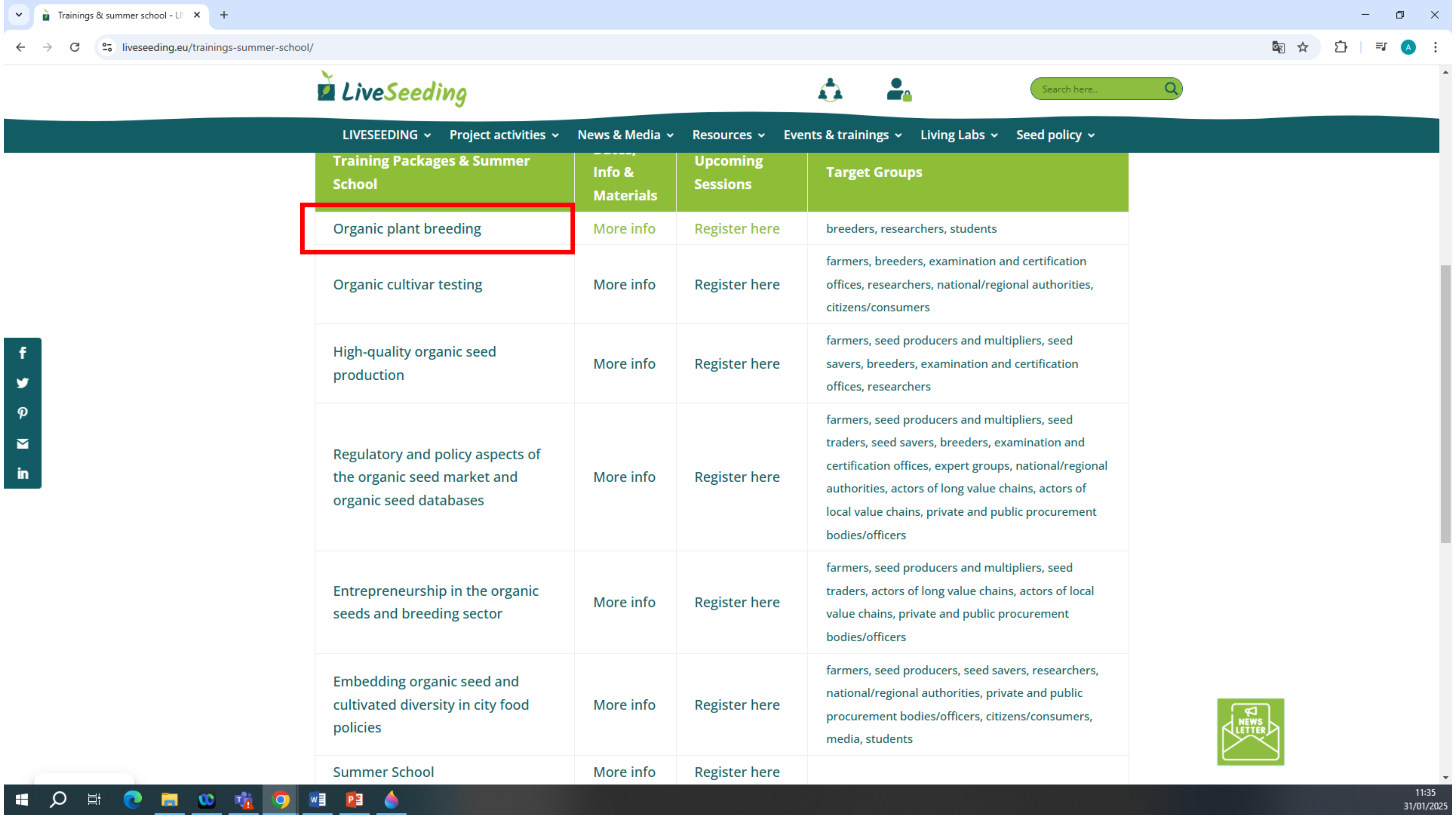
TRAINING IN ORGANIC BREEDING!

CONTEXT: Training in LIVESEEDING project

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


Trainings & summer school - LI
liveseeding.eu/trainings-summer-school/
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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

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MARCH 7th 2025 - 9:00 to 18:00 CET

Unit 5.1: Composite Cross Populations: setting-up & selection
- 9:00-11:00 - UPV (A. Rodriguez-Burruezo) + INRAe (Isabelle Goldringer)

- 11:00-11:30 Break

Unit 5.2: Dynamic Mixtures: setting-up & selection
- 11:30-13:00 - IPC (Pedro Mendes Moreira)

- 13:00-14:30 Lunch Break

Unit 5.3: Fundamentals of populations genetics applied to OHM development and use
- 14:30-16:00 - UPV (A. Rodríguez-Burruezo) + INRAe (Isabelle Goldringer)

- 16:00-16:30 Break

Unit 5.4: Using genomics to track the evolution of heterogeneous organic materials
- 16:30-18:00 - FiBL (Michael Schneider)

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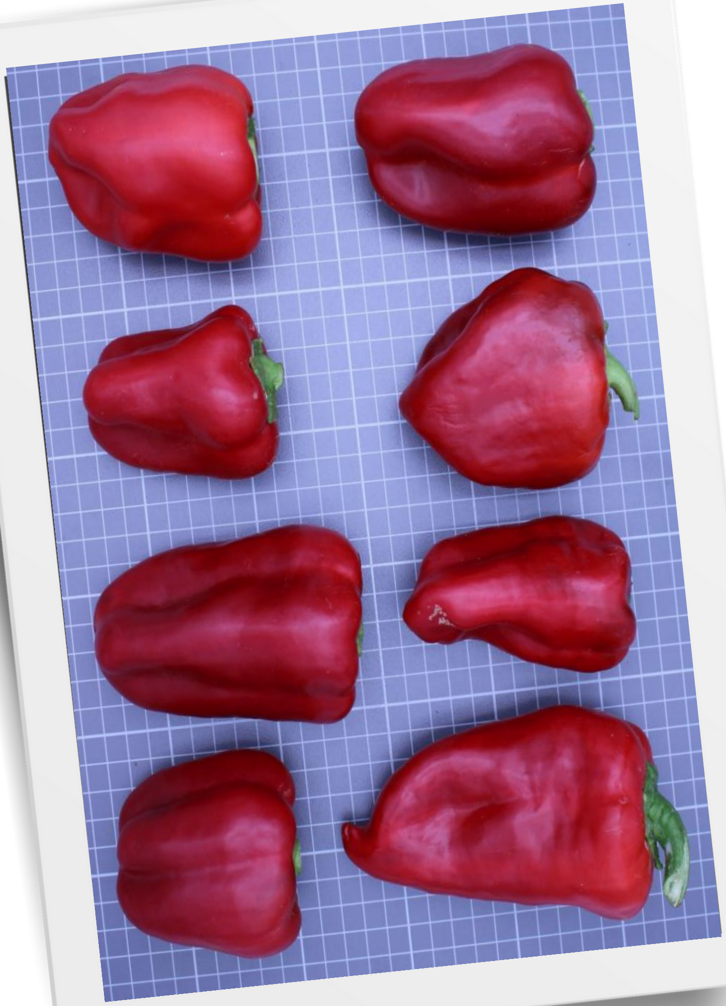
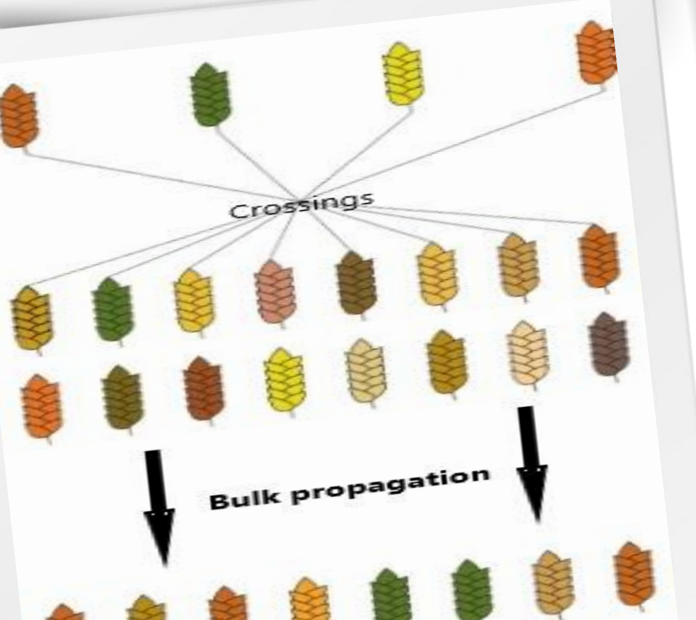


Training in organic breeding

Module 5:
Organic heterogeneous material (OHM) design&development

Unit 5.1: Composite Cross Populations: setting-up & selection



Authors: A. Rodríguez-Burruezo (UPV), I. Goldringer (INRAe)

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

Module 5 – Unit 1 CCPs: setting-up & selection

IMPORTANT

1. *Questions through the chat*

2. *FOR CERTIFICATES:*
   - *2.1. Class work (30 min)*
   - *2.2. Quiz (10 min)*

   SEND TO ME adrodbur@doctor.upv.es

   and Ananmarija Coric (IPS) anamarija.coric@ips-konzalting.hr

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Module 5 – Unit 1 CCPs: setting-up & selection

Things to be treated today

1. *What is a Composite Cross Population?*
2. *Why CCPs? Reasons (genetic, breeding, agrobiodiversity, application on O Farming and O breeding, etc.)*
3. *Procedure for their obtention (first crossings)*
4. *Further development (by itself as evolutionary population, by mass selection towards directed OHM)*
5. *Examples in vegetables and crop species*
6. *Work (instead homework) (30 min)*
7. *QUIZ (10 min)*
8. *Wrap up, conclusions and take home messages (about 5 min)*

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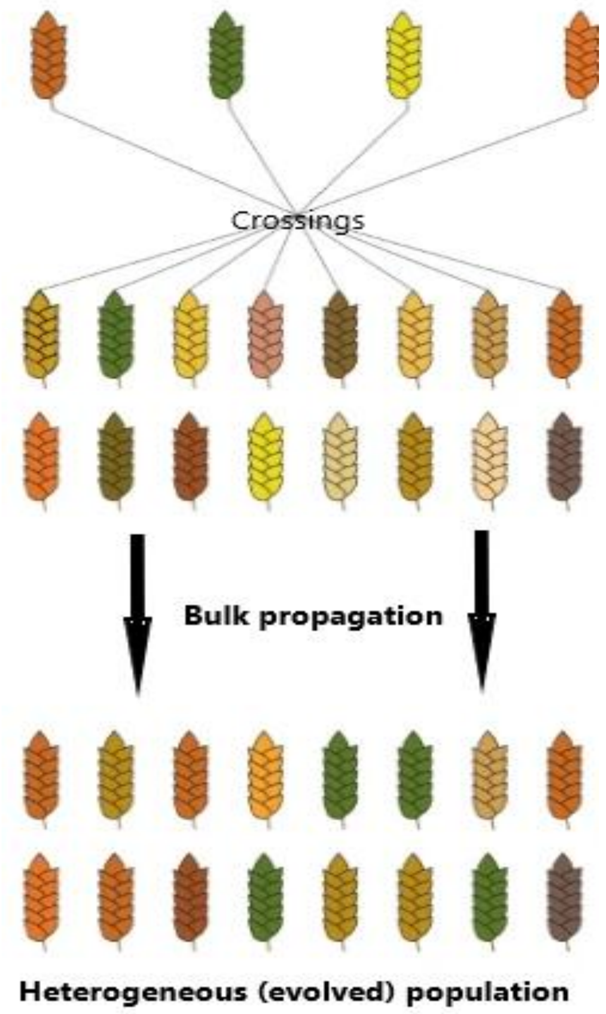
Module 5 – Unit 1 CCPs: setting-up & selection

What is a CCP?

- ❑ *By crossing a range of lines (diallel or others)*
- ❑ *Complementary for a range of traits*
- ❑ *Then, left to evolve on-farm for generations*
- ❑ *At the end, becomes a mixture of genotypes, which recombines the genetic backgrounds of the parent lines*
- ❑ *Almost inbred (autogamous)*
- ❑ *Homozygous & heterozygous (alogamous)*



Adapted from source:
Wuest et al. 2021. Nature ecology & Evolution 5:1068-1077

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Module 5 – Unit 1 CCPs: setting-up & selection

What is a CCP?

- ❑ *Encompasses a wide genetic diversity*

Against F1s, clones, inbred varieties:

- ❑ *Not the most excellent performance…*
- ❑ *…but resilient and adaptable*
- ❑ *Stability against changing conditions*
- ❑ *Bulk propagation favors genetic mixture*
- ❑ *Strategy for organic and other low input farming conditions*

Source: Fresh Plaza

Source: Michigan State University

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Module 5 – Unit 1 CCPs: setting-up & selection

Why CCP?

- *Resilient and sustainable farming systems based on diversity:*
  - *Promoting the use of landraces… increase intervarietal diversity*
  - *CCPs contribute with intravarietal diversity*
- *At a genetic level:*
  - *Great genetic mixture of individuals*
  - *A plethora of genetic factors to face challenges (short or long term)*
- *At breeding level:*
  - *The selection of the best individuals standardize main appearance traits*
  - *Also with the help of pedoclimatic conditions (nature selection)*
  - *Bulk/mass selection procedure + open pollination keeps diversity underground*

Module 5 – Unit 1 CCPs: setting-up & selection

Why CCP?

- ❑ *Applications and advantages in Organic farming:*
  - *These population varieties contribute to agrodiversity*
  - *Adaptation to low input farming*
  - *Populations adapted to local conditions in the hands of small organic farmers*
  - *Easy to multiply and maintain (no need of buying F1s seeds all years)*
- ❑ *Applications and advantages in Organic breeding:*
  - *The wide genetic diversity at the beginning offers many opportunities to adapt to different pedoclimatic conditions*
  - *The co-evolution during their development enables dynamic adaptation to changing conditions (e.g. climate change, erratic rains)*

Module 5 – Unit 1 CCPs: setting-up & selection

Procedure for their obtention and development

- ❑ *Chosing the best parents (IMPORTANT)*
- ❑ *Exploit recombination events. The more parents involved, the higher segregation and recombination (IMPORTANT: large populations at the beginning)*
- ❑ *Selection to shape for specific traits*
- ❑ *All generations, ensure minimum individuals selected*
- ❑ *Bulk/mass method keeps underlying diversity for other not visible or future traits*

Future OHM

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Module 5 – Unit 1 CCPs: setting-up & selection

Procedure for their obtention

- *Chosing the best parents (IMPORTANT)*
- *Exploit recombination events. The more parents involved, the higher segregation and recombination (IMPORTANT: large populations at the beginning)*
- *No Selection: just leaving nature selection*
- *Bulk/mass mixture of large amount of individuals, good performance/appearance*
- *Evolutionary heterogeneous population*

Module 5 – Unit 1 CCPs: setting-up & selection

Examples in crop species

Agroforest Syst (2024) 98:1891–1904
https://doi.org/10.1007/s10457-024-00997-6

Performance of a winter wheat composite cross population in two temperate agroforestry systems – a Swiss case study

Christina den Hond-Vaccaro · Fabio Mascher · Johan Six · Christian Schöb

https://doi.org/10.1007/s10457-024-00997-6

Abstract In agroforestry systems (AFS), where environmental conditions are highly variable at small spatial scales, the use of uniform genetic material of a single cultivar commonly grown in monoculture cropping might not be optimal. However, the use of composite cross populations (CCPs) that contain an inherent genetic variability might be a promising approach under the environmental variability created by trees in AFS. In this experimental trial, the performance of a CCP ('CC-2 k') of winter wheat was compared to a commercial variety ('Wiwa') in a split-plot design at two AFS (Feusisberg and Wollerau) in Central Switzerland. Yield of CC-2k (1.9 ± 0.7 Mg ha−1) was higher than yield of Wiwa (0.7 ± 0.4 Mg ha− 1) in Wollerau, but yields did not differ between CCP and variety in Feusisberg (1.9 ± 0.7 Mg ha−1 and 2.0 ± 0.8 Mg ha− 1, respectively). The interaction of site and variety was significant ($p < 0.05$). Wiwa had a higher protein, Fe and Ca content than CC-2k. Therefore, while the CC-2k outperformed Wiwa in terms of yield in one of the two AFS, Wiwa outperformed CC-2k in terms of quality. In this one-year field experiment, the composite cross population might have been better adapted to the heterogenous environment of agroforestry systems (found in one out of two sites) but failed to reach the high-quality product of modern cultivars. These initial results must be seen as first insights which need to be complemented by larger field experiments for generalisation. The findings of this study may be interpreted as an indication that further improvements in terms of quality might make CCPs a viable option for diversified agricultural systems with larger environmental heterogeneity than common monoculture cropping systems.

agronomy MDPI

Article

Constitution of Composite Cross Maize (*Zea mays* L.) Populations Selected for the Semi-Arid Environment of South Madagascar

Alberto Masoni *, Alessandro Calamai, Lorenzo Marini, Stefano Benedettelli and Enrico Palchetti

https://doi.org/10.3390/agronomy10010054

Abstract: In many African countries, such as Madagascar, a large part of the population is currently estimated to be undernourished, and self-subsistence agriculture represents the primary source of food available for the family. Smallholder farmers cultivate crops with limited agricultural input and use old landraces or obsolete hybrid varieties, with a total country-wide production that is far from being able to sustain the national food demand. In this study, we have developed two maize composite cross populations (CCPs) of different kernel colors, through a selection process among 30 half-sib lines, chosen both for their agronomic performance and their environmental adaptability to a Malagasy farm context. The best half-sib lines, identified through field tests, were clustered as a parental group for open-pollinated crosses. The new CCP created, after two years of seed multiplication in an open field, showed promising yields compared with the hybrids, parental varieties, and local landraces, with average values of 2.7 t/ha for the white CCP and 3.5 t/ha for the yellow one. The seeds produced were then distributed among 15 local farmers to begin a participatory breeding program. Our approach represents an innovative step to improve and stabilize maize yields, employing populations adapted to the cultivation environment and able to cope with different stresses, thereby helping farmers' life conditions.

Module 5 – Unit 1 CCPs: setting-up & selection

Examples in vegetables

sustainability MDPI

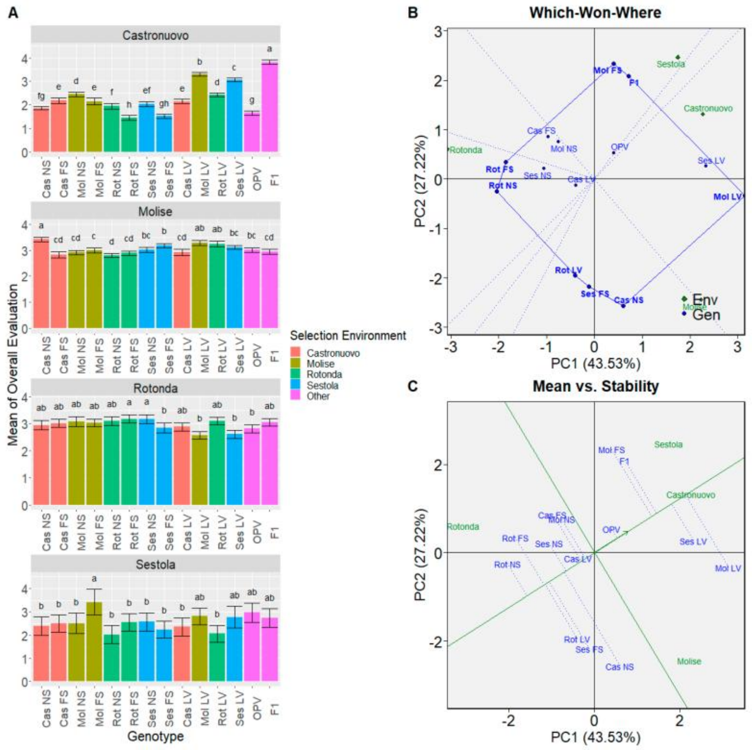
Article

Evolutionary Participatory Selection for Organic Heterogeneous Material: A Case Study with Ox-Heart Tomato in Italy

Matteo Petitti [1,*], Sergio Castro-Pacheco [1], Antonio Lo Fiego [2], Domenico Cerbino [3], Paolo Di Luzio [4], Giuseppe De Santis [1], Riccardo Bocci [1] and Salvatore Ceccarelli [5]

https://doi.org/10.3390/su141711030

Abstract: Cultivars specifically adapted to organic agriculture are lacking in most crops, and tomato is no exception. Evolutionary-participatory breeding (EPB) combines the adaptive ability of evolutionary populations with farmers' selection, thus representing a cost-effective strategy for the development of novel organic heterogeneous material, as introduced by the European regulation on organic agriculture (EU) 2018/848. An F4 ox-heart tomato composite cross population (CCP), derived from a half-diallel cross of four local varieties chosen for their superior performance under organic conditions, was submitted to both natural and farmers' selection on three organic farms and at one research station in Italy. During field days held at each location before harvest, farmers visually scored 400 plants, all of which were carried forward to develop the natural selection (NS) population, while the 20 best ranking plants were chosen to develop the farmers' selection (FS). After two cycles of selection (2018 and 2019), one NS and one FS population were obtained at each location. After this two-year selection process, in 2020, the eight populations (four NS and four FS), were evaluated in a randomised complete block trial in the four locations of selection and evolution. Four local varieties chosen by farmers and two modern varieties (one open pollinated variety and one F_1 hybrid) were added as controls. The ANOVA showed significant differences among entries for all traits. Entry-by-location interactions were larger than the genetic effect for the overall evaluation, yield at first harvest, total yield and percentage of marketable yield. This confirms the importance of decentralising selection when seeking to develop specifically adapted varieties and/or populations. Evidence was observed of the effectiveness of participatory selection for improving the yield at first harvest, with a slight trade-off effect for the total yield and plant vigour.



Module 5 – Unit 1 CCPs: setting-up & selection

Example for work (30 min)

agronomy

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Article

High Buffering Potential of Winter Wheat Composite Cross Populations to Rapidly Changing Environmental Conditions

Odette D. Weedon [1,*], Sarah Brumlop [2], Annette Haak [3], Jörg Peter Baresel [1,4], Anders Borgen [5], Thomas Döring [6], Isabelle Goldringer [7], Edith Lammerts van Bueren [8], Monika M. Messmer [9], Péter Mikó [10], Edwin Nuijten [11], Bruce Pearce [12], Martin Wolfe [12,†] and Maria Renate Finckh [1]

10.3390/agronomy13061662

- How was this CCP created?
- Experiments performed?
- Traits studied?
- Advantages/disadvantages?
- Further studies?
- Any other interesting issue?

Send to: adrodbur@doctor.upv.es and anamarija.coric@ips-konzalting.hr

IMPORTANT FOR CERTIFICATES!!!!

Module 5 – Unit 1 CCPs: setting-up & selection

Example for work (30 min)

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Article

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- ❑ *How was this CCP created?*
- ❑ *Experiments performed?*
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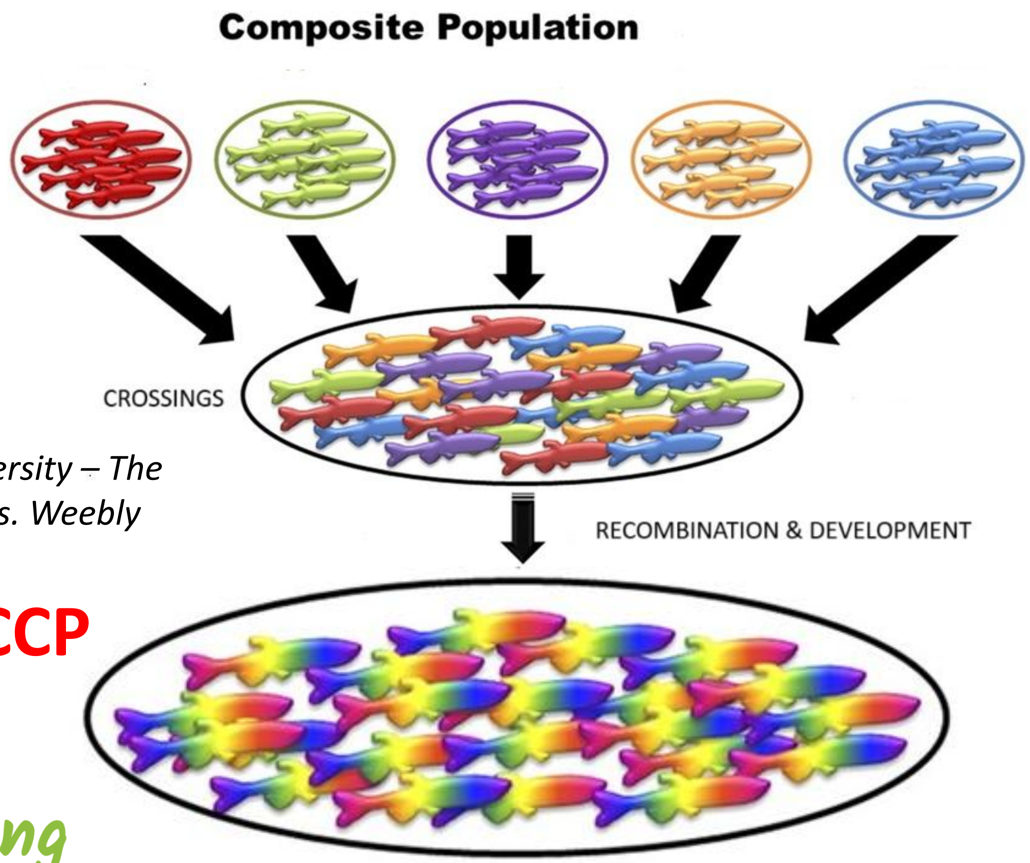
Module 5 – Unit 1 CCPs: setting-up & selection

QUIZ (10 min)

- *Advantages of CCPs*



Source: Genetic Diversity – The evolution of genetics. Weebly

Final CCP

VS.

Sources: Gardenerspath.com and Valleyspuds.com

Send to: adrodbur@doctor.upv.es and anamarija.coric@ips-konzalting.hr

IMPORTANT FOR CERTIFICATES!!!!

LiveSeeding

Module 5 – Unit 1 CCPs: setting-up & selection

What we have learned today?

- ❑ *DIVERSITY = RESILIENCE*
- ❑ *Mass selection + Bulk propagation = keeps diversity*
- ❑ *CCPs enable plasticity and adaptative varieties*
- ❑ *Easy to propagate and keep by farmers*
- ❑ *Fit many organic farming and breeding principles*
- ❑ *Contribute to increase (intravarietal) diversity in the agrifood sector*

ADDITIONAL MATERIALS

https://www.biodiversecarbonfarming.com/biodiverse-farming/composite-cross-populations/

S. Brumlop, O. Weedon, W. Link, M.R. Finckh. 2019. Effective population size (Ne) of organically and conventionally grown composite cross winter wheat populations depending on generation. European Journal of Agronomy 109: 125922, https://doi.org/10.1016/j.eja.2019.125922

Weedon, Odette D., Sarah Brumlop, Annette Haak, Jörg Peter Baresel, Anders Borgen, Thomas Döring, Isabelle Goldringer, Edith Lammerts van Bueren, Monika M. Messmer, Péter Mikó, and et al. 2023. "High Buffering Potential of Winter Wheat Composite Cross Populations to Rapidly Changing Environmental Conditions" Agronomy 13, no. 6: 1662. https://doi.org/10.3390/agronomy13061662

Vollenweider C, Spieß H (2018) Composite cross populations: legal considerations and their value for plant breeding. In: Vereinigung der Pflanzenzüchter und Saatgutkaufleute Österreichs (Ed), 68. Jahrestagung 2017, 20-22 November, Raumberg-Gumpenstein, pp 49-50. BOKU-University of Natural Resources and Life Sciences, Vienna, Austria. ISBN-13: 978-3-900932-53-4