Breeding strategies for new resilient cultivars for strawberry production in Marocco.

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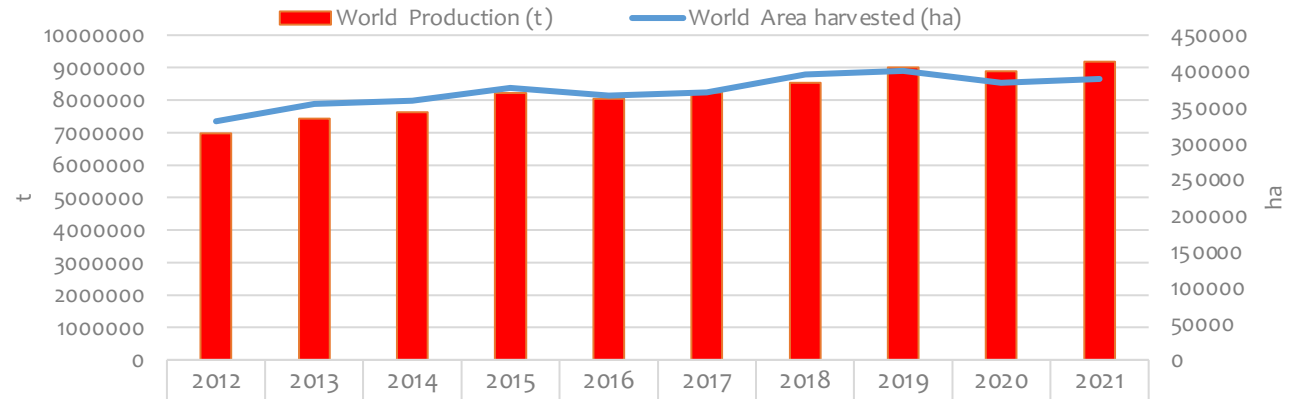
Background

01

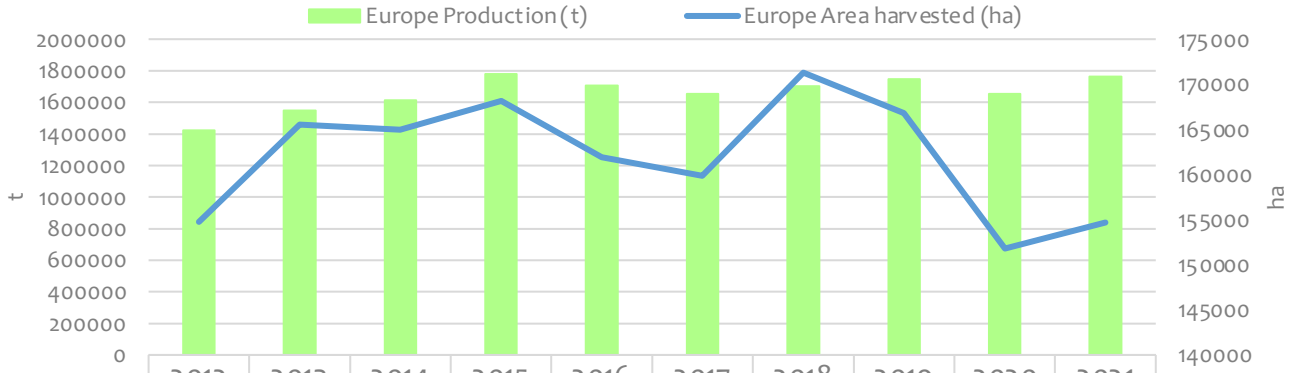
GLOBAL PRODUCTION VS GLOBAL HARVESTED AREA LATEST 10 YEARS (2012-2021)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
World Production (t)	7E+06	7E+06	8E+06	8E+06	8E+06	8E+06	9E+06	9E+06	9E+06	9E+06
World Area harvested (ha)	330669	354617	359029	377115	365864	370952	395178	400521	383591	389665

(FAO, 2021)

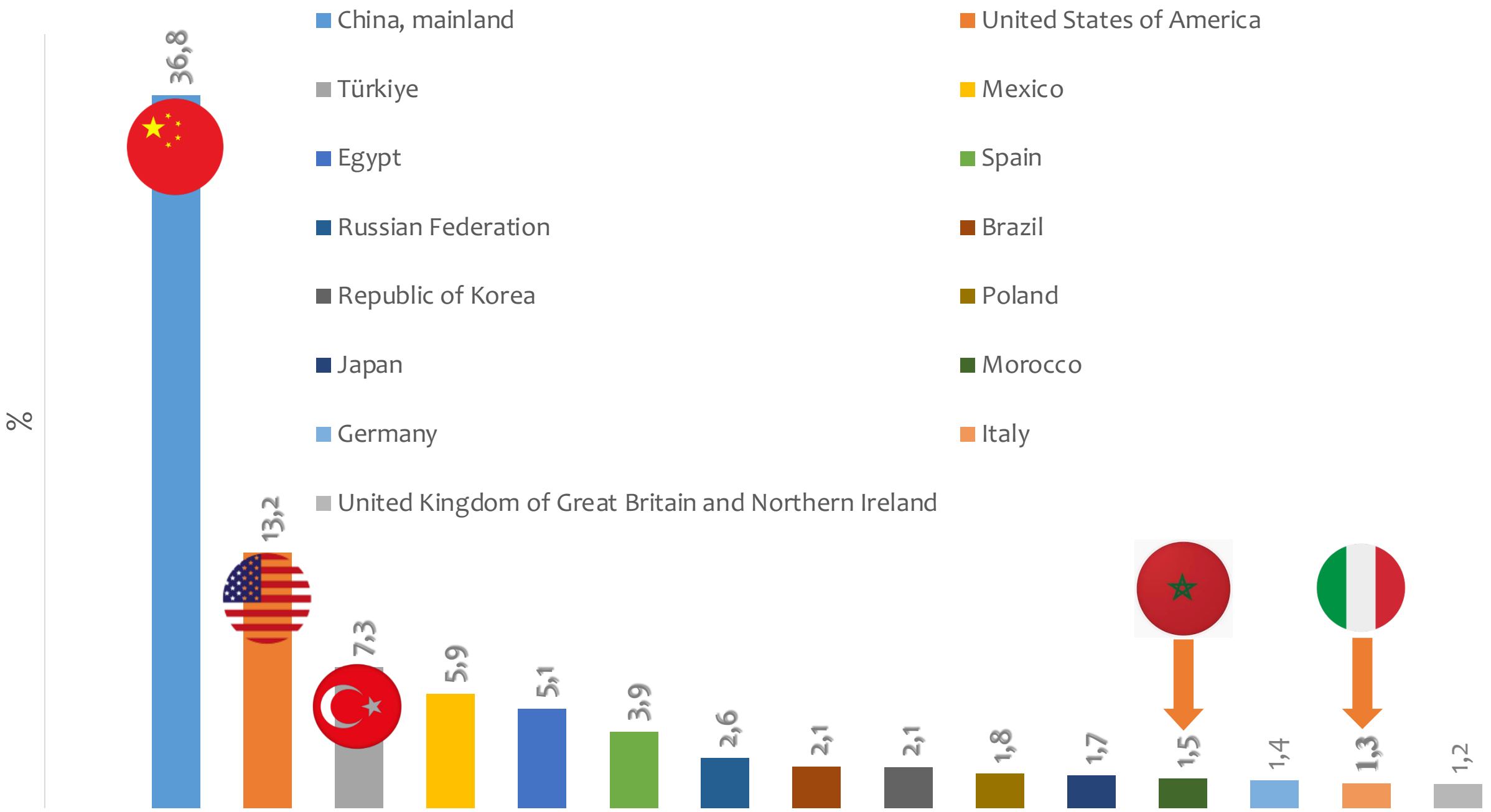
EUROPE PRODUCTION VS EUROPEAN HARVESTED AREA LATEST 10 YEARS (2012-2021)



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Europe Production (t)	1E+06	2E+06	2E+06	2E+06	2E+06	2E+06	2E+06	2E+06	2E+06	2E+06
Europe Area harvested (ha)	2E+05	2E+05	2E+05	2E+05	2E+05	2E+05	2E+05	2E+05	2E+05	2E+05

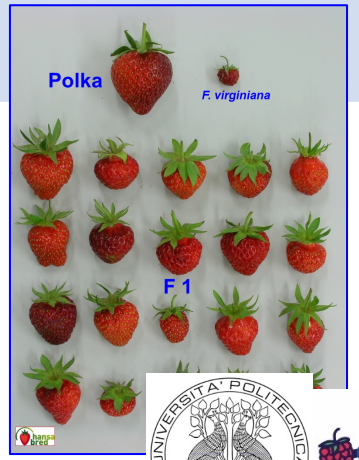
(FAO, 2021)

TOP 15 PRODUCERS 2021

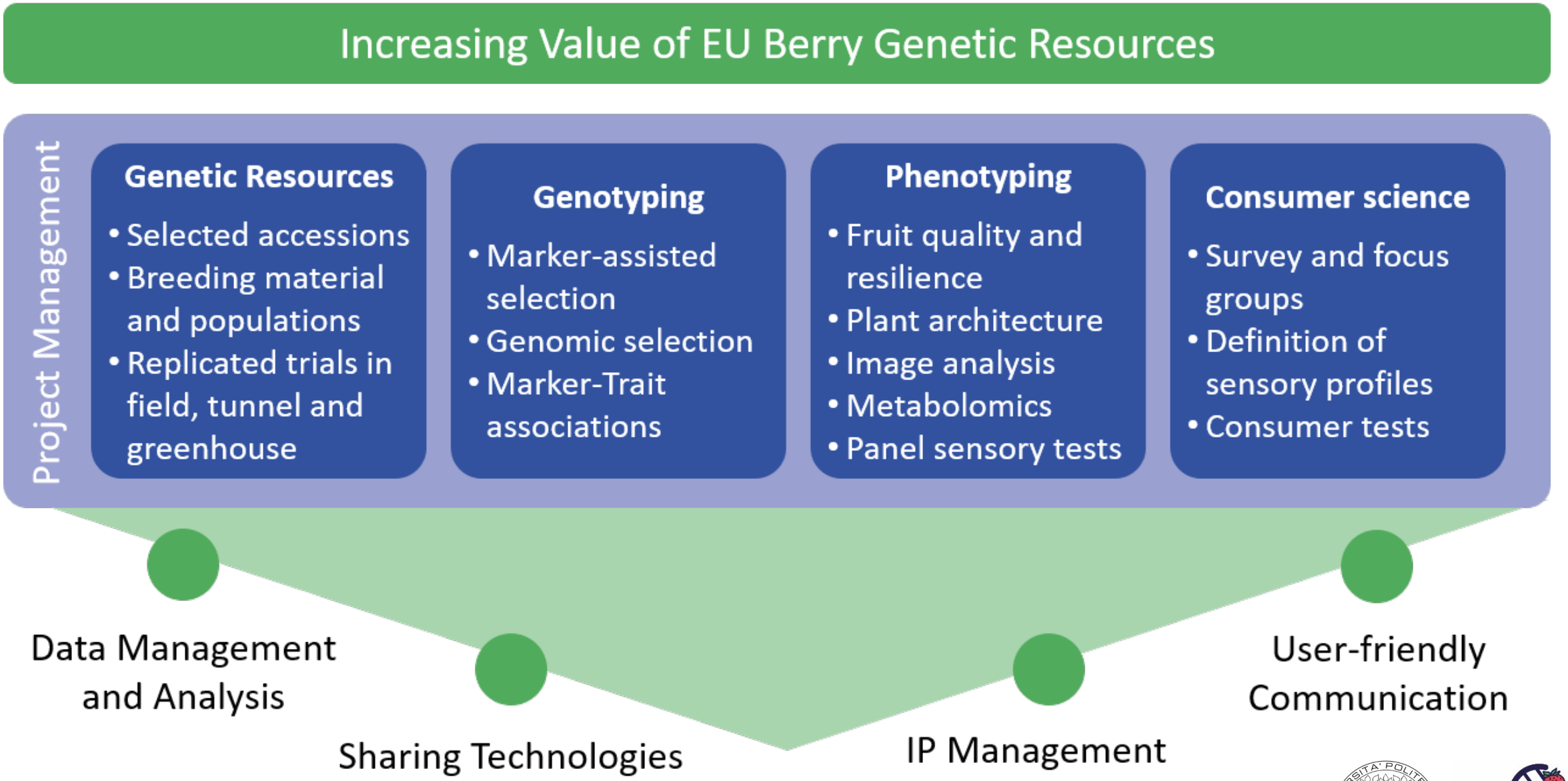


Importance of genetic diversity for creating new resilient cultivars :

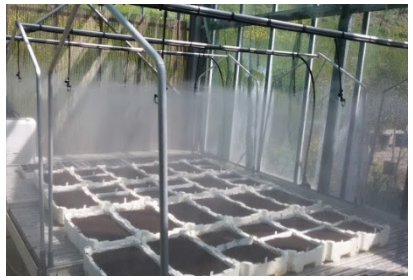
- Investigation of the domestication effect by determination of allelic diversity and answering the question: How resilient is our breeding base for future breeding?

Plant category 1 Old cv. (until 1960)	Plant category 2 Modern cv. (1960-2005)	Plant category 3 Newest (released) cv. (2005 till now)	Plant category 4 Pre-breeding (advanced selections or selections in new breeding directions)	Plant category 5 Species	Plant category 6 Populations
					

How to develop a new cultivar?



BREDDING AND SELECTION IN RESILIANT CONDITIONS



1. *IN OPEN FIELD*
2. *HEAVY AND CHALKY SOIL*
3. *NO SOIL FUMIGATION*
4. *SHORT ROTATION – 3 YEARS*

PLANTATION: END OF JULY
COLD STORED – FRESH PLANTS
Early May – Early June: fruit harvesting and assessment
GENETIC MATERIAL PER YEAR:
about 4000 seedlings, 500 selections, 60-70 cultivars

CREATING NEW STRAWBERRIES WITH INCREASED HEALT BENEFITS FOR THE CONSUMER

Field and quality assessment

Field program and Assessment

SENSORIAL QUALITY

Nutritional quality assessment

EARLY SCREENING FOR MAIN NUTRITIONAL QUALITY PARAMETERS (TAC, TPH, ACY)

HPLC QUANTIFICATION OF BIOACTIVE COMPOUNDS

IN VITRO EVALUATION

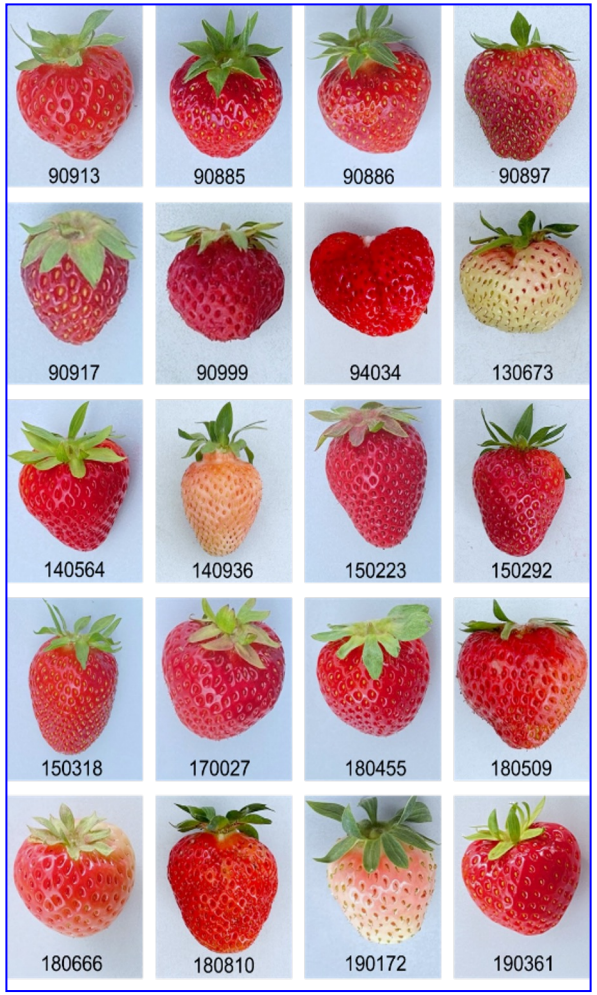
IN VIVO CONFIRMATION

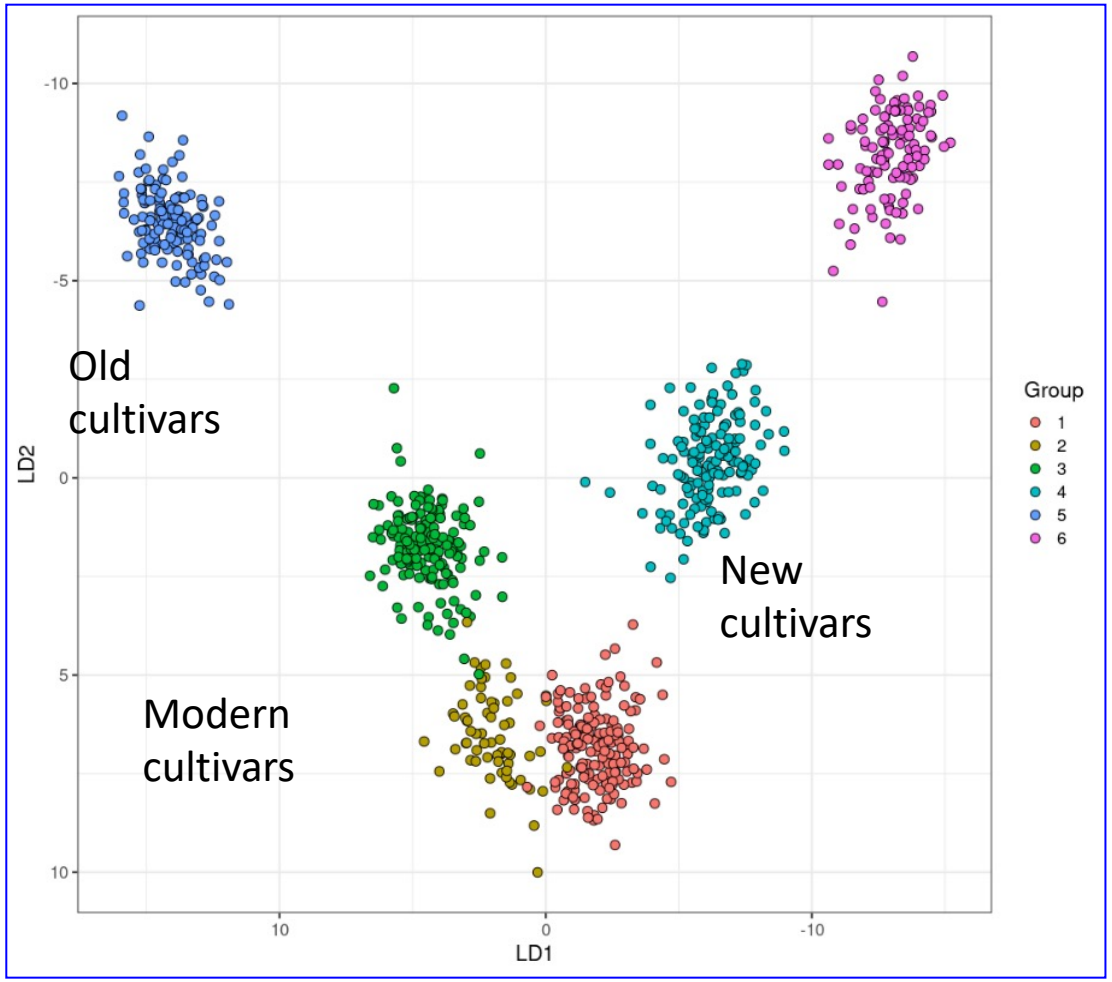
NEW HEALTHY STRAWBERRY

Biomedical assessment

Consumer assessment

WP 1, 2, 3: Fruit Evaluation, Genetic and Metabolomic Diversity Studies

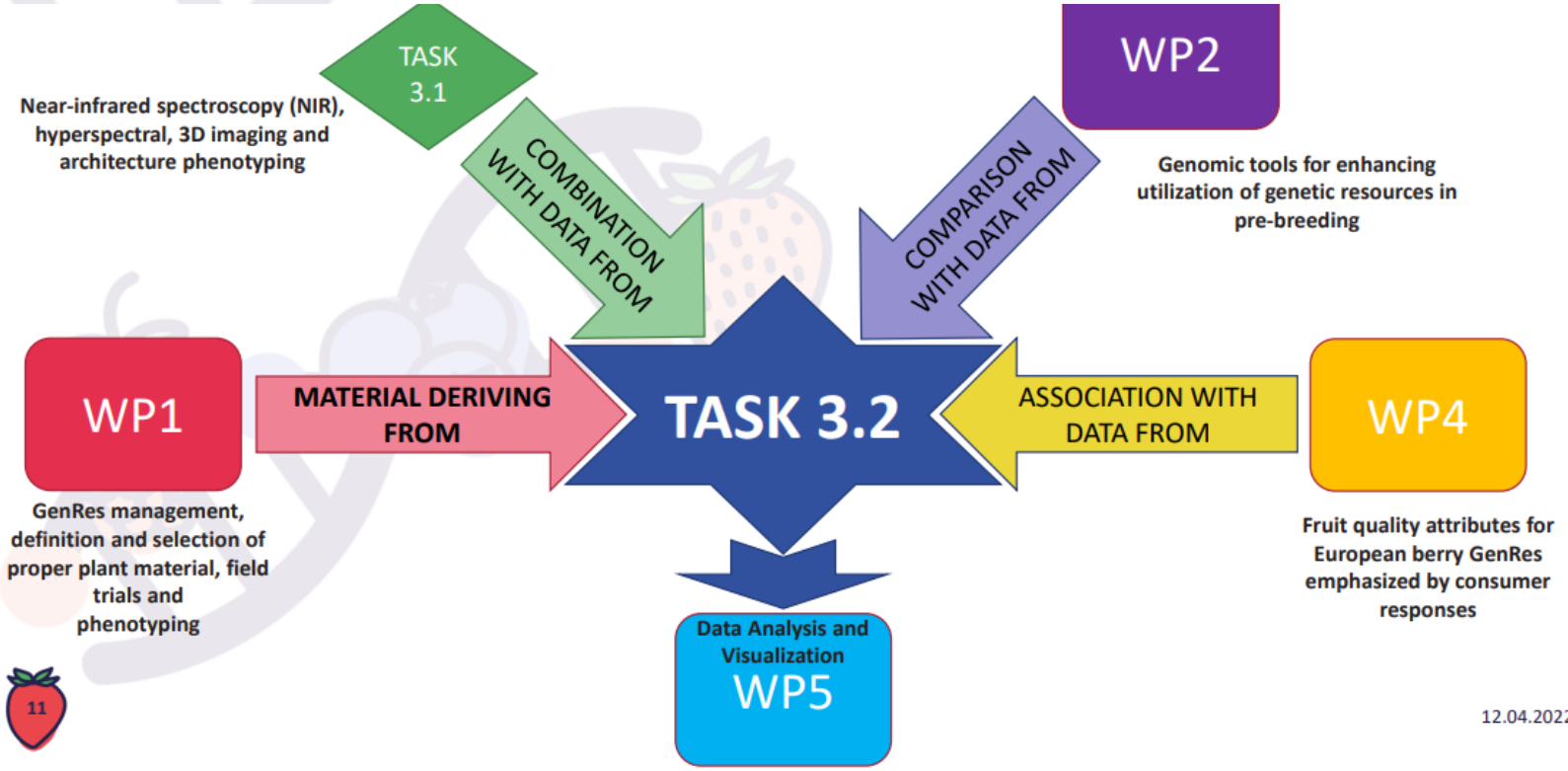


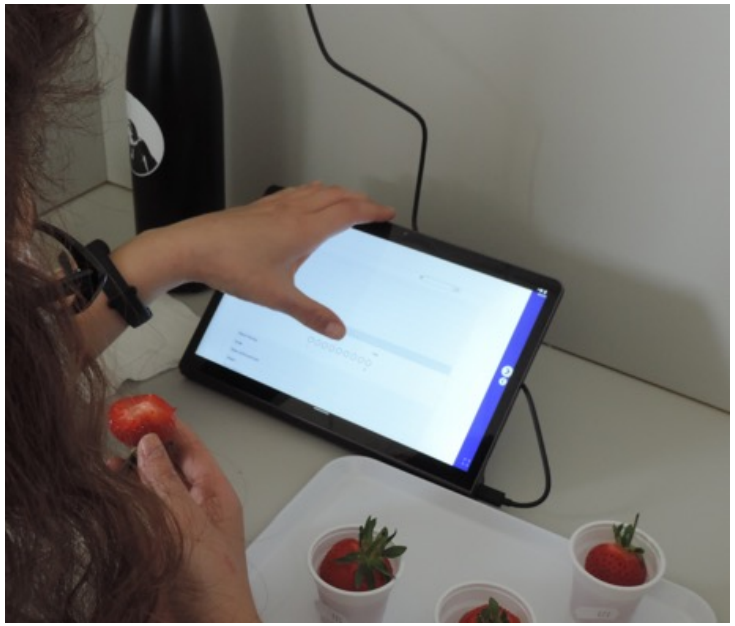


Genetic Diversity study using strawberry cultivars defined by WP 1 and performed by WP 2: preliminary results show clear clustering of different groups

New tools for plant Phenotyping

- **Task 3.1:** Near-infrared spectroscopy (NIR), hyperspectral, 3D imaging and architecture phenotyping
- **Task 3.2:** Analysis of chemical components conferring nutritional and aroma/taste quality (metabolomics)
- **Task 3.3:** Postharvest parameters
- **Task 3.4:** Validation through inter laboratory ring-testing



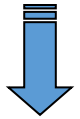


Sensorial and consumer study

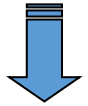
STRAWBERRY MONOCULTURE WILL STILL EXIST?

For high-value fruit and vegetable crops, yields are maintained with intensive production practices, such as monoculture system and soil fumigation.

- Increase of soilborne pathogens
- Increase of weed and difficulty in its control
- Decrease of the biodiversity
- Increase of the soil erosion and decline of soil fertility



Yield decline - Decrease profitability



THE NEED OF RESILIENT CULTIVARS

- Integrated crop management (ICM)
- Organic farming – how it can go
- Soilless culture

FIELD CULTIVATION SYSTEMS: NEED OF OTHER METHODS

- **SOIL STERILIZZATION, ROTATION, TYPE OF MULCHING**
- Methyl bromide BANNED IN EU SINCE 2005
- Eliminates soilborne diseases (*Verticiliium dahliae, Phytium, Rhizoctonia, Cylindrocarpon…)*
- Reduces weed population
- Enhances plant growth response

NEED OF OTHER SYSTEMS TO CONTROL DISEASES

EFFICIENCY IN MANAGEMENT OF WATER SUPPLY AND PLANT NUTRITION

Methods for monitoring water stress:

Leaf gas exchange

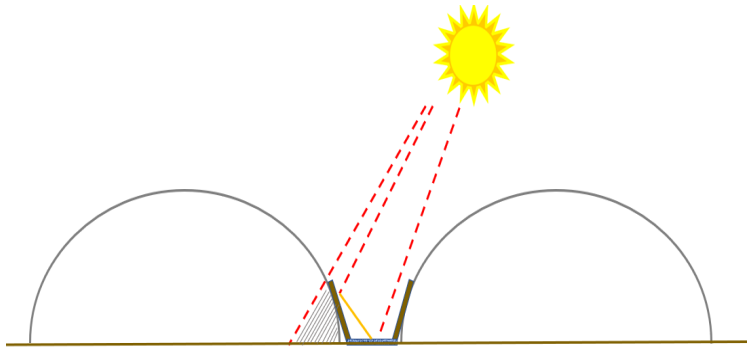
- **Equipment:** Photosynthesis system
- **Measurements:**

1. **E**: Transpiration rate (mmol*m-2s-1)
2. **VpdL:** Vapor pressure deficit (kPa)

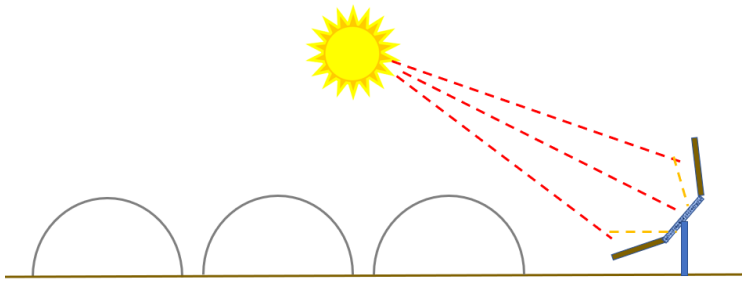
- **Timing:** when the % of pot water content of the WS plants achieved the theorical «stress point»

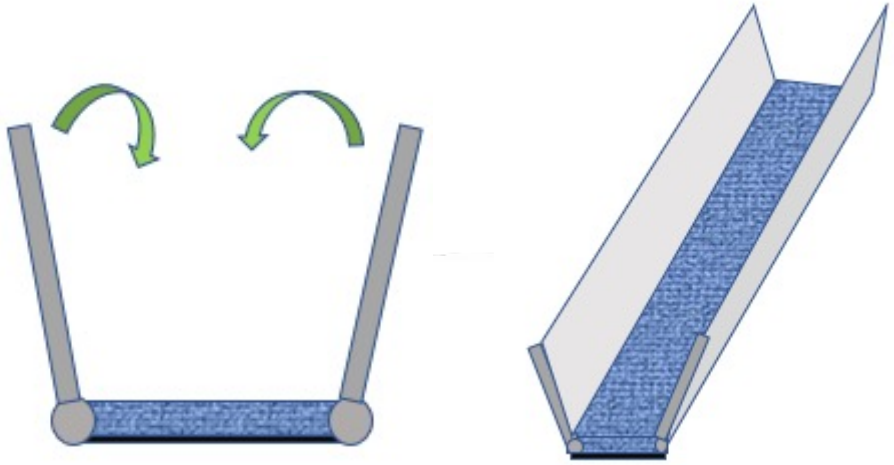
New solar panels to produce energy by exploiting greenhouse spaces.

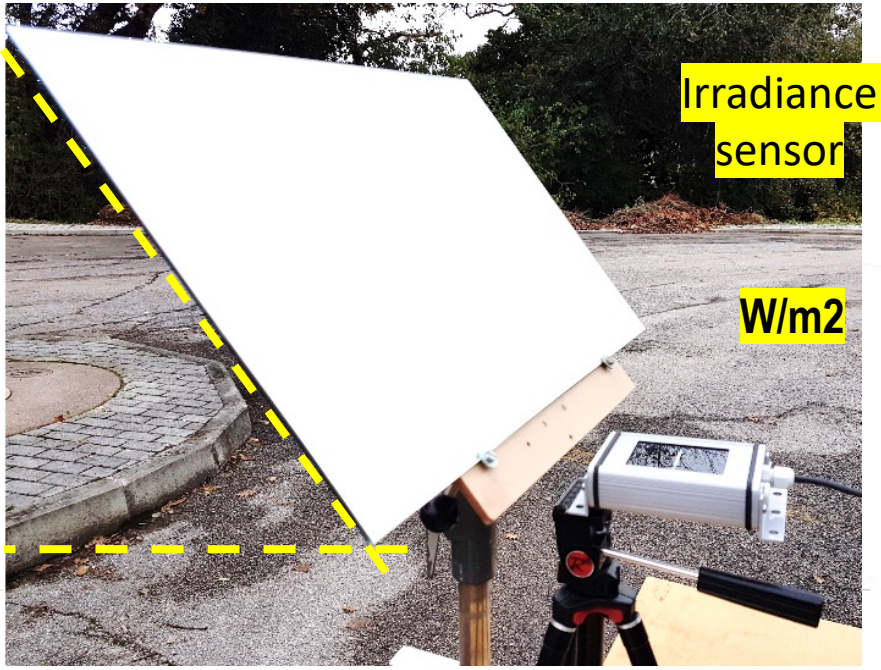
Intra-greenhouse



External area







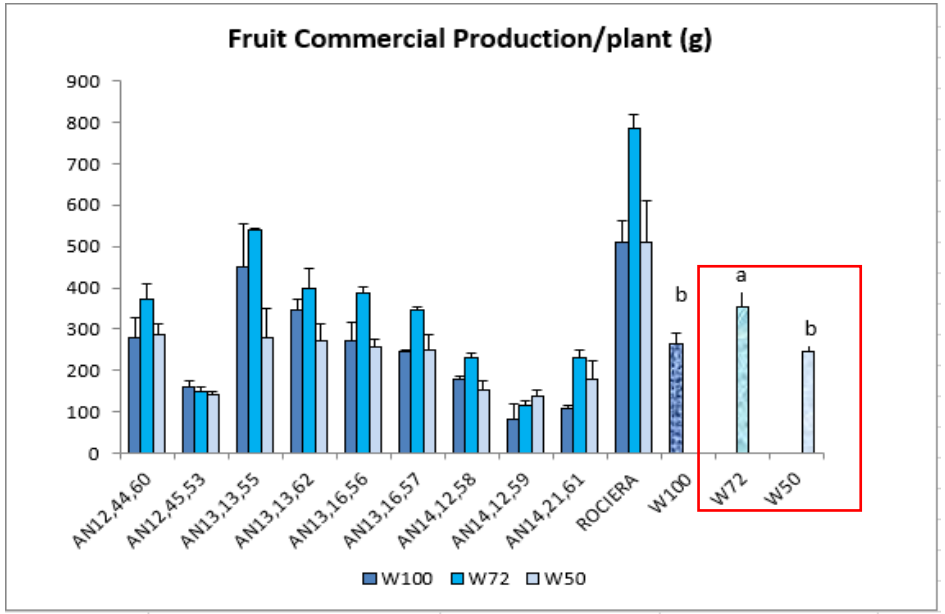
new modular panels for the spaces between tunnels and greenhouses

TESTING BREEDING SELECTIONS AT REDUCED WATER MANAGEMENT

Sites 3: Moguer (SP)- plantation October 2018 – data spring 2019 https://goo.gl/maps/LQ1Y4rbLNXu

Tested selections
(Plug plants)

- AN 14, 12, 59
- AN 13, 13, 55
- AN 12, 44, 60
- AN 13, 16, 56
- AN 13, 16, 57
- AN 14, 12, 58
- AN 12, 45, 53
- AN, 13, 13, 62
- AN14, 21, 61



In comparison with
Rosiera (fresh plants)

High difference among Breeding material. Rosiera Different performance is probably due to the different type of plants used.

Best performance for all at W72 – saving 28% of irrigation water.

Evaluation of varieties and pre-breeding lines in Turkey

The advanced selections from UPM and INVENIO was evaluated based on their botrytis and some agronomical traits and this issue was one of master student subject and entitled «THE PERFORMANCES OF SOME FOREIGN STRAWBERRY GENOTYPES IN ADANA ECOLOGICAL CONDITIONS».

Considering the total yield per plant, AN142161 genotype came to the fore with 832.15 g. When we evaluate the total yield values per plant, it is seen that the Italian genotypes have high values .

*In the AN131355 genotype, was the most aromatic among them.

When we evaluated the sugar contents, the best results were excellent with the EXP 121 genotype.

*Measuring the mean total anthocyanin values, the highest value was found in AN124553 genotype.

*When the total antioxidant values were examined, the highest value was obtained from AN124553 genotype in March, also.

Evaluation of varieties and pre-breeding lines in Morocco

Trials layout

- **Controlled environment experiments**

Powdery mildew

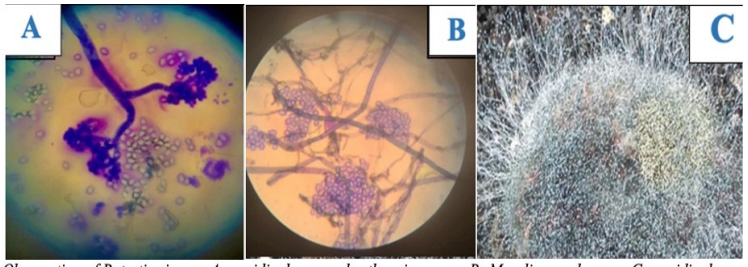
plants infected by natural dissemination from contaminated plants; Direct sunlight; T= 28°C; H = 10-65 % (infection) ; 65-99% (dissemination)

➢ **Scoring**

Number of infected leaves on 2 reps; degree of attack ; total number of contaminated leaves

Botrytis

Artificial lights (12h of light/day) ; T=24°C ; H=100% ; artificial infection of fruit and flowers by fungal isolate suspension



Observation of Botrytis cinerea A: conidiophores under the microscope B: Mycelium and spores C: conidiophores seen with the naked eye

➢ **Scoring**

Number of inoculated and infected flowers; time interval between inoculation and first infection ; degree of infection.

- **In field experiments**

(2019/2020)

1 experimental site in **organic cropping system** in Ain Aouda region

(2020/2021)

2 experimental sites in both **organic** (Ain Aouda) and **conventional cropping system** (Larache)

➢ The cultivars were characterized for production parameters

Plant material

Cultivars	Origine
EXP 118 EXP 121 EXP 129 EXP 645 EXP 801	Invenio (FR)
AN 12, 20, 53 AN 13, 13, 55 DINA AN 13, 13, 62 AN 12, 45, 53	Marche Polytechnic University (Ancona, IT)
AN 12,13,58 AN 15,07,53 AN 15,19,55 AN 14,20,51 AN 12,44,60	

1st year

2nd year

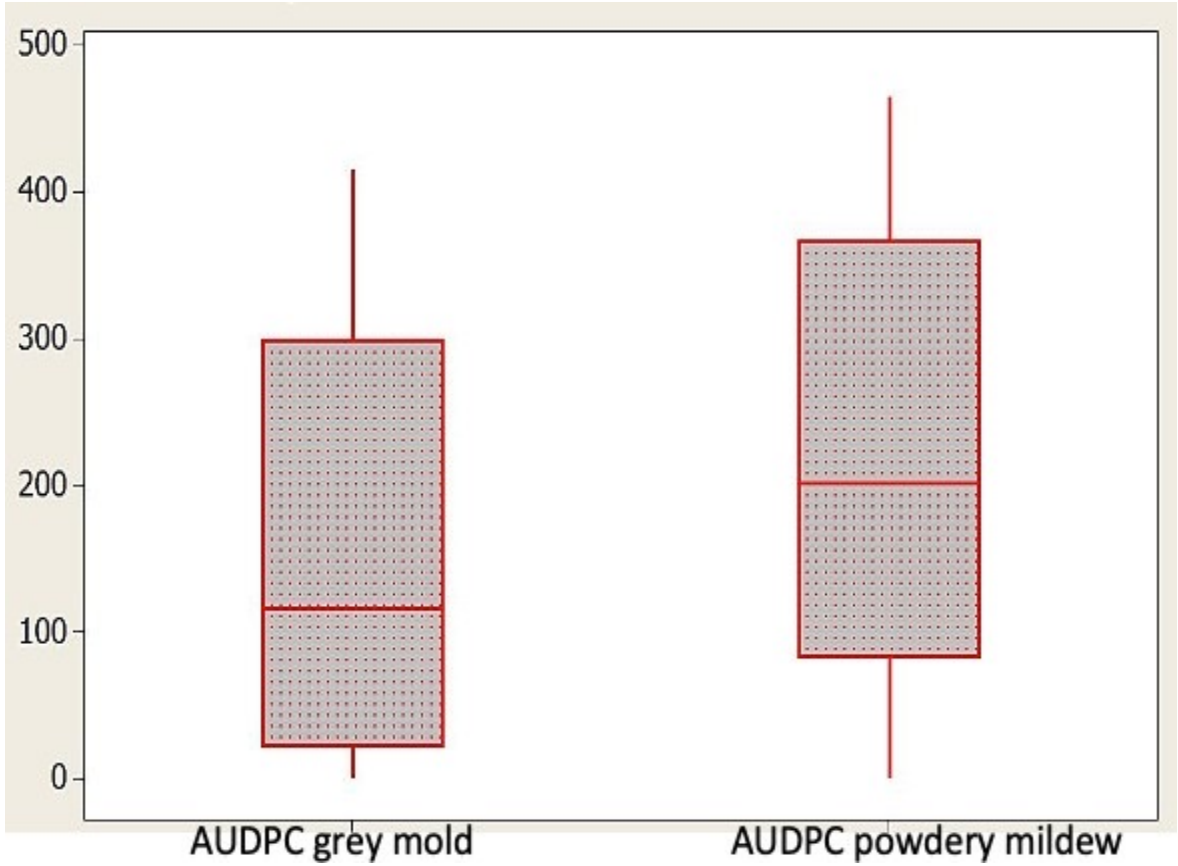
Control

+

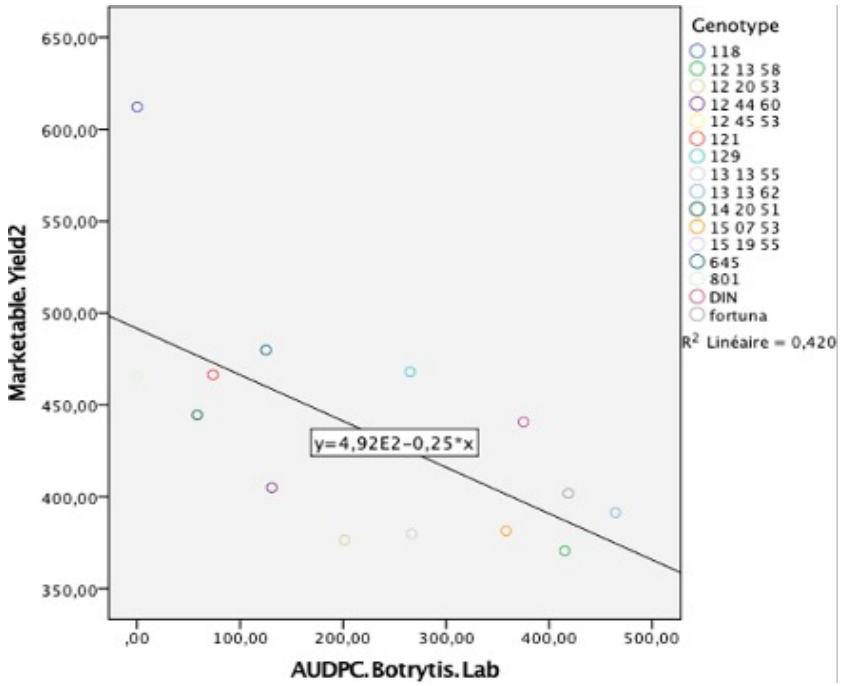
Fortuna (field + controlled environment)

Victory (controlled environment)

Evaluation of production and disease tolerance



The attack of *Botrytis cinerea* is more important on the cultivars than attack caused by *Podosphaera aphanis* as shown by the Boxplot



The regression line of marketable production in controlled environment and botrytis AUDPC

Botrytis infection can cause significant damage in the absence of an adequate control strategy for sensitive genotypes.

This is demonstrated with a drop in production.

Powdery mildew

Cultivars	Severity index	AUDPC
An131355	0	0,00
Exp801	0	0,00
Exp129	0	0,00
An124553	5,9	20,60
An151955	16,6	24,90
Exp121	111,1	44,40
Exp118	31,9	89,70
Exp645	25	100,00
Fortuna	48,2	115,90
An121358	76,4	212,90
Victory	60	253,30
An124460	120,8	292,90
An142055	173,8	298,10
Dina	107,7	300,00
An131362	107,1	321,80
An122053	143,3	321,90
An150753	236,9	414,50

The cultivars AN 13 13 55, EXP 801, EXP 129, AN12 45 53, AN 15 19 55, EXP 118, EXP 645 and Fortuna; showed severity indexes lower than the mean.

The cultivars AN 13 13 55; EXP 801 ; EXP 129 ; AN 12 45 53 ; AN 15 19 55 ; EXP 121 ; Dina and Victory have AUDPC values lower than the mean.

Grey mold

Cultivars	Severity index	AUDPC
An131362	0	0,00
Dina	0	0,00
An122053	83,33	58,33
An142051	60,1	73,51
Victory	70,2	93,48
An151955	50	125,00
Exp129	74,4	130,65
Exp 645	72,3	181,36
Exp 121	49,2	201,25
An150753	45	265,00
An121358	33,3	266,67
An124553	83,3	325,00
An124460	183,5	358,04
An131355	75	375,00
Exp118	95	415,00
Fortuna	181,3	418,45
Exp801	164,3	464,29

The cultivars AN 12 13 58, AN 131362, AN 14 20 51, AN 15 07 53, AN 15 19 55, Dina and EXP 118; showed severity indexes lower than the mean.

The cultivars AN 12 20 53, AN 131362, AN 14 20 51, AN 15 19 55, Dina, EXP 129 and Victory have AUDPC values lower than the mean.

- The expansion of the disease on the plant does not imply its severity for Botrytis.
- The disease severity depends on the defense mechanisms and characteristics of each cultivar.
- The cultivars with lowest severity indexes have **potential for breeding for fungal resistance**:

Powdery mildew

AN 13 13 55 ; AN 12 45 53; AN 15 19 55 ; EXP 801 ; EXP 129 ; EXP 645

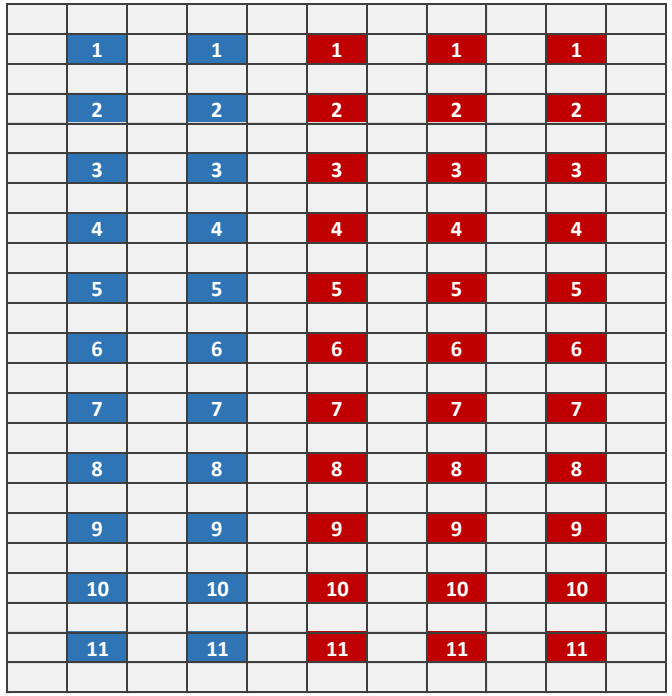
Grey mold

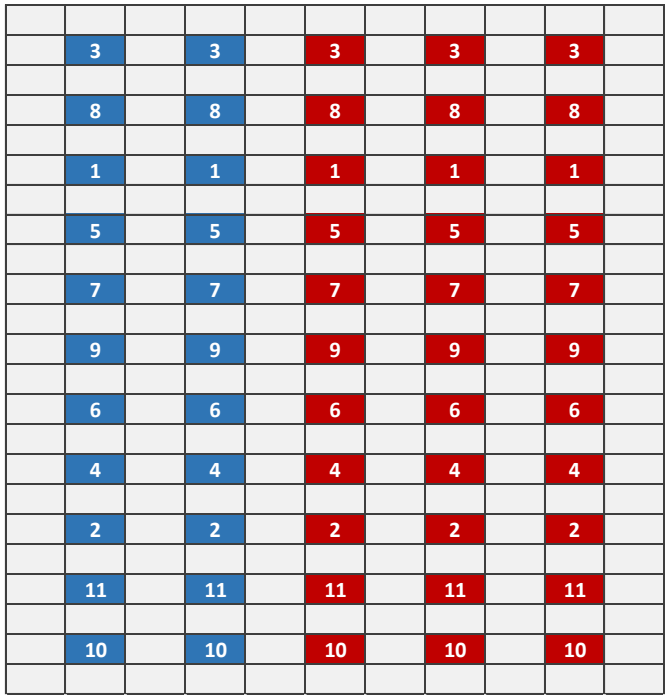
AN 13 13 62 ; Dina ; AN 15 07 53 ; AN 12 13 58 ; EXP 121 ; AN 15 19 55

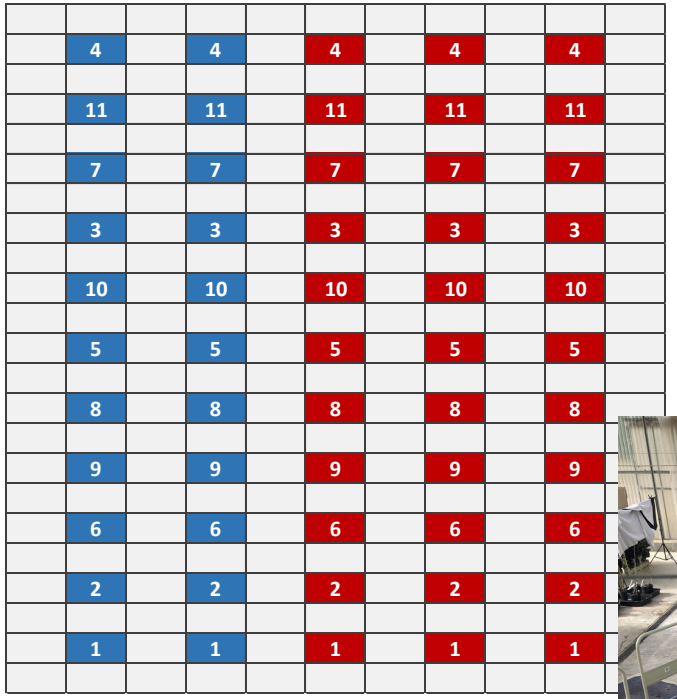
Drought stress trial

- Tested plants: *Fragaria x ananassa* (11 genotypes)
- Cultivation system: soilless with pot 3.8L
- Substrate compositiion: “Kaper Substrato Profesional”, perlite “Projar Perlita Expandida”, generical gravel (pF1 waterl volume≈44%)

- Location: Centro IFAPA de Málaga, Spain
- Experimental timing: March2023-April 2023
- Objective: finding a reliable phisiological parameter detecting the plant’s stress point caused by drought condition





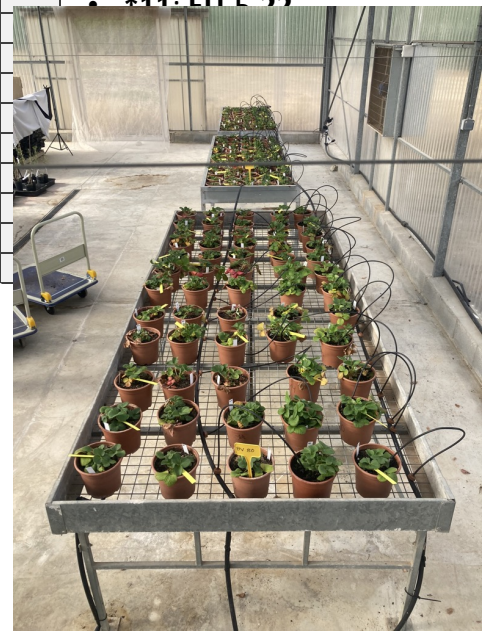


- **1**: **Selva**
- **2**: **Madame Moutot**
- **3**: **Fortuna**
- **4**: **Aïberry**
- ***5**: **EU-4-22**
- **6**: **Candonga**
- ***7**: **CS-9-2**
- **8**: **EU-4-18**
- **9**: **Rociera**
- **10**: **San Andreas**
- ***11**: **EU-5-22**

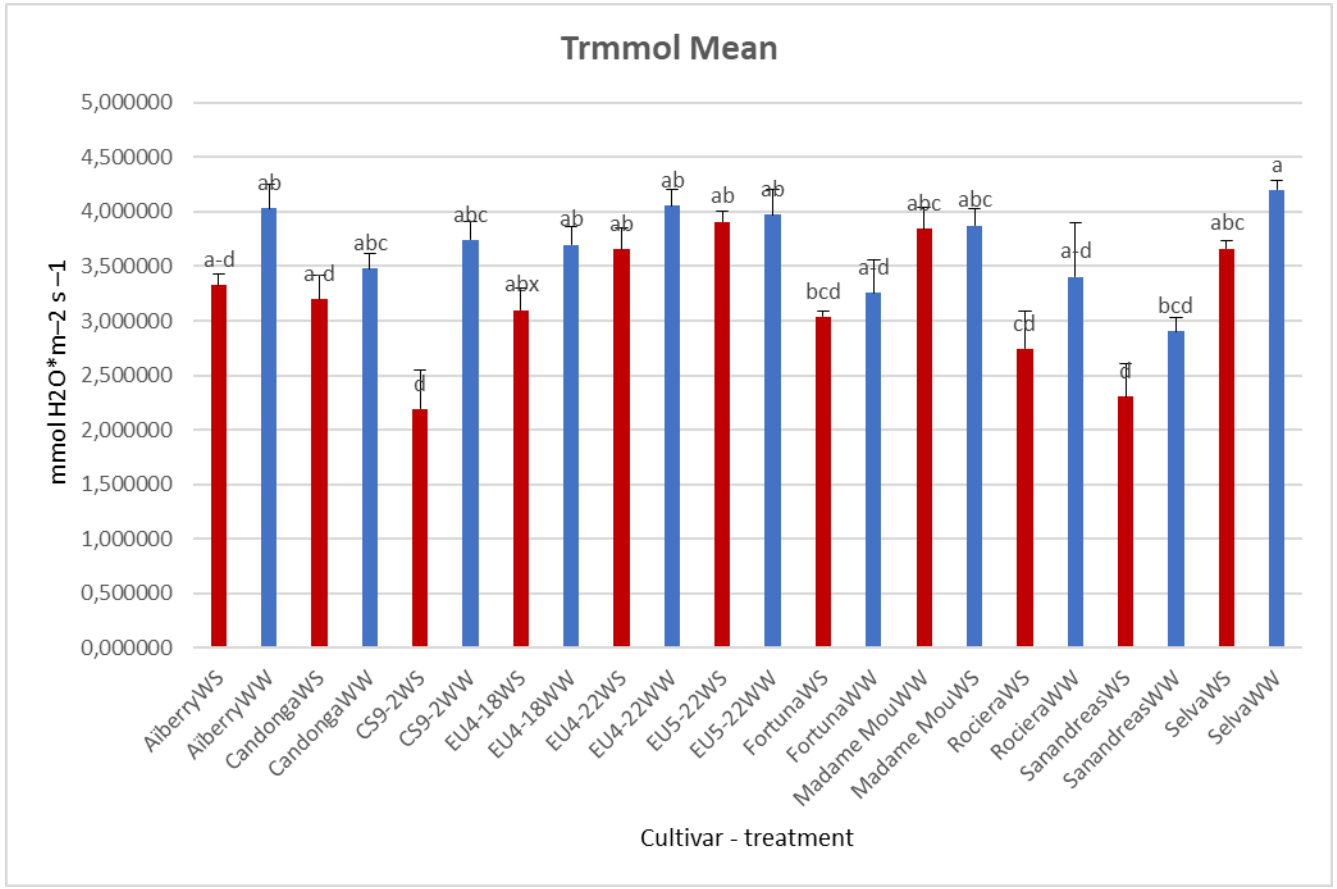
Water control (100% of pot water content volume)

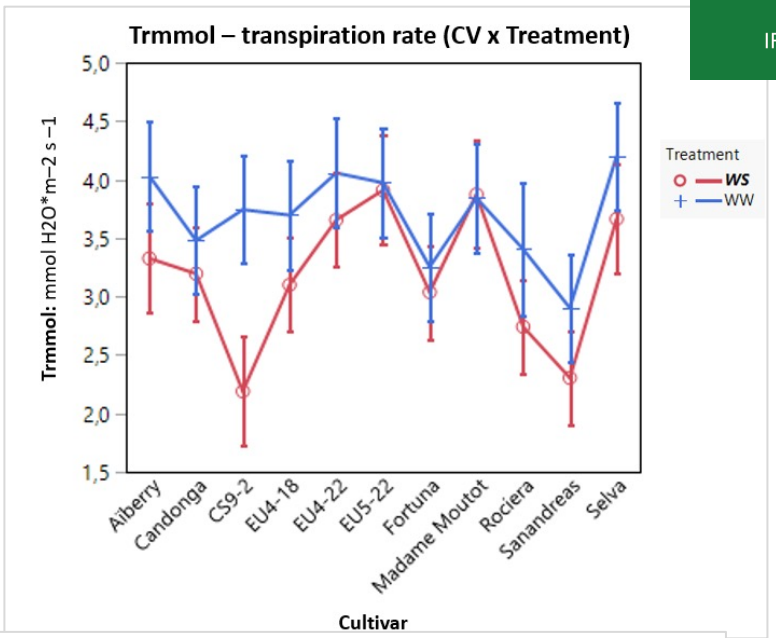
Water stress (37% of pot water content volume)

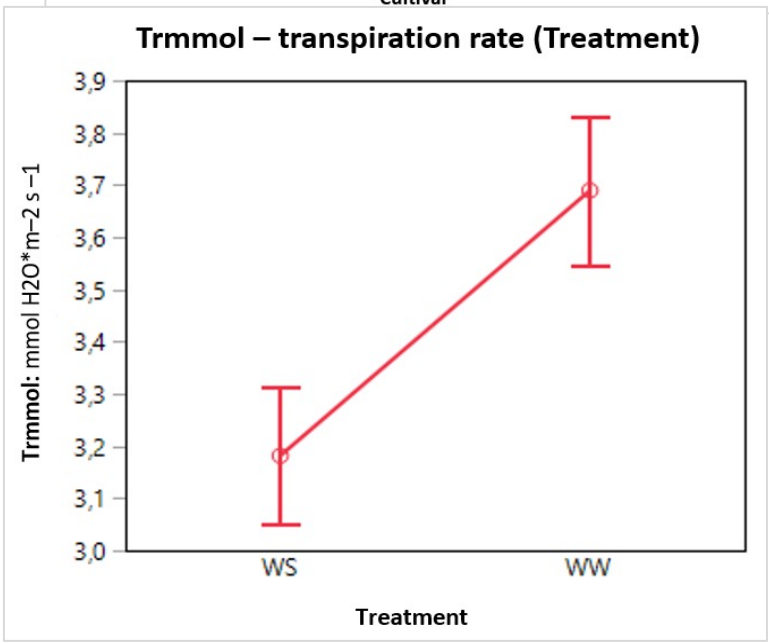
*EU-4-22: (Candonga x CS13/2)
*CS9-2: (F.chiloensis (277) x Ventana)
*EU-5-22: (Fuentepina x CS13/2)



Evapotranspiration rate

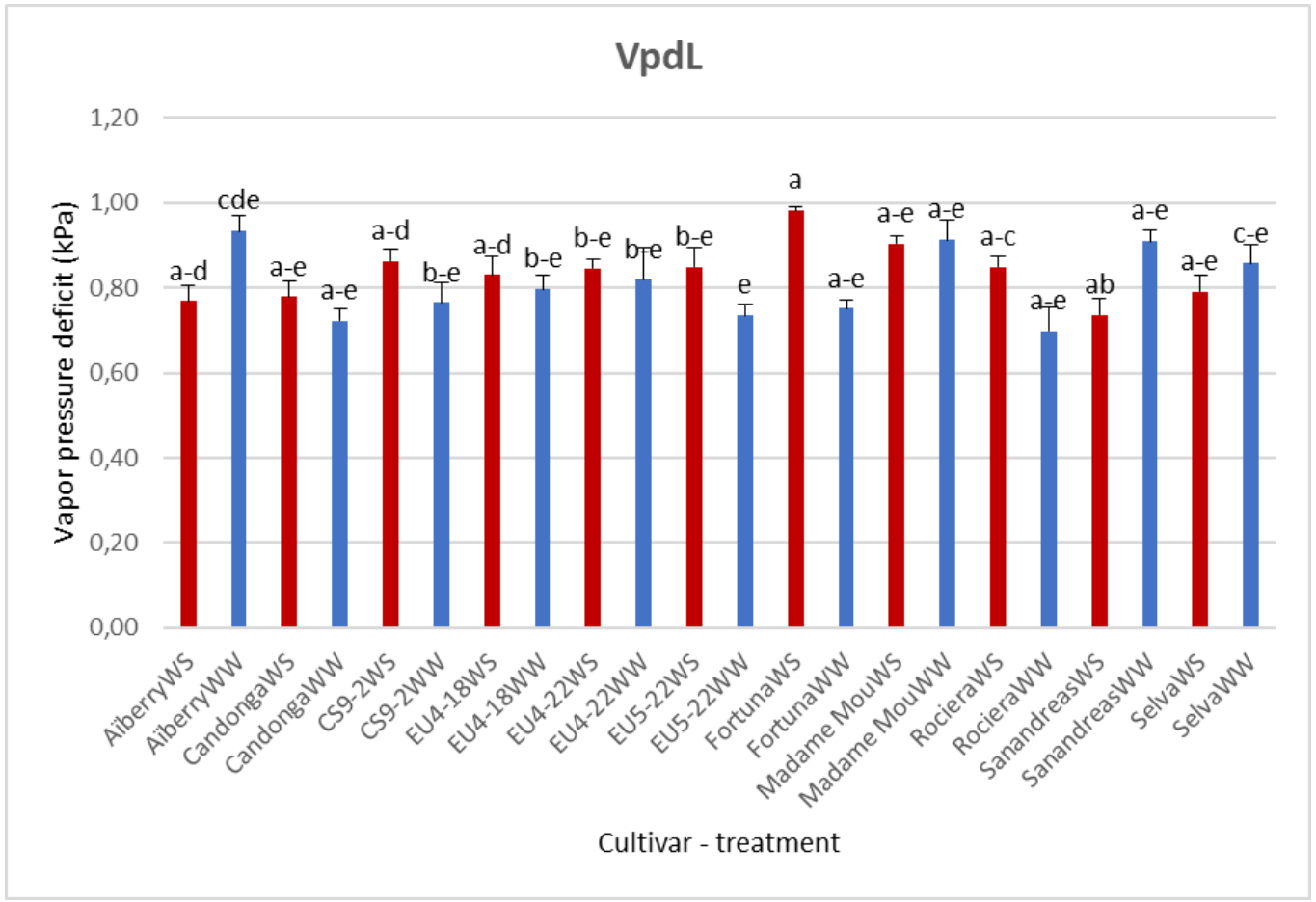


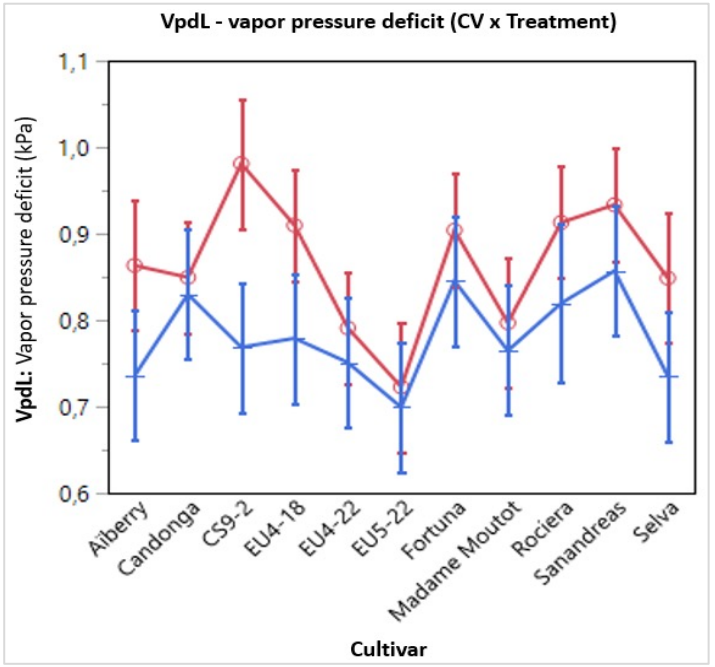


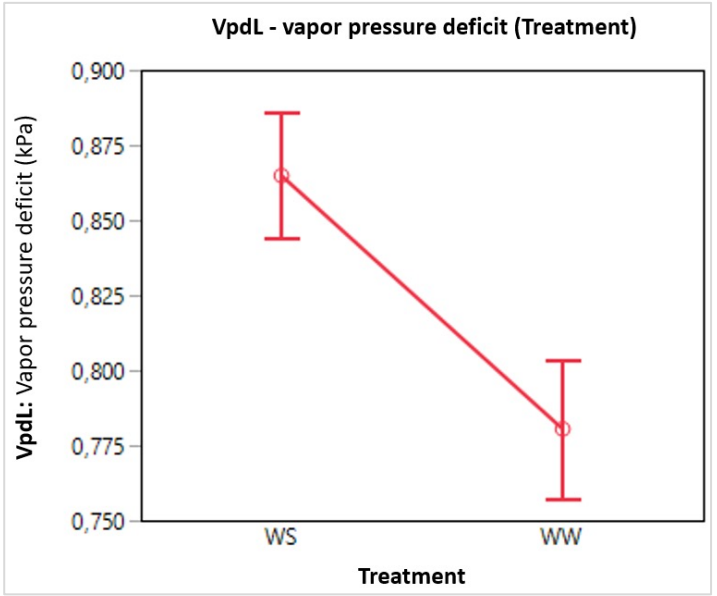


- The WW plants showed a higher evapotranspiration rate (3,69 mmol*m-2s-1) compared to WS plants (3,18 mmol*m-2s-1)

Vapor pressure deficit







- The WS plants showed a higher vapor pressure deficit (0,866 kPa) compared to WW plants (0,780 kPa)

TO ORGANIZE THE LABORATORY – FIELD NURSERY PRODUCTION: EXAMPLE OF STRAWBERRY

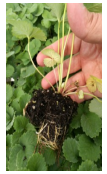
No-low chilling requirement

Nursery production system for plug plants

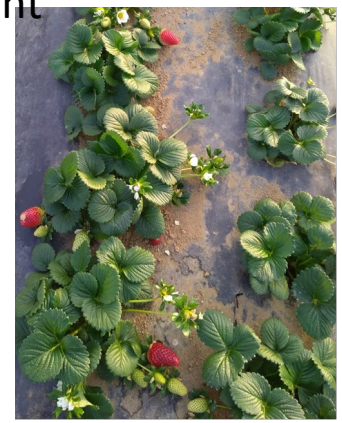
For cultivation in mild climate conditions – highest sanitary quality – good production, it can be anticipated, high yield and fruit quality, for longer period.

To posticipate the plantation.

Micropropagation mother plants



Plug plants production



Plantation, growth, harvest

june	july	augu	septe	octo	nove	dece	janua	febru	marc	april	may	june	july	augu	septe	octo	nove	dece	janua	febru	marc	april	may

Nursery production system for bare-root/fresh plants or tips for cultivation in mild climate conditions – high sanitary quality – good production, high yield and fruit quality, for longer periods. To anticipate the plantation.

Open field nursery in colder areas, to provide some cold

Micropropagation mother plants

Bare root plants/tips

Plantation, growth, harvest

june	july	augu	septe	octo	nove	dece	janua	febru	marc	april	may	june	july	augu	septe	octo	nove	dece	janua	febru	marc	april	may


The future is to compare strawberry fruit produced under different farm managements, thus
OPEN FIELD
GREENHOUSE
SOILLESS

OPPORTUNITIES FROM NEW CULTIVATION SYSTEMS

There are two categories of soilles farming, based on the growing media used

Aerated nutrien solution

Aquaponics

- Integrated production of plants and fish in a water recirculating system via a biofilter with nitrifying bacteria,
- Natural ecosystem in which fish and bacteria produce the perfect fertilizer for plant cultivation,
- Producing a large quantity of food in an extremely small space.

Aeroponics

- Process of growing plants in air, sustained by a support structure,
- Plants are fed by spraying the plant's dangling roots and lower stem with an atomized or sprayed, nutrient-rich water solution,
- Reduces the spread of pathogens and pesticide and herbicides usage, saves the use of water,
- Nutrient solution could be recycled easily for reuse.

Hydroponics

- Plants grows by exposing their roots directly to a nutrient-rich water solution,
- Use a range of inert medias to support the plants' roots,
- Eliminate the thread of pests as without soil there isn't the environment in which to host them,
- Closed loop systems with the recycling of the nutrients

Soilless substrate culture

- Agriculture out of the soil,
- When there is no appropriate land,
- Problems associated with soilborne pathogens and salinity of the soil can be solved,
- There are many types of media available, and each has unique physical and chemical properties.

Organic substrate:

Rice husk, cononut coir, peat, bark…

Inorganic substrate:

Perlite, clay, rockwool, vermiculite…

Conclusions: use Life Cycle Assessment (LCA) to measure sustainability of:

- New cultivars
- New breeding material
- Cultivation systems: tunnel, open field, soilless, glass greenhouse.
- Different soil type, heights of bed, different fertigation solutions, etc...



For more information on the project: https://breedingvalue.eu/

Breeding Value @BreedingValue

I thank all the BreedingValue partners, collaborators and all of you for your attention.

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PERSPECTIVES

Towards smart and sustainable development of modern berry cultivars in Europe

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INTERNATIONAL AND NATIONAL PROJECTS

RESO: REsilience and SUSTAINABILITY of the fruit and vegetable and cereal supply chains to enhance the territories

BREEDINGVALUE: Pre-breeding strategies for obtaining new resilient and added value berries

Med-Berry PRIMA Project: Developing new strategies to protect strawberry crop in Mediterranean countries.

GOODBERRY: Improving the stability of high-quality traits of berry in different environments and cultivation systems for the benefit of European farmers and consumers

iPLANTA: Modifying plants to produce interfering RNA. 0C-2015-2-20281

MIUR-PRIN2017: Small RNAs and peptides for controlling diseases and development in horticultural plants 20173LBZM2,

MINISTERO DELL' ISTRUZIONE, DELL'UNIVERSITÀ E DELLA RICERCA

D3A – UPM RESEARCH GROUP

Prof. Mezzetti e Prof. Capocasa supervisors

Angela Ricci Research Grant

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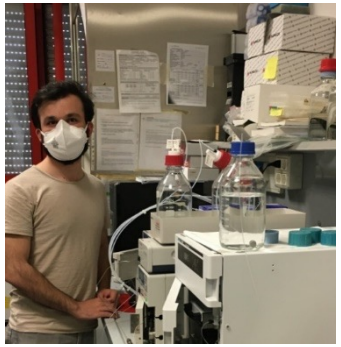

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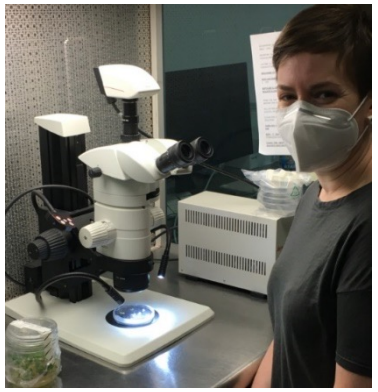

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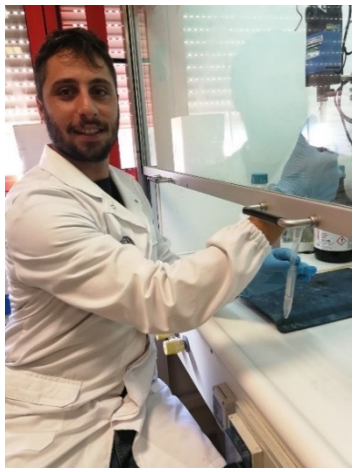

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