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Organic plant breeding for sustainable agriculture

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Introduction

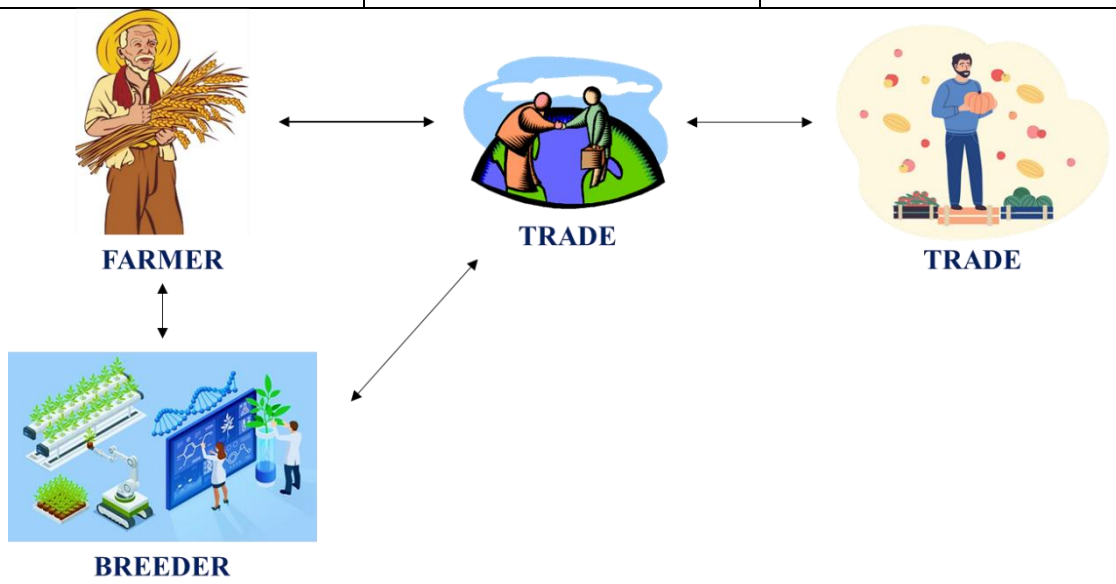
Organic farming currently relies largely on plant and animal varieties bred under non-organic conditions, many of which are poorly suited to organic systems and inconsistent with its holistic principles. To strengthen both performance and integrity in organic agriculture, it is essential to develop varieties specifically through organic breeding programmes. Such breeding must occur entirely under certified organic conditions, respecting natural reproductive barriers and avoiding methods that compromise plant integrity such as genetic modification, cytoplasmic male sterility without restorer genes or protoplast fusion.

Techniques like DNA marker-assisted selection and meristem culture can be used, provided they do not involve GMOs or radiation. Open-pollinated varieties are encouraged, especially in biodynamic systems, though fertile F_1 hybrids from organic parent lines are acceptable. Unlike organic seeds, which may come from non-organic breeding but are multiplied organically for at least one generation, true organic varieties originate from organic breeding itself, allowing gradual transition towards full reliance on them.

Breeding targets differ from conventional programmes, focusing more on traits like weed competitiveness, plant height, nutritional quality and maintenance of genetic diversity within varieties to promote adaptability to local environments. Yield while important, shares priority with quality and resilience in organic systems. An example of these principles in practice is the creation of composite cross populations in wheat, where numerous elite European varieties are intercrossed and the resulting diverse populations adapt across multiple organic and non-organic sites. Such populations can serve both as directly usable, highly adaptable genetic resources and as breeding material for future organic variety development.

The criteria of organic production at the three levels of organic plant breeding

Farm level	Plant level	Socio-economic level
▪ Closed production cycles ▪ Natural self-regulation ▪ Rich variety of organisms: agro-biodiversity	▪ Natural reproductive ability ▪ Ability to adopt independently to environment ▪ Genetic diversity with respect for natural species authenticity and species characteristics	▪ Close interaction between farmers, trade and industry and breeders ▪ Regulations incorporating organic principles ▪ Cultural diversity: many different breeding programmes



Parties in organic plant breeding

Farmers: Farmers engaged in organic agriculture rely on natural fertilizers and nitrogen-fixing legumes, making their management practices dependent on regional soil conditions and climate. Their experience guides the selection of crop varieties that perform well under organic systems, acknowledging the importance of adaptation to local fluctuations in temperature and nutrient availability.

Trade and Industry: Trade and industry participants focus on producing and supplying organic goods that meet rigorous quality and environmental standards. These stakeholders are attentive to consumer preferences for safe, healthy and seasonal foods, prioritizing varieties that maintain their quality and appeal throughout the supply chain without the use of synthetic additives.

Breeders: Breeders play a specialized role in organic agriculture by developing varieties suited to organic management through careful crossing and selection. Their expertise ensures

the creation of plant populations with traits that reflect cultural heritage and adaptability, maintaining genetic diversity to enhance resilience and reliability under varying organic conditions.

Relationship in organic production chain

The relationship between these parties is built on a shared commitment to organic principles and a holistic production chain. Farmers, breeders and industry members work collaboratively, ensuring that breeding and crop management methods respect living ecological systems. This integrated approach excludes external genetic modification, focusing instead on natural procedures that promote healthy crop development and sustainable food production.

General principles of organic plant breeding

Organic plant breeding uses sustainable methods, maintains genetic diversity and preserves the natural reproductive ability of crops. This breeding approach respects natural crossing barriers and focuses on plants that form stable relationships with living soil, ensuring resulting varieties are adapted specifically for organic farming systems. Organic plant breeding promotes sustainability by encouraging genetic diversity and protecting natural reproductive processes of crops. All stages of breeding must be completed under certified organic conditions, taking at least four years for annuals and six years for perennials. This approach ensures varieties are adapted for organic farming and respects ecological and biological barriers throughout the process.

Requirements for organic plant breeding

1. **Selection Environment:** All cultivation and selection processes during breeding must occur under certified organic management, with the possible exception of meristem culture.
2. **Source Material:** Only genetic material approved for use as seed and planting stock in organic agriculture can be used, explicitly excluding any modified by genetic engineering or direct cellular-level interventions.
3. **Transparency:** Breeders must disclose the full breeding methodology before the variety is commercially released, ensuring method information is publicly accessible.
4. **Allowed Methods:** The genome and cellular integrity must be maintained without direct technical alterations such as genetic engineering, CRISPR, chemical mutagenesis, ionizing radiation, DNA/RNA transfer or protoplast fusion. Techniques reducing fertility or germination in subsequent generations are prohibited.
5. **Patents:** Neither organic varieties nor the breeding techniques used may be patented to promote open access and exchange.

6. **Maintenance Breeding:** Ongoing maintenance breeding of organic varieties must be conducted under certified organic conditions to preserve variety integrity.

These criteria ensure that organic breeding adheres strictly to organic principles and ecological sustainability.

Methods and tools used in organic plant breeding:

1. Breeding methods allowed:

- Intraspecific crossing without breaking natural reproductive barriers.
- Backcrossing to introduce or reinforce desired traits.
- Mass and individual selection based on whole-plant performance.
- DNA marker-assisted selection to enhance efficiency without genetic modification.
- Hybrid cultivar development, provided resulting progeny are fertile and sterility is not chemically induced.
- Meristem culture, primarily for virus elimination and clonal propagation.

2. Prohibited techniques:

- Genetic engineering including creation of genetically modified organisms (GMOs).
- Use of synthetic hormones or chemical treatments such as colchicine.
- Cisgenesis and reverse breeding, as these involve processes analogous to GMO development.

3. Integration of modern technologies:

- While new breeding techniques enable precise incorporation of traits from wild relatives or landraces, they must be critically evaluated for compatibility with organic principles (health, ecology, fairness and care).

4. Breeding strategy - Shuttle breeding:

- Alternating selection between optimal conventional and organic or low-input environments aimed at developing broadly adapted cultivars with enhanced disease resistance.
- Advanced generation progenies generated via conventional breeding can be evaluated and selected under certified organic conditions to optimize resource use.

This framework ensures that organic plant breeding employs conventional, biologically respectful methods aligned with organic farming principles while exploring selective integration of innovations that do not compromise plant integrity or ecosystem health.

What is new and what needs to be done for Organic Plant Breeding:

- Conduct broad multi-location trials to better understand genotype-by-environment (G × E) interactions and identify key regional sites for cultivar yield evaluation.

- Explore shuttle breeding techniques between organic farming and conventional farming systems to develop cultivars adapted to both conditions.
- Increase screening of genetic resources stored in gene banks to discover valuable germplasm for organic breeding.
- Utilize high-throughput genotyping and extensive phenotypic data from multi-location trials to predict germplasm performance effectively.
- Investigate the feasibility of breeding perennial crops suited for sustainable organic farming, considering systems with crop rotations.
- Implement remote sensing technologies for phenotyping traits such as weed competitiveness, to enhance selection efficiency and genetic gain.
- Promote quantitative and association genetics studies to elucidate genetic variation and architecture of traits beneficial for organic farming.
- Assess the deployment of cultivar mixtures to enhance host plant resistance and improve resilience against abiotic stresses in organic agro-ecosystems.
- Evaluate the compatibility of emerging breeding technologies with the principles and restrictions inherent to organic farming.
- These strategies can advance the development of cultivars specifically tailored for organic production systems, addressing limitations of conventional breeding in such contexts.

Conclusion

Organic plant breeding employs conventional crossing and selection methods that preserve natural reproductive barriers, including intraspecific crossing, backcrossing, mass and individual selection and DNA marker-assisted selection without genetic modification. Hybrid development is allowed if the progeny remain fertile and sterility is not chemically induced. Meristem culture is utilized primarily for virus elimination and is compatible with organic certification. However, genetic engineering, synthetic hormones, colchicine treatments, cisgenesis and reverse breeding are prohibited due to their alteration of genome integrity and incompatibility with organic principles. Modern technologies enabling incorporation of traits from wild relatives require careful evaluation against organic farming's core values (health, ecology, fairness and care). Shuttle breeding, involving alternating selection under conventional and organic environments, is a practical strategy to develop cultivars broadly adapted for organic systems while optimizing resource use. This approach allows some conventional breeding steps before final organic condition evaluation, aligning with organic standards and financial or institutional constraints

References

Crespo-Herrera, L.A. and Ortiz, R., 2015. Plant breeding for organic agriculture: something new? Agriculture & Food Security, 4(1), p.25.

Lammerts van Bueren, E.T., Hulscher, M., Jongerden, J., van Mansvelt, J.D., den Nijs, A.P.M. and Ruivenkamp, G.T.P. (1999) Sustainable organic plant breeding. Driebergen: Louis Bolk Institute, p. 60.

Powell, J., *et al.* (eds.) (2002) UK Organic Research: Proceedings of the COR Conference, 26–28 March 2002, Aberystwyth. Aberystwyth: Organic Centre Wales, pp. 303-305.