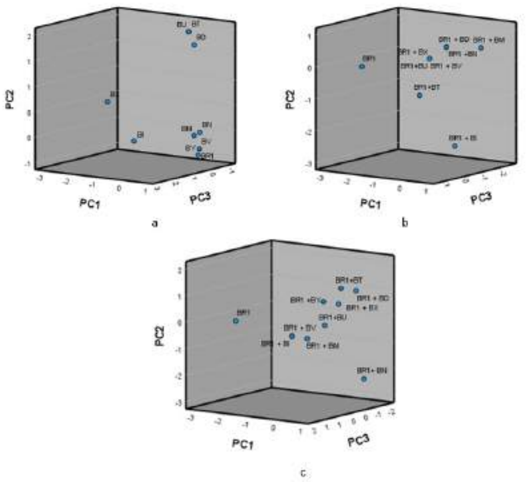
8 accessions

28 SSRs tested
→ Selection of **4 SSRs**

Inter-specific panel

11 accessions

6 SSRs



PCA analysis to check the discriminative power of markers for inter-specific contamination

The selected sets of SSRs were useful to detect the contamination at 1:3 and 1:2 ratios.

WP5 - Multi-sites evaluation of pre-breeding lines on-farm

Objectives

Number	Description
O5.1	Evaluate a shortlist of breeding **lines compatible with organic farming** for the production of crops of enhanced quality and marketing value.
O5.2	**Provide farmers with new materials** to be tested alongside commercial organic varieties on-farm
O5.3	**Enhance crop performance** (i.e. stress tolerance and nutrition) using **bioactive** products.
O5.4	**Promote crop rotations** for improved performance of brassicas, snap bean and tomato crops.

Task 5.2: On-farm evaluation for agronomic performances in crop rotation models (M24-M48).

- Developed Questionnaires
  - for the agronomic evaluation of varieties of tomato, bush beans and broccoli
  - For the assessment of each variety from the farmer’s perspective
- Evaluation forms available in Deliverable 5.2, a tool for future uses.
- Performance of the common varieties tested in T5.2 is described in Deliverable 5.4, submitted in January 2023.

Call identifier: H2020-SFS-2017-2
BRESOV
Grant agreement N°: 774244

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Breeding for Resilient, Efficient and Sustainable
Organic Vegetable production

Deliverable No. D5.2

List of crop performance measurements to be collected at all location and a questionnaire for the farmers involved

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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

Task 5.2: On-farm evaluation for agronomic performances in crop rotation models (M24-M56*). D3.4

- Two years of on-farm trials, and three for VRDS and UTAD (broccoli) completed.

- Broccoli trials
  - P4-UTAD
  - P5-VURV
  - P6-FiBL
  - P9-UNILIV
  - P11-VRDS
  - P18-ITAKA
  - P21-SECL
  - P13-BAAFS
  - P14-ZAAS.
- Bean trials
  - P6-FiBL
  - P11-VRDS
  - P16-SERIDA
  - P18-ITAKA
  - P21-SECL
  - P14-ZAAS.
- Tomato trials
  - P6-FiBL (GH)
  - P11-VRDS (OF)
  - P12-CREA(OF)
  - P18-ITAKA (OF,GH)
  - P21-SECL (GH)
  - P13-BAAFS (GH)
  - P14-ZAAS (GH).

- Material from the breeding set were added in 2nd year of tomato & beans

Greenhouse Tomato

- **FiBL3- 236x, & FiBL7-TZ24 trials were excluded** from 2021 trials due to poor marketable yield and fruit quality (fruits' heterogeneity & waste).
- No overall good variety in tomato (diff. In broccoli and beans)
- 4 varieties from the Breeding Set were newly added to the trials of 2021:
  - **Rosa de Barbastro** (BT04150)→ Beautful fruits, Yield and taste +
  - **Uco Plata (BT00900)** → High rejects
  - **Valenciana d'el Perelló (BT04260**) → Interest SECL
  - **Benissoda (BT04250)** → High rejects /Phytophthora , taste –
  - PSR variety **Bads Atomic**: Looks and taste ++ / Interest SECL

Open field Tomato

- **Varieties performed differently according to the location and low and high inputs in line with 2020, and 2021(VRDS)** except for FiBL10 which was excluded from CREA's second year of trial.
- No overall good variety in tomato, some were interesting for specific market
- Two new advanced breeding material were procured and are evaluated by CREA and VRDS in the second (& 3rd) year: FiBL 14 gave highest yield in 1 location in Italy
- No breakthrough discovery of variety. Location dependant performance described in D5.4.



- → In 2022, difference found between seed multiplication of the same variety (VRDS)

Broccoli

- Rasmus and CN-bro-09 performed differently depending on location but were often comparable to F1 references. Especially CN-Bro-09 was very well appreciated. Rasmus produced high yields, but lacked homogeneity in certain trials. Both are recommendable varieties for organic farming. Location dependant performance described in D5.4.
- Broccoli production suffered in many locations in the wet spring/summer 2021. Trials repeated in Romania and Portugal in 2022. In portugal in 2022, Rasmus gave the lowest yield.
- In 2022, Rasmus was best in Romania, followed by CN-Bro09.

Bean

- Both commonly tested varieties Slenderwax and La Victoire gave for the second-year good results and high yields, comparable or better than standard references. Both varieties are good for organic cultivation in all regions.
- Their success depended on the location. In some trials, Slenderwax outperformed La Victoire. In others, it was the opposite. Regional visual appreciation of the varieties also differed, such as Slenderwax's yellow pods were not found attractive in Italy.
- The trials also showed good results with other tested BRESOV bean lines (at VRDS and Serida) such as Prennel.

Task 5.3: On-station evaluation of Natural bioactive products and microorganisms to increase crop performance (M12-M36).

- In previous periods, the effect of microorganisms formulation could not be proven in production trial or pods. At UNICT, an effect of microbial-based (MO) treatments on increasing yields, alone and in combination with Betaine (BE) was observed in beans and on flowering and yield of MO and BE in tomato. Results presented at IHC2022: Effects of microbial consortia and betaines on snapbean grown under water stress conditions *(In press; Acta horticulturae)*

- A litterature review was published

Malgioglio, G., Rizzo, G. F., Nigro, S., Lefebvre du Prey, V., Herforth-Rahmé, J., Catara, V., & Branca, F. (2022). **Plant-Microbe Interaction in Sustainable Agriculture: The Factors That May Influence the Efficacy of PGPM Application.** Sustainability, 14(4), 2253.

- Farmer survey on use of alternative fertilizers and microorganism formulations (EN, SP, DE & FR): 93% recommend the use of alternative fertilisers (residue reduction, OF) & 59% the use of microorganisms (insect control, SI, root stimulation, mostly on Solanaceae and orchard crops). **Article by the EC.**

Task 5.4: Socio-economical study on the influence of crop rotation on crop performance (M36-M48).

- Data collected on T5.2 on-farm trials
  - LCA (LCA CREA OF Tomato done, others ongoing)
  - Social assesment
  - Economical assessment
  - Survey on farmers' opinions on the innovations

- Soil attributes
- Seedling production
- Transportation
- Cost and Gain
- Cultural operations
- Fertilisation
- PPP
- Irrigation
- Residue and waste management

→ Compared to an IT tomato monoculture, organic productions in crop rotation were found **more sustainable for both human and environmental health**.

WP6 - Communication, Dissemination, Training and Exploitation

Objectives

- O6.1: Communication, create visibility and encourage project outreach
- O6.2: Disseminate results to targeted stakeholders and the scientific community
- O6.3: Training of relevant stakeholders
- O6.4: Foster innovation management by maximising the exploitation of results

(Key) Achievements until now

Communicaiton, Dissemination & Training

- BRESOV KPIs
- BRESOV survey in EIP-AGRI newsletter
- BRESOV 6th Newsletter
- BRESOV 3rd set of practice abstracts
- BRESOV in CORDIS Results Pack
- BRESOV events
- BRESOV and social media
- BRESOV and the media

BRESOV survey on the use of alternative fertilizers and microorganisms featured in EIP-AGRI newsletter

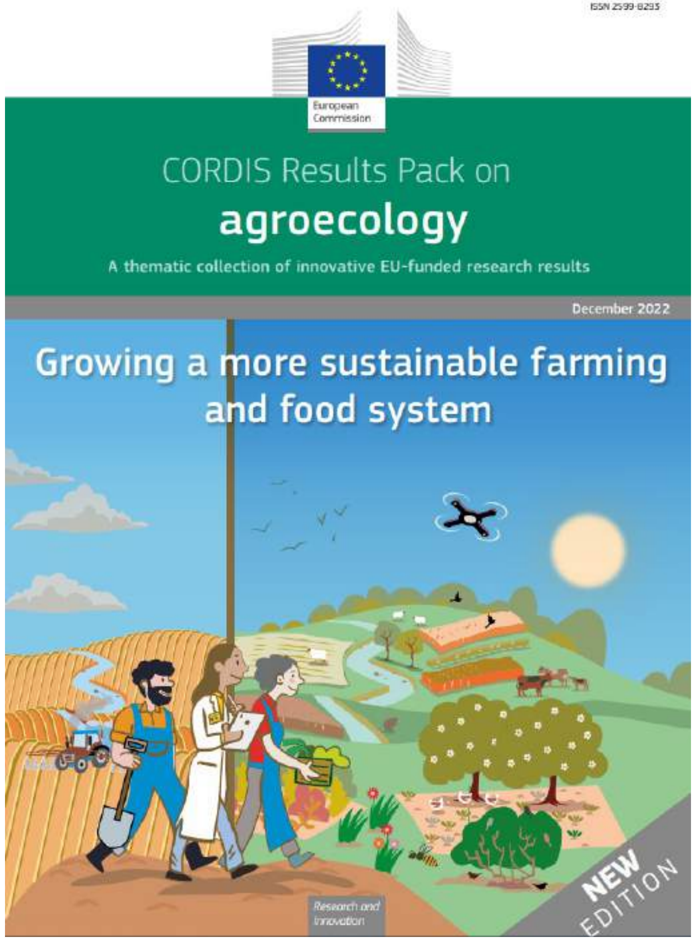
Farmers feedback on the use of alternative fertilisers and microorganisms

BRESOV, a Horizon 2020 project, recently carried out a survey on alternative fertilisers and microorganisms. 93% of respondents recommend the use of alternative fertilisers and 59% the use of microorganisms. The survey found that amongst the respondents, alternative fertilisers are mainly used for residue reduction and on open field vegetables. Microorganisms are used for insect control, soil improvement and root stimulation, mostly on Solanaceae and orchard crops. More info on the project.

BRESOV 6th Newsletter

BRESOV 3rd set of practice abstracts – Deliverable 6.8

BRESOV featured in CORDIS Results Pack



CORDIS Results Pack on agroecology
Growing a more sustainable farming and food system

Breeding climate-resilient crops for organic agriculture

To tackle the nutritional challenges for a growing world population in a context of changing climatic conditions, the EU-funded BRESOV project aimed to enhance the productivity of vegetable crops in organic farming.

The global population is estimated to reach 9.8 billion by 2050. Coupled with changing climatic conditions, this presents a huge impending risk to food security in the 21st century.

Organic agriculture must both increase and evolve to face these challenges. Farmers will need crops that maintain nutritional value and are able to deal with multiple unprecedented stressors in the coming decades. Without new climate-resilient crops, many small farmers across the EU will go out of business as their plants stop producing seeds.

The BRESOV (Breeding for Resilient, Efficient and Sustainable Organic Vegetable production) project, which runs until April 2023, is working to discover and enhance the genetic resources of organic crop production for farmers throughout the EU and beyond. Through breeding programmes, BRESOV is exploiting the genetic diversity of three economically significant crops: broccoli, green bean and tomato, improving the competitiveness of these crops for use in organic farming.

"The BRESOV consortium's overall aim is to increase the plants' tolerance to biotic and abiotic stresses and adapt these varieties to the specific requirements of organic and low-input production processes," explains Ferdinando Branca, associate professor of Horticulture and Floriculture at the University of Catania in Italy, and BRESOV project coordinator.

5

BRESOV events

UNICT: BRESOV at the International Horticultural Congress in Angers.

Euroseeds: BRESOV at the Euroseeds 2022 Congress in Berlin.

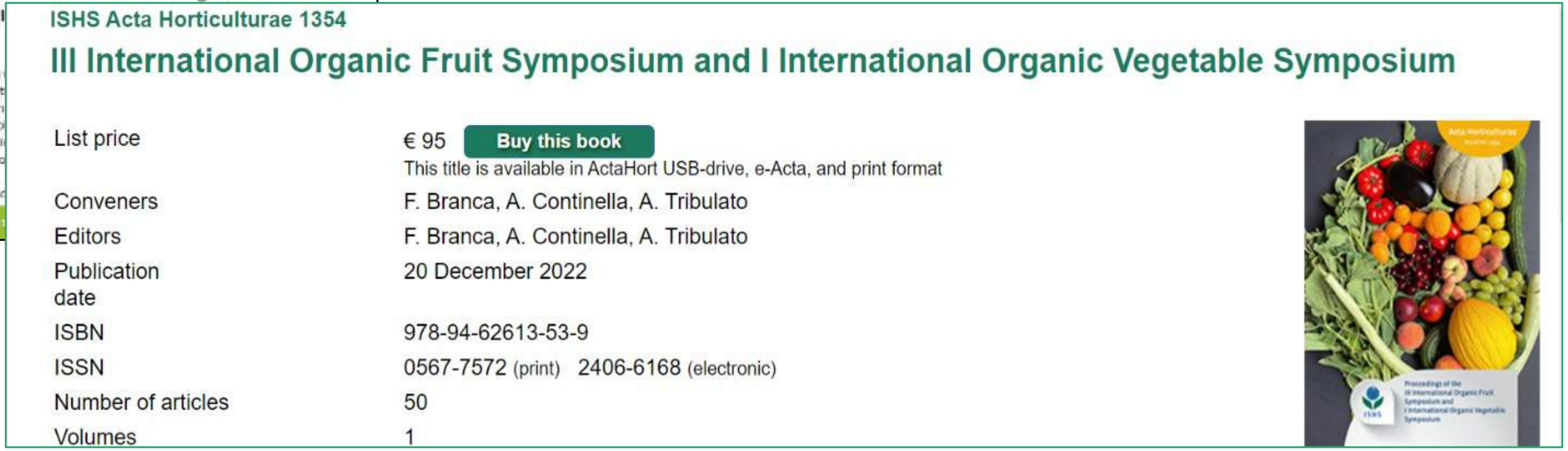
BRESOV BRESOV

✓December 2021 - OrgHort2020 ISHS Symposium in Catania (Italy)

www.orghort2020.it

OrgHort 2020

Acta Horticulturae n. 1354



BRESOV events

Università di Catania

Uni ct

Winter School Sicily 2022

Exploiting the diversity of broccoli, snap bean and tomato: the case of study of the H2020 BRESOV project

13 – 15 December 2022

Catania, Agrigento (and virtual meeting)

SERIDA: BRESOV at the I National Congress of Legumes in Asturias.

https://www.youtube.com/watch?v=5DGvA48Bh5Q

BRESOV events

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BRESOV events

BRESOV   Università di Catania   Uni ct Di3A   SOI

Final Conference of the EU Horizon 2020 BRESOV project

“The Improvement of the Broccoli, Snap Bean and Tomato organic farming by Exploiting their Biodiversity: the results of the H2020 BRESOV project”

Dioscuri Bay Palace Hotel
Agrigento, 28-31 March 2023

BRESOV Conference 2023 Agrigento 29-31 March 2... + Invita

Photos of the 1th day of the "BRESOV Final Conference 2023". Stay tuned with the 2th Day

Vedi traduzione

BRESOV Conference 2023 Agrigento 29-31 March 2... + Invita

31March.
This morning we visited “Terre del Barone” organic farm: focus on participatory organic breeding and farming of vegetable
crops populations (Valley of Temples).

Vedi traduzione

BRESOV and social media

BRESOV_EU @BRESOV_EU · Dec 19, 2022

📢#NewsAlert

#BresovEU project has been featured in the new @CORDIS_EU Results Pack "Agroecology: research for resilient, sustainable, climate-, ecosystem- and social-friendly farming systems".

Read how the project is helping secure the future of food 👉
europa.eu/!Bgnhfx

CORDIS Results Packs

Multilingual collections of up-to-date articles that focus on a specific theme, bringing you results that you can apply in your domain

13 DECEMBER 2022

Agroecology: research for resilient, sustainable, climate-, ecosystem- and social-friendly farming systems

The EU has set ambitious targets for the agricultural sector. Not only do Europe's farmers need to ensure a reliable supply of high quality food – fruit, vegetables, nuts, cereals and animal products – and non-food products at competitive prices, they must also deliver on the environmental commitments of the EU Green Deal and farm to fork strategy.

Read more

BRESOV_EU @BRESOV_EU · Sep 13, 2022

The results of the #BresovEU survey on the use of alternative fertilizers and microorganisms developed by @fiblorg and @ItakaCrop have been featured in the latest @EIPAGRI_SP newsletter!

Check it out below👇

@COPACOGECA @OrganicsEurope @REA_research @EUgreenresearch

EIP-AGRI Support Facility @EIPAGRI_SP · Sep 13, 2022

#EIPagri September newsletter on #Sustainable use of #pesticides in #agriculture 🌱🐝🐞🌽

All about EU proposal to reduce chemical pesticides by 50% by 2030 - #EUFarm2Fork

Inspirational ideas from Austria & Poland, publications, videos, events ...

👉 bit.ly/3qvOklb

BRESOV and social media

BRESOV_EU @BRESOV_EU · Aug 18, 2022

Today, the @unict_it team led by project coordinator @brancaferd paid a visit to @Vegenov labs and facilities.
A particular attention was brought to the ongoing broccoli 🥦 trials within T4.2.

BRESOV_EU @BRESOV_EU · Nov 28, 2022

.@unict_it 🇮🇹 sampled the organic cross pollination populations established by CREA 🇮🇹 utilizing the selected Sicilian landraces of broccoli 🥦 and cauliflower in the framework of the #BresovEU project.
#organicfarming #organicagriculture

BRESOV_EU @BRESOV_EU · Nov 2, 2022

Last week, #BresovEU project got exposure on numerous occasions during the #Euroseeds2022 Congress in Berlin 🌱🇩🇪.
See below some snaps from the presentation by A. Detterbeck and T. Cardi 👇

Euroseeds @EuroseedsEU · Oct 25, 2022

At the #Euroseeds2022 SVO meeting, A. Detterbeck presented the @BRESOV_EU project, its structure and objectives and T. Cardi @CREA_Ricerca gave a deeper overview of the breeding activities and results of the project looking into snap bean, broccoli and tomato.
#GrowingTheFuture

Euroseeds @EuroseedsEU · Oct 26, 2022

Euroseeds is involved in various EU-funded research projects, such as @BRESOV_EU, @invite_eu & a new @GeneBEcon which were showcased at the #Euroseeds2022 🌱🇩🇪.
In these projects we provide our expertise in technical, communication, dissemination and exploitation areas.

Organic Farm Knowledge @farm_knowledge · Jan 12

Latest @BRESOV_EU Practice Abstract about strategies to produce tomato seeds during regular #tomato harvest 🍅
➡️Learn how to produce and preserve seeds from interesting, locally adapted varieties 🌱🍅
🔗 Link to tool: organic-farmknowledge.org/tool/44659
#cropproduction #seeds #breeding

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PRACTICE ABSTRACT 14

Strategies to produce tomato seeds during regular tomato harvest

Tomato production can be time consuming especially when it is done to produce and keep small amounts of seeds from several varieties. It is nevertheless important to produce and preserve seeds from interesting varieties which are well adapted to your production system and environment.

In a trial conducted over two seasons at FiBL in Switzerland, two harvest regimes were tested on eight tomato genotypes. One regime consisted of a regular harvest of fruits twice a week followed by seed extraction, while the other consisted of a harvest of fruits every three weeks for seed extraction. The main difference between the fruits from the two regimes is their stage of maturity i.e. all fruits are at the optimal stage for consumption with the frequent harvest while fruits are at various maturity stage – from optimal to overripe – with the less frequent harvest.

Seeds were also extracted from fruits regularly harvested (twice a week) and stored in a cool chamber (ca. 7°C) for up to 4 weeks prior to extraction.

Mashed tomato fruits in buckets, left for 3 days at 26°C with regular stirring to enable fermentation.

Fermentation facilitates the separation of seeds from fruit flesh (left) and extracted and dried tomato seeds (right).

Pictures: Patricia Schwitter, FiBL

Our results show that using fruits from irregular harvest including overripe fruits does not negatively affect seed viability and seed production per Kg fruit. We however advise – as we did – to remove fruits or part of fruits with clear disease symptoms prior to seed extraction.

However, plants from which fruits were frequently harvested produced a higher fruit yield than those harvested every three weeks. This increase of fruit yield indirectly increased the seed yield. Cooling of the fruits did not impact seed production and viability. A way to save on time, space and resources while enhancing production, is therefore to pool fruits from several regular harvests and store them in a cool room until the quantity is enough for the desired seed extraction. This also allows to have a small side production of seeds in parallel to the regular production of fruits. If the cultivation is done for the sole purpose of seed production, a less frequent harvest procures a large quantity of fruits at once for the seed extraction and does not negatively impact the seeds.

If you are cultivating several tomato varieties to produce seeds and want to preserve your variety, it is important to prevent cross pollination by either separating the varieties with a net or making sure pollinators have no access to your plants.

By pointing out different seed multiplication strategies, we hope to support small scale seed producers and farmers working with niche cultivars to produce seeds and be independent from seed companies.

You and FiBL

BRESOV and the media


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Bresov Report

A project to select brassicas, tomatoes and other species resistant to biotic and abiotic stress

The European project H2020 BRESOV (Breeding of Resilient, Efficient and Sustainable Organic Vegetable production) has reached its fourth year of activity (www.bresov.eu) and, during the 4th annual meeting, held in Spain at the Polytechnic University of Valencia, the results acquired during the penultimate year were presented.

Field visits


A Deeper Look at the BRESOV Project

By European Seed - October 26, 2022

153 0

UNICT: BRESOV project results and the 4th Annual meeting in Valencia featured on the leading portal for the fruit and vegetable sector Fresh Plaza.

Euroseeds and CREDA: An interview with A. Detterbeck and T. Cardi organized during the Euroseeds 2022 Congress where they discussed BRESOV project and whether organic agriculture can feed the planet.

KERs overview

KER 3B

Tools and products to control the sanitary quality of organic broccoli, snap bean and tomato seed lots.

(KER Leading Partner: VEG)

KER 3A

Agronomical practices to increase the production of high-quality organic seed in broccoli, snap bean and tomato.

(KER Leading Partner: VEG)

KER 2

Breeding material of broccoli, snap bean and tomato for the development of new resilient and improved organoleptic and nutritional quality organic cultivars.

(KER Leading Partner: UPV/UNIVPM)

KER 1

Genetic and phenotypic characterization of plant genetic resources (PGR) for Broccoli, snap bean and tomato including crop wild relatives and segregating populations.

(KER Leading Partner: UNILIV)

BRESOV has received funding from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement No. 774244.

Final Conference of the EU Horizon 2020 project BRESOV
28th-30th March 2023, Agrigento, Italy

Università di Catania

BRESOV

Breeding for Resilient, Efficient and Sustainable Organic Vegetable production

KER 1: Genetic and phenotypic characterization of plant genetic resources (PGR) for broccoli, snap bean and tomato including crop wild relatives and segregating populations.

UNIVERSITY OF LIVERPOOL

BRESOV

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Final Conference of the EU Horizon 2020 project BRESOV
28th-30th March 2023, Agrigento, Italy

Università di Catania

BRESOV

Breeding for Resilient, Efficient and Sustainable Organic Vegetable production

KER 2: Breeding material of broccoli, snap bean and tomato for the development of new resilient and improved organoleptic and nutritional quality organic cultivars

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

UNIVERSITÀ POLITECNICA DELLE MARCHE

BRESOV has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 774244.

Final Conference of the EU Horizon 2020 project BRESOV
28th-30th March 2023, Agrigento, Italy

Breeding for Resilient, Efficient and Sustainable Organic Vegetable production

KER3: Agronomic practices to increase the production of high-quality organic seed and advanced tools to control the sanitary quality of organic broccoli, snap bean and tomato seed lots.

[redacted]

BRESOV Output - ForEVA

- ForEVA legume network: Fostering the need for implementation of the ECPGR European Evaluation Network (EVA) on grain legumes
- First in-person meeting on 10-11 October 2023 in Bucharest, Romania with 40 project partners and stakeholders to review ongoing initiatives on legumes across Europe and jointly discuss the options for the establishment of an EVA Legumes network, develop a draft work plan and budget proposal for this new initiative
  - https://www.ecpgr.cgiar.org/working-groups/grain-legumes/foreva
  -

EVA
European Evaluation Network

BRESOV Output – policy brief

- **Key policy recommendations**
  - **High quality seed:** Healthy seed are crucial to produce healthy well-performing plants and to contribute to the reduction of crop protection products. This is especially true for organic production.
  - **End of derogations:** **For investments in seed production** in view of the goal to reach 25% of organic agricultural land by 2030 and 100% use of organic certified seed**, clarity on derogations is** needed. This includes a clear commitment to end derogations and the development of an EU-wide strategy.

BRESOV Output – policy brief


BRESOV - Breeding for Resilient, Efficient and Sustainable Organic Vegetable production

BRESOV

POLICY BRIEF

ON ORGANIC VEGETABLE PRODUCTION IN EUROPE

BRESOV received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 774244.

- **Key policy recommendations**
  - **Advanced breeding methods:** Advanced, **accessible breeding and selection methods** (such as marker assisted breeding, on the basis of genetic information and sources) are needed to adapt varieties to low-input, high-stress conditions. Access to **genetic and phenotypic information is key for breeding for sustainable production** in a changing climate.
  - **Breeding for sustainability:** Crop production under organic conditions can provide beneficial ecosystem services; however, depending on the species this can be challenging in view of food production security. Plant breeding for sustainability specifically **promotes new resistant, tolerant, and resilient varieties** and thus contributes **to decrease the gap** in productivity **between a conventional and a low-input, low-impact farming system**. Varieties bred for these production systems can serve both conventional and organic farming.

Thank you for your attention!

Whom to contact in case of interest?

[redacted]

- **University of Catania**

[redacted]

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