Training in organic breeding

Module 3: Breeding methods fundamentals

Unit 3.2: Common methods and strategies in organic breeding

Authors: Pedro Mendes Moreira (PUC-ESAC, PT), Adrian Rodríguez-Burruezo (UPV), Barbara Pipan (KIS)

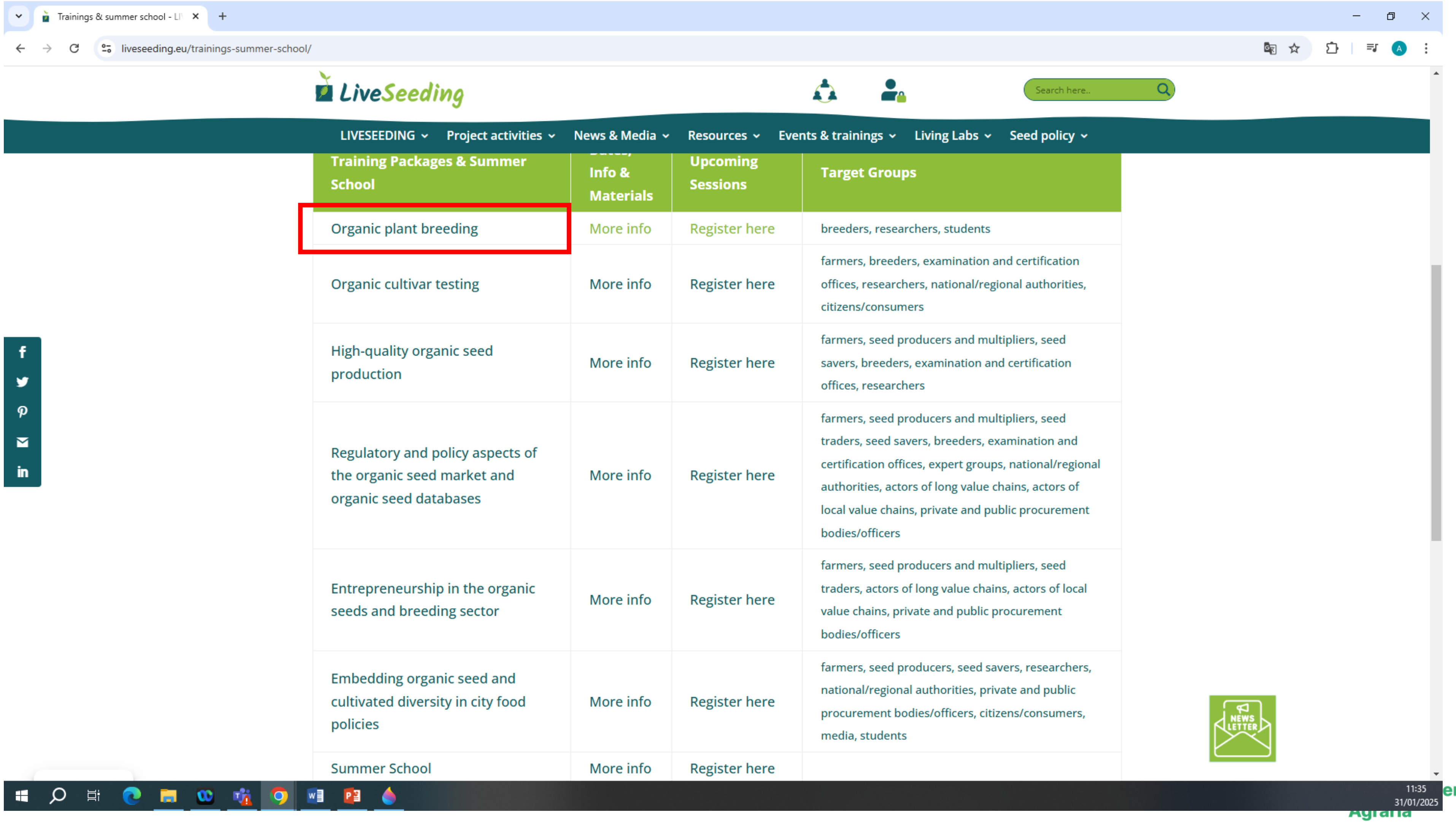
Co-funded by the European Union

Funded by the European Union, the Swiss State Secretariat for Education, Research and Innovation (SERI) and UK Research and Innovation (UKRI).

UK Research and Innovation

CONTEXT: Training in LIVESEEDING project

https://liveseeding.eu/trainings-summer-school/



Training Packages & Summer School	Info & Materials	Upcoming Sessions	Target Groups
Organic plant breeding	More info	Register here	breeders, researchers, students
Organic cultivar testing	More info	Register here	farmers, breeders, examination and certification offices, researchers, national/regional authorities, citizens/consumers
High-quality organic seed production	More info	Register here	farmers, seed producers and multipliers, seed savers, breeders, examination and certification offices, researchers
Regulatory and policy aspects of the organic seed market and organic seed databases	More info	Register here	farmers, seed producers and multipliers, seed traders, seed savers, breeders, examination and certification offices, expert groups, national/regional authorities, actors of long value chains, actors of local value chains, private and public procurement bodies/officers
Entrepreneurship in the organic seeds and breeding sector	More info	Register here	farmers, seed producers and multipliers, seed traders, actors of long value chains, actors of local value chains, private and public procurement bodies/officers
Embedding organic seed and cultivated diversity in city food policies	More info	Register here	farmers, seed producers, seed savers, researchers, national/regional authorities, private and public procurement bodies/officers, citizens/consumers, media, students
Summer School	More info	Register here	

Training in organic breeding organized in 5 Modules

1. **Module 1** - Plant Genetic Resources (PGRs): collection, conservation and exchange to support the increase of agrobiodiversity in farming systems
2. **Module 2 - Phenomics: approaches and tools for genetic resources and breeding material characterisation - FEBRUARY 3rd 2025, 9:00 to 17:30 CET**
3. **Module 3 - Breeding methods fundamentals - FEBRUARY 13th 2025, 9:00 to 18:00 CET**
4. **Module 4** - Development and application of molecular methods in organic breeding - MARCH 4th 2025, 9:00 to 18:00 CET
5. **Module 5** - Organic heterogeneous material (OHM) design and development - MARCH 7th 2025, 9:00 to 18:00 CET

LiveSeeding

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Module 3 – Breeding methods fundamentals

February 13th 2025 - 9:00 to 18:00 CET

Unit 3.1: Generation of new diversity

- 9:00-10:30 - UPV (Adrián Rodríguez-Burruezo, Neus Ortega Albero)
- 10:30-11:00 Break

Unit 3.2: Common methods and strategies in organic breeding

- 11:00-13:00 - IPC (Pedro Mendes Moreira) + UPV (Adrian Rodríguez-Burruezo) + KIS (Barbara Pipan)
- 13:00-14:30 Lunch Break

Unit 3.3: Calculation and evaluation of key breeding parameters

- 14:30-16:00 - UPV (Adrian Rodríguez-Burruezo) + KIS (Barbara Pipan)
- 16:00-16:30 Break

Unit 3.4: Fundamentals in Participatory Plant Breeding

- 16:30-18:00 - IPC (Pedro Mendes Moreira) + INRAe (Véronique Chable)

Planned for today

DYNAMIC MIXTURE OF:

1. *Presentations about main topics on **Common methods and strategies on organic breeding,** i.e. basics and practical examples on 3 crops (90 min):*
   - *Basics – A. Rodríguez-Burruezo (UPV, Spain)*
   - *Maize (allogamous) – Pedro Mendes Moreira (IPC, Portugal)*
   - *Beans (autogamous grain crop) – Barbara Pipan (KIS, Slovenia)*
1. Fast quiz (about 10-15 min) ***
2. Debate, Wrap up & Proposed homework (about 10-15 min) ***
3. QUESTIONS: THROUGH THE CHAT (Petra Jelincic will manage)

*** = IMPORTANT for CERTIFICATES (ALL THE UNITS!!!!)

SEND TO: pmm@esac.pt adrodbur@upv.es petra.jelincic@ips-konzalting.hr

Basics on methods and strategies. Fast review

REPRODUCTIVE SYSTEM defines the genetic structure of the populations.

- Autogamous equilibrium: homocigous (inbred lines mixtures)
- Allogamous equilibrium: mixtures of homocigous and heterozygous individuals (Hardy-Weinberg´s law)
- Vegetatively reproduced: clones (one variety can be a unique clone or a mixture of clones)

Implications on inbreeding depression: No problem in autogamous Quite usual in allogamous

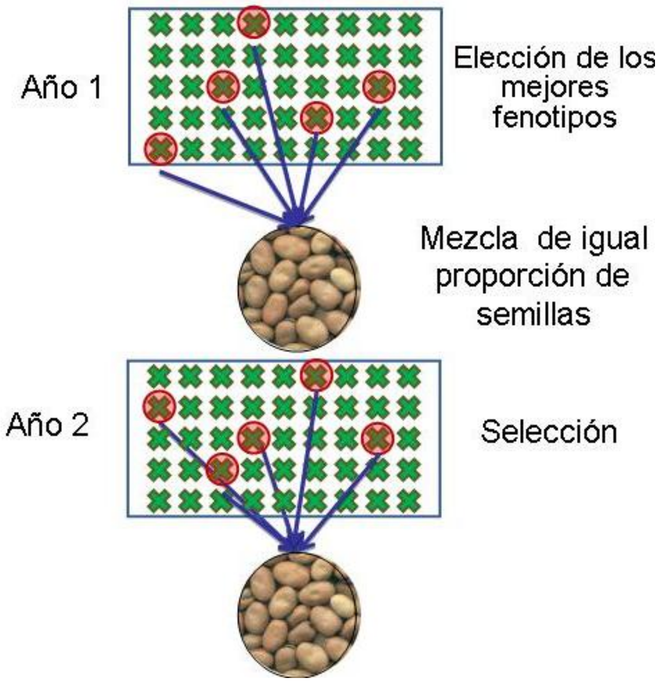
Self-compatibility: Usual in autogamous Difficulties in allogamous (different mechanisms)

Flower biology essential to decide the breeding method (in some cases, hybrids are not economically viable)

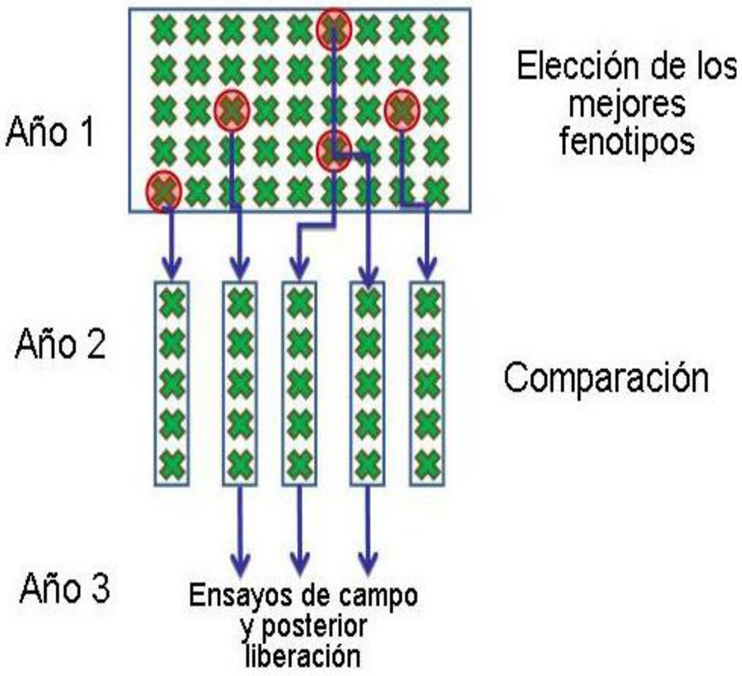
Basics on methods and strategies. Fast review

When the starting population is heterogeneous

Mass selection



Individual selection

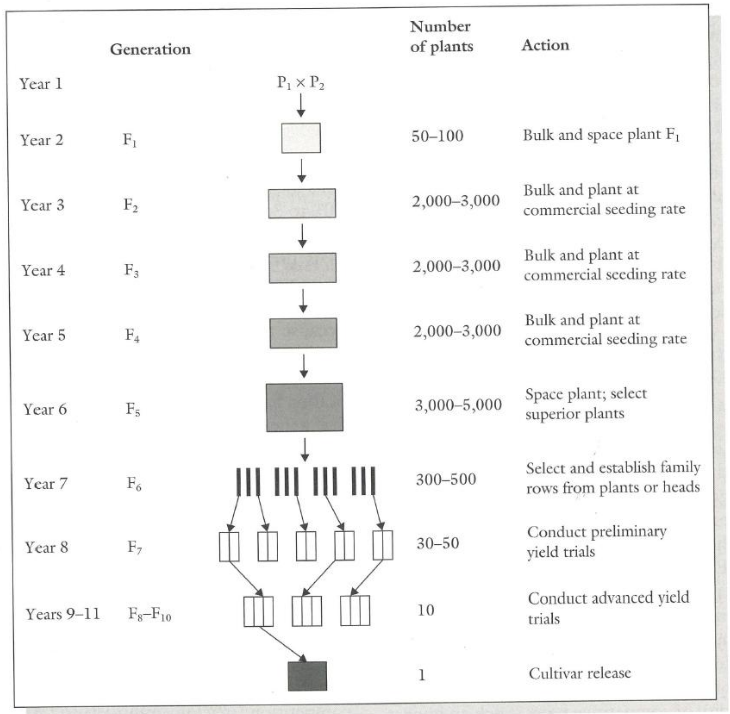


M3 – U2 Common methods and strategies in organic breeding

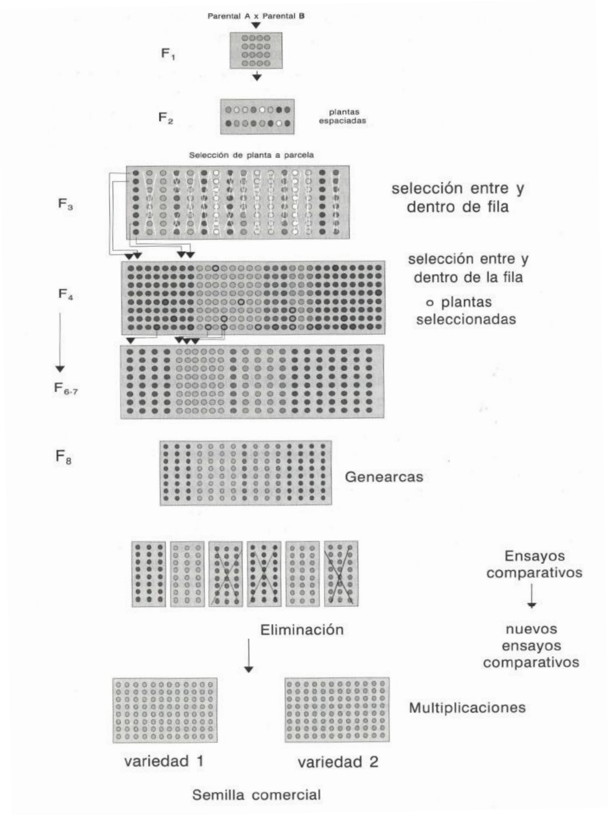
Basics on methods and strategies. Fast review

Creating diversity at the beginning by hybridization

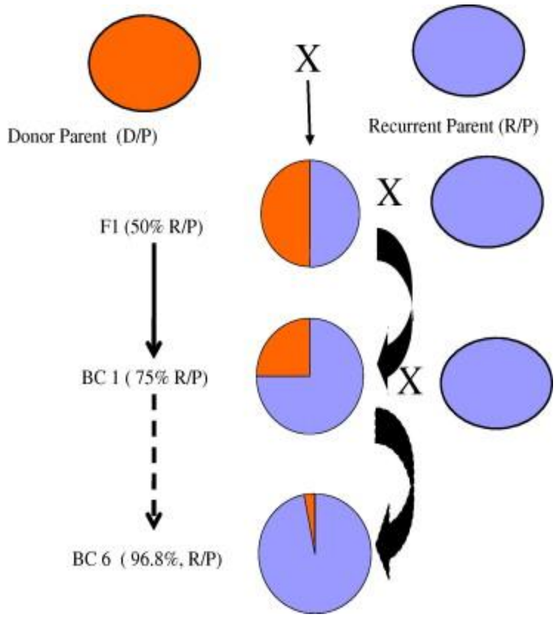
Mass selection



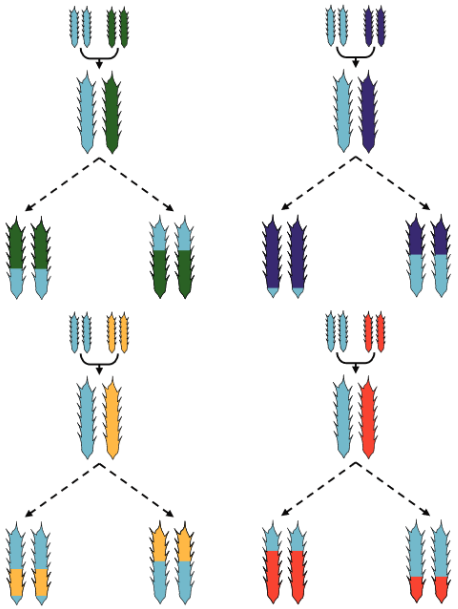
Pedigree method



Backcross method



CCPs



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Basics on methods and strategies. Fast review

As said…. The reproductive system determines the most accurate breeding method

In autogamous no problem on using selfing profusely

In allogamous selfings are limited

Practical example: Maize (allogamous crop)

Pedro Mendes Moreira (IPC, Portugal)

Module 3 - Breeding methods fundamentals – Allogamic species

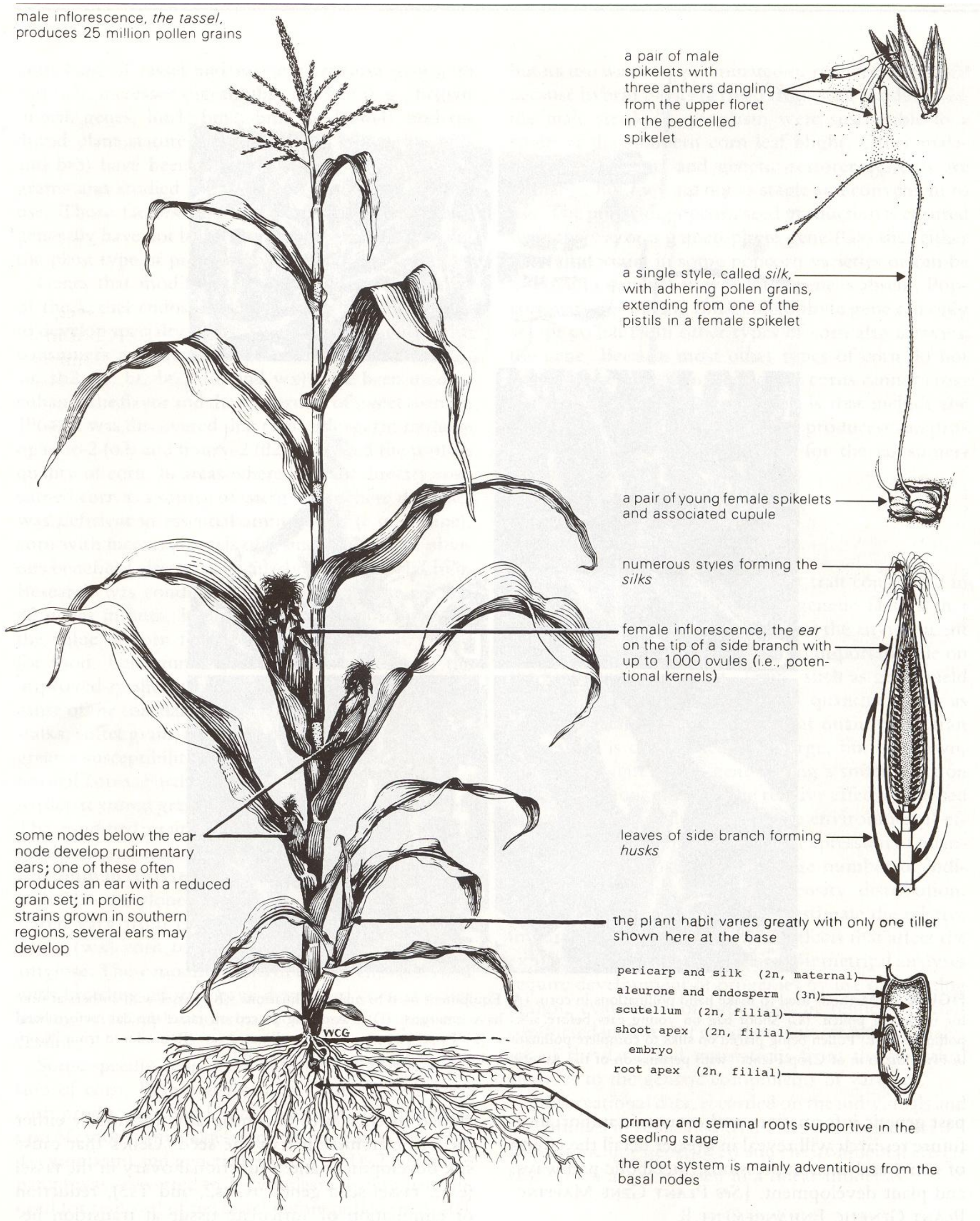
Allogamic plants = allogamous or cross-pollinating plants

Species that primarily reproduce through **cross-fertilization** rather than self-fertilization. This reproductive strategy is characterized by the **exchange of genetic material between different individuals**, which **enhances genetic diversity within populations**.

The genetic variability resulting from allogamous reproduction is crucial for the **adaptability and resilience** of plant species in changing environments.

Some facts that we need to know about the plant we are working in

male inflorescence, the **tassel**, produces **25 million pollen grains**
a pair of male spikelets with three anthers dangling from the upper floret in the pedicelled spikelet
a single style, called silk, with adhering pollen grains, extending from one of the pistils in a female spikelet
a pair of young female spikelets and associated cupule
numerous styles forming the silks
female inflorescence, the ear on the tip of a side branch with up to 1000 ovules (i.e., potentional kernels)
Leaves of side branch forming husks



Morphology of maize

FIGURE 1 Morphology of the corn plant showing the physical structure of the corn plant and the placement of the male (tassel) and female (silk) flowers. (Drawing was by Walter G. Galinat and reproduced with his permission).

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Some facts that we need to know about the plant we are working in - Morphology of maize

The plant habit varies greatly with only one tiller shown here at the base
pericarp and silk (2n, maternal aleurone and endosperm (3n)
scutellum (2n, filial).
shoot apex (2n, filial)
embryo root apex (2n, filial)

some nodes below the ear node develop rudimentary ears; one of these often produces an ear with a reduced grain set; in prolific strains grown in southern regions, several ears may develop

primary and seminal roots supportive in the seedling stage
the root system is mainly adventitious from the basal nodes
FIGURE 1. plant showing the physical structure of the corn plant and the placement of the male (tassel) female (silk) flowers. (Drawing was by Walter G. Galinat).

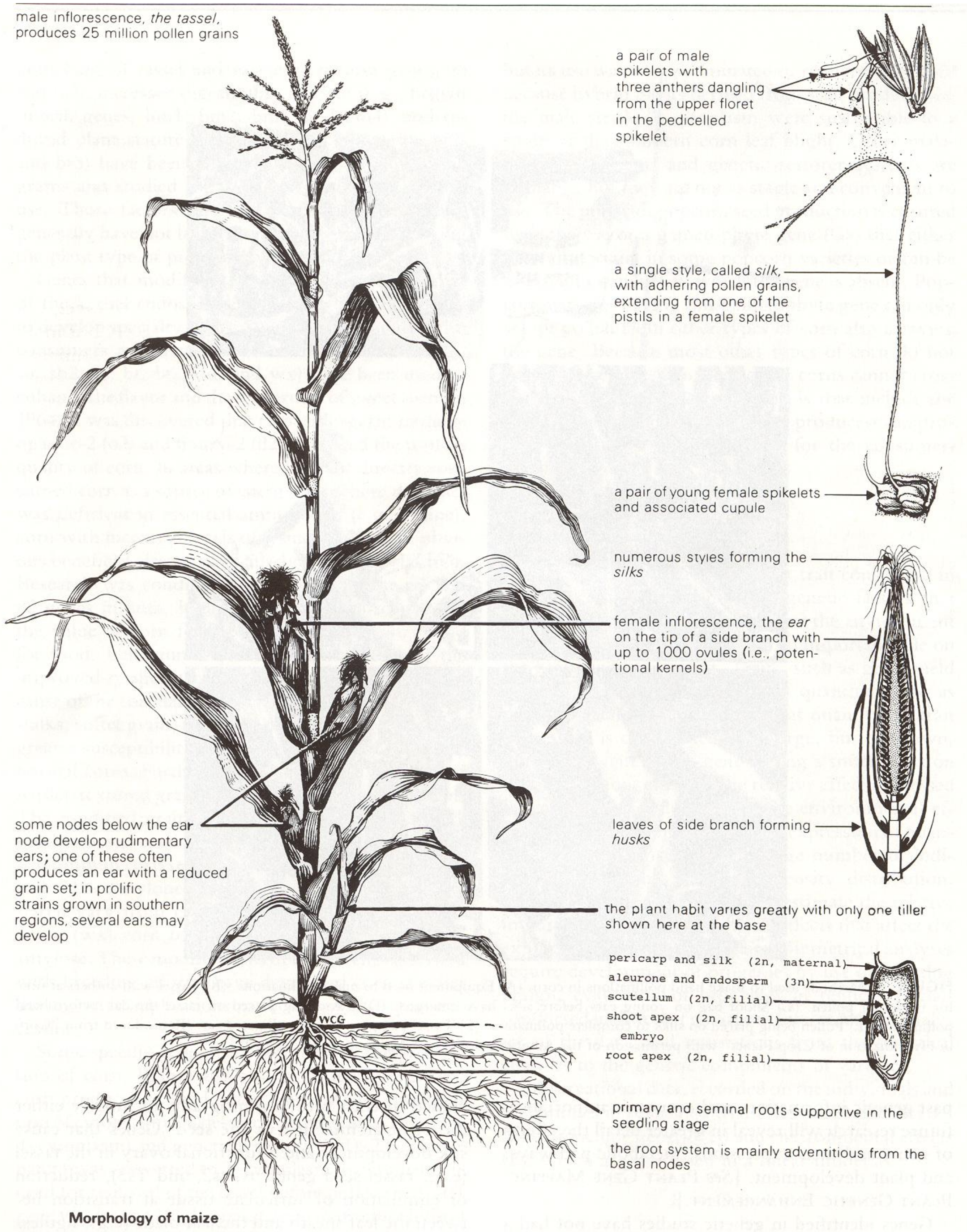

FIGURE 1 Morphology of the corn plant showing the physical structure of the corn plant and the placement of the male (tassel) and female (silk) flowers. (Drawing was by Walter G. Galinat and reproduced with his permission).

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Flowering implications

Flowering allows us to know and classify the type of cycle. Early or late?

The homogeneity of the population

Studying possible diallel. Do we need to sow on separate dates?

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Stratified mass selection trials

On-farm trials

Selection

- Farmer' germplasm
- Given germplasm

Varieties

- Germplasm
- Cycles of selection

The ABC of phenotypic recurrent selection

Two parental control mass selection:

in the field

- before pollen shedding

- before harvesting

- at the storing facilities

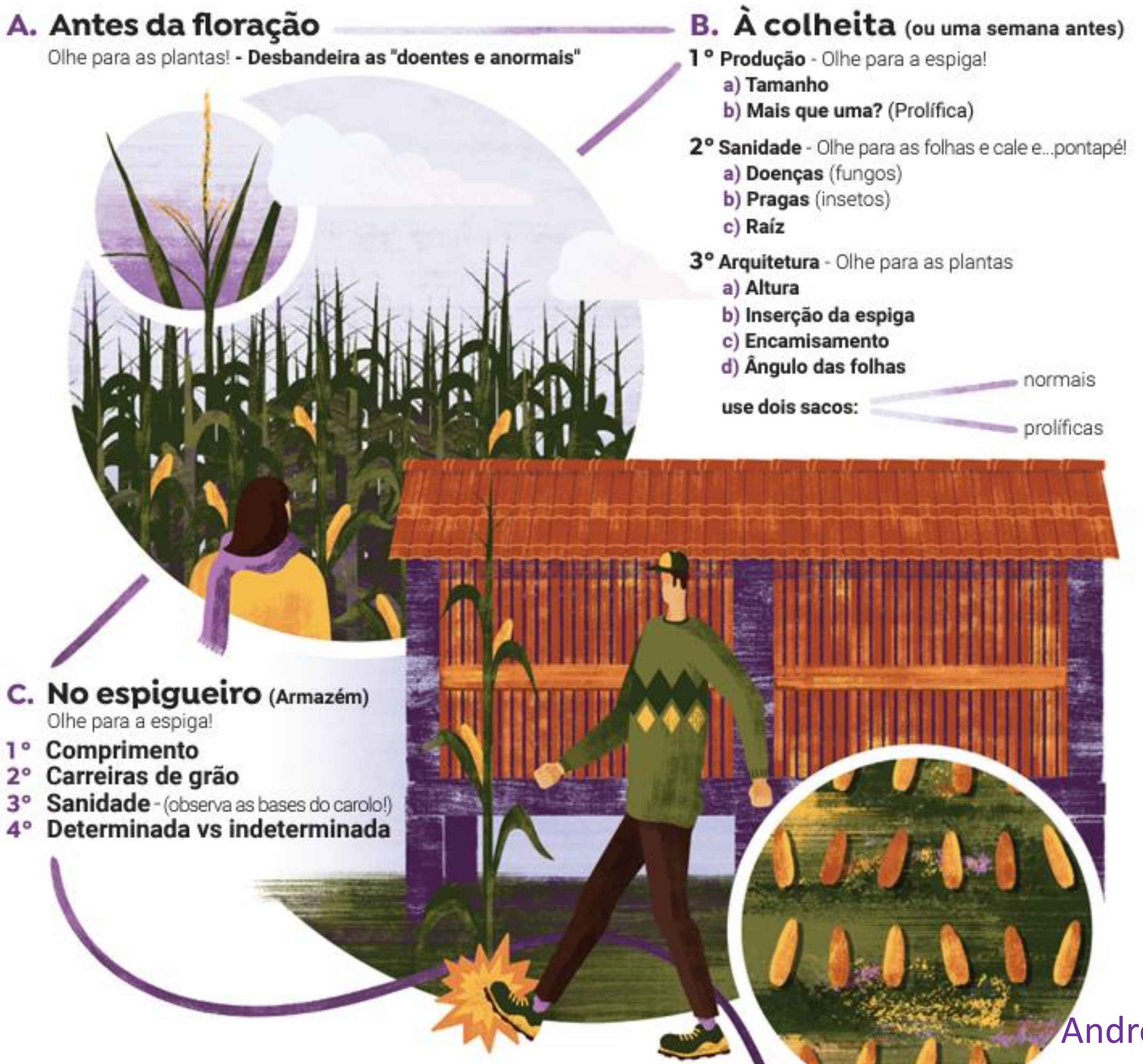


Figura 3. Esquema de duas seleções de controle parental no campo, Fase A e B ao que se segue a Fase C no espigueiro ou armazém.

André Barata

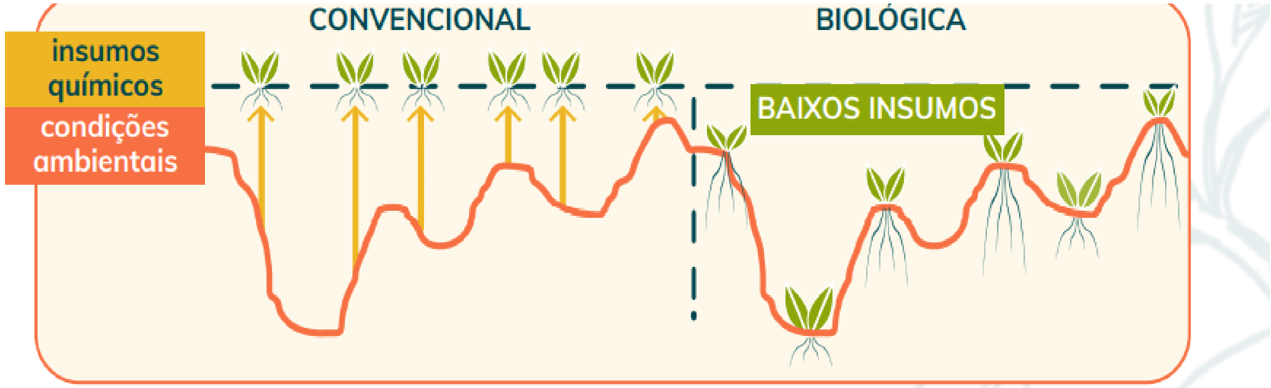
LiveSeeding

What context and requests?

What is stratified selection?

What traits did you define to target?(e.g. Ear height, stand)

Bordadura	Bordadura	Bordadura	Bordadura	**Bordadura**
Bordadura	Var 1	Var 2	Var 3	**Bordadura**
Bordadura	Var2	Var4	Var5	**Bordadura**
Bordadura	Var 3	Var 5	Var 1	**Bordadura**
Bordadura	Var 4	Var 3	Var 4	**Bordadura**
Bordadura	Var 5	Var 1	Var 2	**Bordadura**
Bordadura	**Bordadura**	**Bordadura**	**Bordadura**	**Bordadura**



LiveSeeding

Trials


Monção
Viana do Castelo
Ponte de Lima
Chaves
Bragança
Braga
Vila Nova de Famalicão
Amarante
Mogadouro
Vimioso
Porto
Paredes
Santa Maria Da Feira
Viseu
Aveiro
Guarda
Águeda
Tondela
Ciudad Rodrigo
Coimbra
Covilhã
Figueira da Foz
Pombal
Coria
Castelo Branco
Leiria
Alcobaça
Torres Novas
Abrantes
Cáceres
Rio Maior
Torres Vedras
Santarém
Alenquer
Mérida
Loures
Montijo
Elvas
Badajoz
Lisboa
Almendralejo
Setúbal
Évora
Zafra
Santiago do Cacém
Beja
Sines
Ourique
Odemira
Portimão
Loulé
Tavira
Huelva
Vila do Bispo
Lagos
Albufeira
Faro
Sanlúcar de Barrameda
Cádiz
E805
E802
IP4
IP5
E806
E802
E-803
IP2
E90
E1
IP1
E-1
E-803
100 km
50 mi

On-station

- On-station trials
  - New combinations
    - Crosses
    - Diallel
    - Dinamic populations
  - Selection (stratified)
    - Populations, synthetics
    - Recurrent selection by S1 or S2
    - Dinamic populations
  - Variety
    - Germplasm
    - Cycles of selection
  - Maintenance
    - Inbreeds
    - Populations

Preparation for Polinations






Pollinations


63
30-7

Story of a synthetic population,

76 yellow elite inbred lines (dent and flint; 20% Portuguese and 80% North American

1	2		76
76	…	2	1

“NUTICA” – 1975-78

1983 - North Carolina Design 1 matting design (1 male crossed with 5 females)

‘Fandango’- on farm introduction and mass selection until today

And other Populations

Maydica 54 (2009): 269-285

‘FANDANGO’: LONG TERM ADAPTATION OF EXOTIC GERMPLASM TO A PORTUGUESE ON-FARM-CONSERVATION AND BREEDING PROJECT

P.M.M. Mendes-Moreira[1,2,9,*], M.C. Vaz Patto[2,9], M. Mota[3], J. Mendes-Moreira[4,5], J.P.N. Santos[1], J.P.P. Santos[1], E. Andrade[6], A.R. Hallauer[7], S.E. Pego[8,9]

[1] *Escola Superior Agrária de Coimbra, Departamento de Fitotecnia, Sector de Protecção Vegetal, Portugal*
[2] *Instituto de Tecnologia Química e Biológica, Universidade Nova de Lisboa, Portugal*
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[7] *Faculty of Agronomy, Iowa State University, Ames, IA 50010, USA*
[8] *Fundação Bomfim. Rua da Boavista, 152-154, 4700-416 Braga, Portugal*
[9] *Zea+, Portugal*

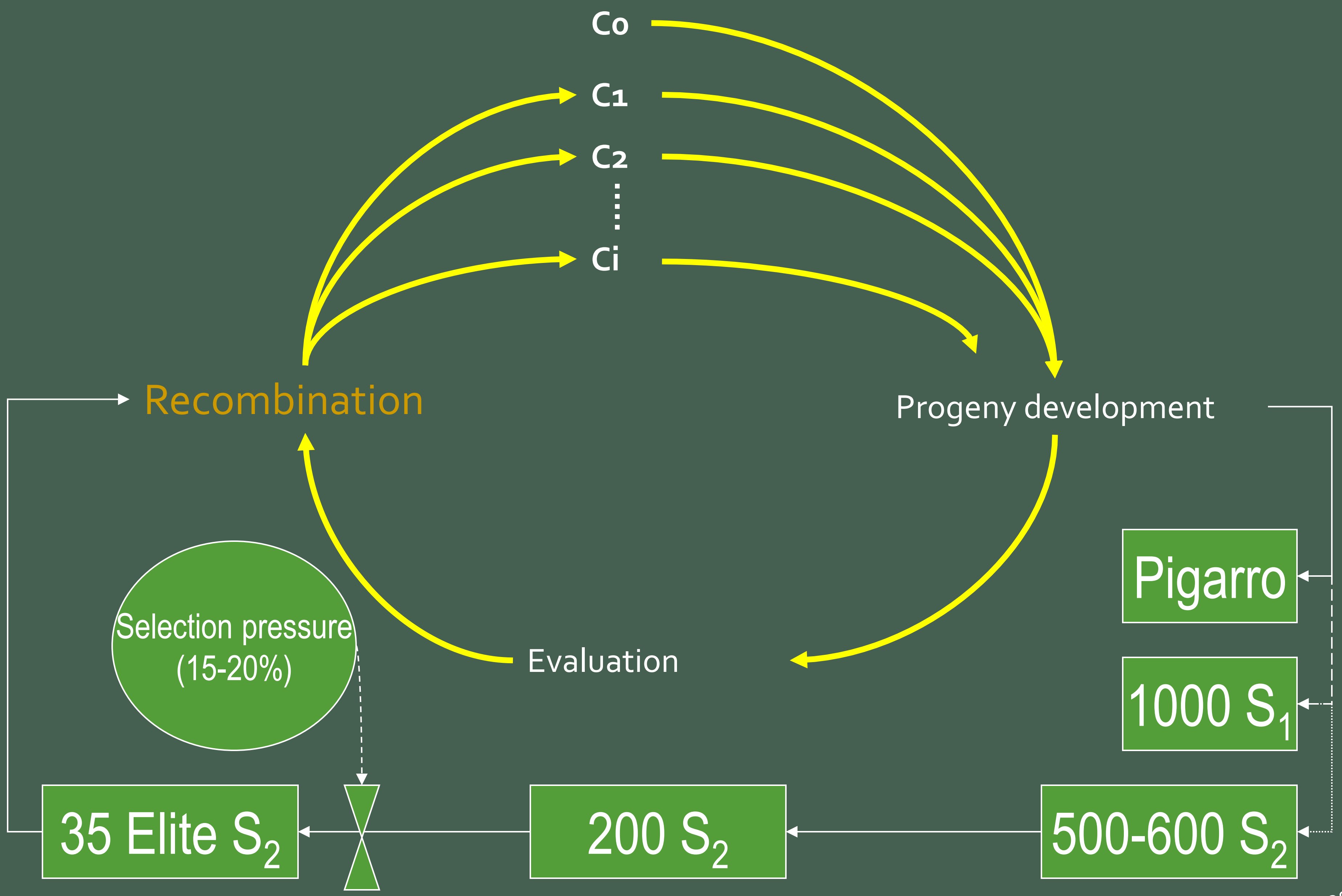
Received July 6, 2009

ABSTRACT - Climatic change emphasize the importance

across cycles was done by the breeder (until cycle 5) and

Mendes-Moreira, P. M. M., Patto, M. V., Mota, M., Moreira, J. P. C. L. M., Santos, J. P. N., Santos, J. P. P., ... & Pego, S. E. (2009). " Fandango": long term adaptation of exotic germplasm to a Portuguese on-farm-conservation and breeding project.

POPULATION Co (SELECTION BY S_2 LINES) PIGARRO



Our varieties are Irreverent!

In this photo you can see mostly hybrid maize and below our traditional varieties that have different vegetation habits.

Module 3 - Breeding methods fundamentals

Broad diversity? Prebreeding Work

The HUNTERS (**H**ight, **U**niformity, a**N**gle, **T**assel, **E**ar, **R**oot lodging and **S**talk lodging) analysis was developed as a method of evaluation

1–9 scale (1: very low, 2: very low to low, 3: low, 4: low to intermedium, 5: intermedium, 6: intermedium to high, 7: high, 8: high to very high and 9: very high) defining an average value per plot (Vaz Patto et al., 2007; Mendes Moreira et al., 2008)

H: Plant high (m) from the stalk basis to the last leaf insertion before the tassel.

U: Uniformity, complementary to diversity, where 1 is the minimum of uniformity and 9 the maximum. In general 1–4 applies to populations and 5–9 to inbreeds.

N: Angle of the adaxial side of the leaf above the ear with the stalk. <5 - angles inferior to 45º and >5, angles higher than 45 . Five = 45 angle.

T: Tassel branching. One - almost absent tassel common in inbreeds and hybrids, and 9 a very branched tassel, frequent in populations with abnormal fasciated ears.

E: Ear location. Five indicates that the ear is located in the middle of the plant.

R: Root lodging. It indicates the percentage of lodged plants and is related with the quality of the root system.

S: Stalk lodging. Percentage of broken plants. Is normally related with the quality of the stalk and the stalk damage caused by some insect attack.

Module 3 - Breeding methods fundamentals

Yes! We can easily connect this traits with SEEEDLINKED

Practical example: Common bean (autogamous crop)

Barbara Pipan (KIS, Slovenia)

Common bean (*Phaseolus vulgaris* L.)

- Is one of the **most important edible legumes** for direct human consumption in the world, as it is a valuable source of **protein, carbohydrates, fibre** and is a rich source of other components with nutritional and health benefits.
- For the Slovenian production area, **common bean is known as a vegetable** of increasing agronomic interest.
- In the past, **four different varieties** of common bean (*Zorin, Klemen, Jabelski pisanec, Jabelski stročnik*) were developed at KIS using **individual selection** procedures from **autochthonous populations.**
- In the last decade we started with **hand cross-pollination** of dwarf and climbing bean for both dry bean and fresh pod consumption.

- *Recently, we are introducing the organic breeding as well in parallel with conventional breeding*

LiveSeeding

Plant breeding and ideotype

- **Plant breeding is the science and art of improving plants to produce desired traits.**
- This involves selecting plants with favorable characteristics and breeding them to enhance qualities such as yield, disease resistance, drought tolerance, and nutritional value.
- The **goal is to develop new plant varieties** that are more productive, resilient, and beneficial for agriculture and horticulture.

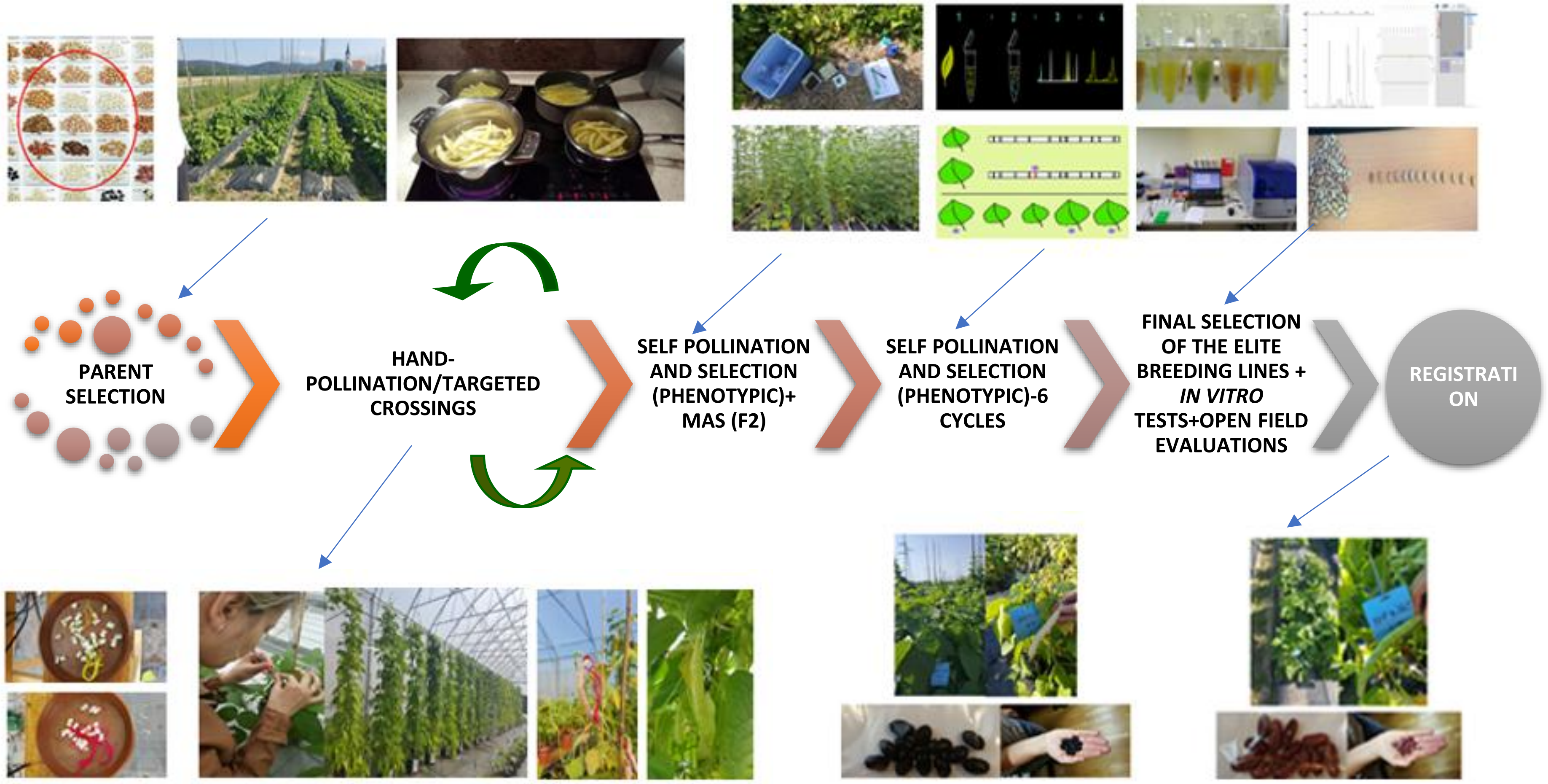
- An **<u>ideotype</u>** refers to an **idealized model of a plant** that possesses a combination of traits aimed at achieving maximum yield and quality within a specific environment. This concept was first introduced by *Donald in 1968.*

- When breeding plants, the goal is to develop new varieties with desirable characteristics. **An ideotype serves as a blueprint for these characteristics, guiding breeders in selecting and combining traits.**
- By targeting these traits, breeders can create plants that are more efficient in utilizing resources and better suited to their growing conditions.

Breeding objectives

- **Tolerant to biotic** (BMMV/BCMNV, CBB, Anthracnose, bruchid) and **abiotic** (high T, water) **stresses**.
- **Earliness** (flowering before high temperatures occur and induce flower shedding).
- Tending to develop new **„maslenec“** type of varieties-> forms <u>yellow</u>/green, long, flat and stringless pods (for climbing types).
- The **favourable position of the pods on the plant** (for dwarf types).
- **High-yielding** varieties.
- **Favourable nutritional composition** (↑proteins, Fe, Zn…; ↓phytic acid).

Breeding workflow



LiveSeeding

Identification of the parental breeding lines and hand pollination

•Available germplasm

•Characterisation and evaluation of the common bean germplasm on different complementary levels /phenomics:

<u>phenotypic</u>: UPOV, CPVO, IBPGR, Phaselieu, internal

<u>genetics and genomics data</u>: DNA markers, SNPs -> trait-associated

<u>tanscroptomics, metabolomics</u>: associated with secondary metaboloites, nutritional characteristsics

<u>general agronomic performance</u>

•Superior parental lines, with desired traits that we want to transfer on progenies via targeted hand –pollination with regards on the breeding objectives.

•Hand cross pollination of superior parental genotypes as described by Ivančič (2002).

•Every morning during flowering period of parental genotypes from June until the end of July under protected conditions.

•Each maternal plant was manually cross pollinated with different paternal genotypes.

Self-pollination, phenotypic selection, MAS and final selection

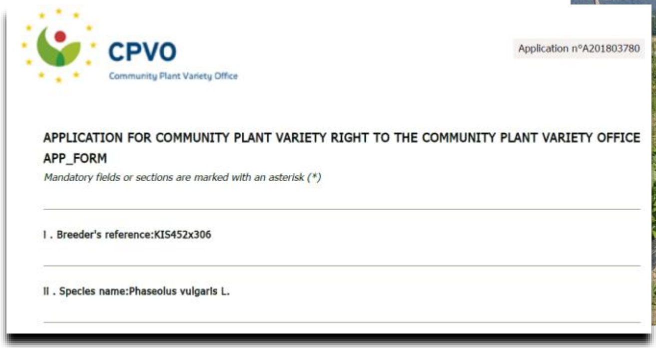
- ❑ **Under protected conditions, from F1 to F6.**
- ❑ **Self-pollination and phenotypic selection regarding breeding objectives.**
- ❑ **MAS** in F2 (a panel of 24 trait-related functional DNA markers).
- ❑ **Biochemical and nutritional quality assessments** (F6) for amino acids, macro/micro elements, fibers, fatty acids, phytic acid, proteins, TI content and activity, sugars (pods)…
- ❑ **Organoleptic traits.**

Selection of the elite breeding lines for open field performance and *in vitro* tests.

LiveSeeding

Open-field performance, in vitro tests and registration

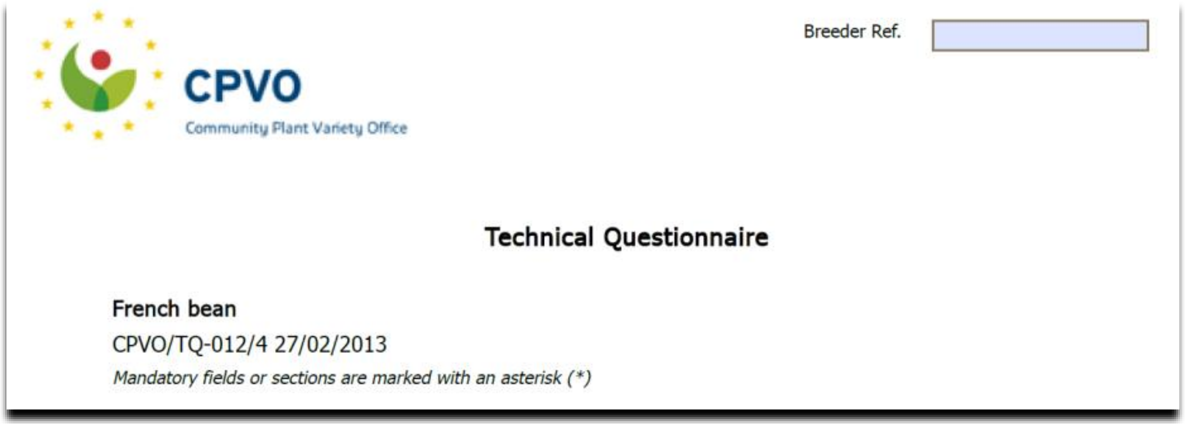
- **Randomised blocks**, 3 rep., along with standard varieties /different locations
- ***In vitro* tests** for susceptibility to BCMNV, *Colletotrichum lindemuthianum* and *Pseudomonas phaseoli*
- ***Final selection***
- ***Seed quality testing*** *(ISTA accredited lab)*
- ***Submission to CPVO*** *technical protocol:* CPVO/TQ-012/4.


CPVO
Community Plant Variety Office
Application n°A201803780

APPLICATION FOR COMMUNITY PLANT VARIETY RIGHT TO THE COMMUNITY PLANT VARIETY OFFICE
APP_FORM
Mandatory fields or sections are marked with an asterisk (*)

I . Breeder's reference:KIS452x306

II . Species name:Phaseolus vulgaris L.


CPVO
Community Plant Variety Office
Breeder Ref.

Technical Questionnaire

French bean
CPVO/TQ-012/4 27/02/2013
Mandatory fields or sections are marked with an asterisk (*)

LiveSeeding

Results_New KIS varieties (3) and OHM (2)

Under registration process: 4 (different stages and years of DUS tests)

LiveSeeding

Results_Scientific publications and additional materials

Naš fižol

Kmetijski inštitut Slovenije

Contents lists available at ScienceDirect
Scientia Horticulturae
journal homepage: www.elsevier.com/locate/scihorti

Genetic diversity of common bean (*Phaseolus vulgaris* L.) germplasm from Serbia, as revealed by single sequence repeats (SSR)

Aleksandra Savić, Barbara Pipan, Mirjana Vasić, Vladimir Meglič

Pipan and Meglič BMC Plant Biology (2019) 19:442
https://doi.org/10.1186/s12870-019-2051-6
BMC Plant Biology
RESEARCH ARTICLE Open Access

Diversification and genetic structure of the western-to-eastern progression of European *Phaseolus vulgaris* L. germplasm

Barbara Pipan and Vladimir Meglič

Disease Note

Diseases Caused by Fungi and Fungus-Like Organisms

First Report of *Colletotrichum incanum* Causing Leaf Spots on Common Bean in Europe (Slovenia)

H.-J. Schroers,† J. Zajc, B. Pipan, V. Meglič, E. Kovačec, and M. Žerjav

Agricultural Institute of Slovenia, 1000 Ljubljana, Slovenia

MULTI-ELEMENTAL COMPOSITION, NUTRIENTS AND TOTAL PHENOLICS IN SEEDS OF *PHASEOLUS VULGARIS* L. BREEDING MATERIAL

Barbara Pipan[1], Lovro Sinkovič

Journal of elementology, ISSN 1644-2296, 2021, doi: 10.5601/jelem.2021.26.2.2143

sustainability MDPI

Article

Morpho-Agronomic Characterisation of Runner Bean (*Phaseolus coccineus* L.) from South-Eastern Europe

Lovro Sinkovič [1,*], Barbara Pipan [1], Mirjana Vasić [2], Marina Antić [3], Vida Todorović [3], Sonja Ivanovska [4], Creola Brezeanu [5], Jelka Šuštar-Vozlič [1] and Vladimir Meglič [1]

cogent - food & agriculture
Food Science & Technology

Comparison of six genomic DNA extraction methods for molecular downstream applications of apple tree (*Malus X domestica*)

Barbara Pipan | Meta Zupančič | Eva Blatnik | Peter Dolničar | Vladimir Meglič

Published: 24 October 2018

plants MDPI

Article

Nutrients, Phytic Acid and Bioactive Compounds in Marketable Pulses

Lovro Sinkovič [1,*], Barbara Pipan [1], Filip Šibul [2], Ivana Nemeš [2], Aleksandra Tepić Horecki [3] and Vladimir Meglič [1]

Open access peer-reviewed chapter

Drought Stress Response in Agricultural Plants: A Case St[udy of] Common Bean (*Phaseolus vulgaris* L.)

By Aleš Sedlar, Marjetka Kidrič, Jelka Šuštar-Vozlič, Barbara Pipan, Tanja Zadraž[nik], Vladimir Meglič

Submitted: January 15th 2019 Reviewed: April 25th 2019 Published: June 4th 2019
DOI: 10.5772/intechopen.86526

agronomy MDPI

Article

QTL Mapping for Drought-Responsive Agronomic Traits Associated with Physiology, Phenology, and Yield in an Andean Intra-Gene Pool Common Bean Population

Aleš Sedlar [1], Mateja Zupin [1], Marko Maras [1], Jaka Razinger [2], Jelka Šuštar-Vozlič [1], Barbara Pipan [1] and Vladimir Meglič [1,*]

COGENT FOOD & AGRICULTURE
2025, VOL. 11, NO. 1, 2439551
https://doi.org/10.1080/23311932.2024.2439551
cogent
SOIL & CROP SCIENCES | RESEARCH ARTICLE
OPEN ACCESS

Combining multi-criteria decision analysis with agro-morphological-biochemical-molecular traits of interest for use in breeding in promising common bean breeding lines (*Phaseolus vulgaris* L.)

Lovro Sinkovič, Hourieh Tavakoli Hasanaklou, Mohamed Neji, Eva Plestenjak, Peter Dolničar, Vladimir Meglič and Barbara Pipan

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Research article

Trypsin inhibitors in seeds and pods of *Phaseolus vulgaris*/*coccineus*: A comparative study of shaking and ultrasonic extraction methods

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Nodulation performance and agronomic traits of European common bean (*Phaseolus vulgaris* L.) genetic resources

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Genomic insights into genetic diversity and seed coat color change in common bean composite populations

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plants MDPI

Article

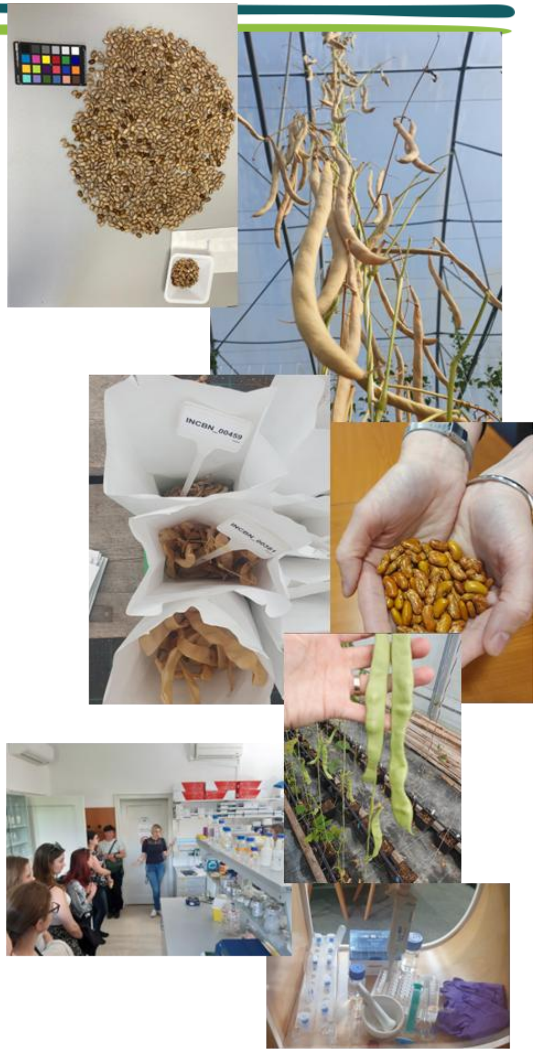
How Nutritious Are French Beans (*Phaseolus vulgaris* L.) from the Citizen Science Experiment?

Lovro Sinkovič [1,*], Vanja Blažica [2,3], Bojan Blažica [3,4], Vladimir Meglič [1] and Barbara Pipan [1]

LiveSeeding

Main challenges for the future

- To find the **elite germplasm** of common bean.
- To address the **breeding objectives** complementary with the **agroecological changes/conditions**.
- To employ **new breeding approaches** into the existing breeding programme.
- To **accelerate** breeding procedure.
- To **implement the organic breeding** in parallel with conventional breeding programme.
- To find the **competent human resources**.
- To implement **citizen science approach**?
- After registration: **Maintenance** and **marketing** of the developed varieties.



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M3 – U2 Common methods and strategies in organic breeding

COMMON QUIZ

COMMON QUIZ

Question 1: Why stratified mass selection is preferably chosen for farmers selection than recurrent selection by S2 lines

- ❑ *More complex/less complex*

Question 2: Should I follow the same methodology for conservation of inbreeds and maize populations, i.e., by selfing

- ❑ *Yes/no*

Question 3: Maize tassel produces circa 25 million grains of pollen

- ❑ *Yes/no*

Question 4: Can farmers produce population hybrid seed?

- ❑ *Yes/no*

Question 5: What is the official name of the test needed for the registration of a new (common bean) variety?

Question 6: Using the example of common bean, how long does it take on average to develop a new registered variety (using traditional breeding methods allowed for organic breeding)?

Question 7: Are the breeding objectives associated with the traits of interest to be improved through the common bean breeding programme?

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In 15 min

M3 – U2 Common methods and strategies in organic breeding

DEBATE

- *Revise the quiz in common*
- *What I know about allogamic plants? And about autogamous?*
- *Own previous experiences*
- *Other questions and doubts*

Additional available materials

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6. E.T. Lammerts van Bueren and J. Myers (editors). 2012. Organic crop breeding. Book. Wiley, West Sussex, UK. 312 p.
7. M. Messmer, K.P. Wilbois, C. Baier, F. Schäfer, C. Arncken, D. Drexler and I. Hildermann 2015. Plant Breeding Techniques: An assessment for organic farming. ISBN 978-3-03736-286-0. FiBL, Switzerland. 48 p.
8. H. C. Brookfield, Helen Parsons, Muriel Brookfield. 2003. Agrodiversity: Learning from farmers across the world. Book. United Nations University Press, New York, USA. 343 p.

WRAP UP

- *What we have learned today?*
- *Proposed homework: You have a maize population (allogamic) that you want to maintain. What strategies can you apply to maintain your population from contamination?*

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By next thursday 20th february

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Thanks for your attention!

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