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Guidebook to Participatory Plant Breeding for organic soybean in the EU



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Introduction

This guidebook is designed for farmers, extension services providers and other stakeholders interested in organic agriculture and in participatory plant breeding (PPB) of soybean. This guide aims to provide you with insights into the practice of PPB and how it can be effectively implemented in growing of organic soybean, in line with EU standards.



What is Participatory Plant Breeding (PPB)?

PPB is an innovative approach to plant breeding that actively involves farmers in the selection and breeding of different plant species. PPB takes place in the field where the crops are grown and ensures that developed varieties are well-suited to the specific pedo-climatic conditions and needs of local farming systems.

Why focus on soybean?

Soybean represents one of the most important crops in the world, with an annual production of over 370 million tonnes (FAOSTAT, 2021). Due to favourable nutritional composition (about 40% protein and 20% oil), soybean is used for feed and food, pharmaceutical and other industries. In addition, soybean is becoming increasingly important in human nutrition. Also, it was noted increased interest in organic soybean farming worldwide due to growing consumer demand for organic products, environmental concerns and a desire for more sustainable agricultural practices.

Organic farming and EU standards

Organic farming is a holistic method of farming that prioritises the use of natural resources and processes, avoiding synthetic chemicals and encourages biodiversity. Strict rules that guarantee the preservation of environmental and health standards apply to organic agriculture in the EU.

Additional resources:

- Ceccarelli S, Grando S (2007) Decentralized-participatory plant breeding: an example of demand driven research. *Euphytica*, 155:349-360.
- Ceccarelli S, Guimarães EP, Weltzien E (2009) Plant breeding and farmer participation. FAO. Rome. pp 671.
- IFOAM (2017) Compatibility breeding techniques in organic systems. Available on <https://www.ifoam.bio/compatibility-breeding-techniques-organic-systems>
- FAOSTAT <https://www.fao.org/faostat/en/#home>



Soybean

Organic agriculture values soybean for several reasons:

- Crop rotation and soil health;
- Nitrogen fixation ability;
- Source of plant based protein.

From the agronomic aspect, it has great agronomic significance, as it enriches the soil with nitrogen, improves physical properties, which makes it a good pre-crop for almost all field and vegetable crops. Soybean has the ability to biologically fix nitrogen in symbiosis with nodules of the genus *Bradyrhizobium* and can achieve high yields with or without the use of mineral fertilisers. Choosing the right soybean variety and production technology is the way to achieve economic viability while maintaining sustainable production.

Additional resources:

- Miladinović J, Hrustić M, Vidić M (2008) Soja. Institut za ratarstvo i povrtarstvo, Novi Sad i Sojaprotein, Bečej, AMB Grafika, NoviSad.
- World Health Organization/Food and Agriculture Organization/United Nations University (1985) Energy and protein requirements Report of a Joint FAO/WHO/UNU Expert Consultation. In: WHO technical report series, no. 724. WHO, Geneva
- EU Commission (2018) Organic Farming in the EU. *European Commission*.



Principles of PPB in Organic Agriculture

Introduction to Participatory Plant Breeding (PPB)

PPB is a cutting-edge method of plant breeding that actively includes farmers in the breeding and selection of various plant species.

Key principles of PPB

- **Genetic diversity:** Genetic diversity is the cornerstone of PPB. It is necessary for new soybean varieties to be more tolerant to different abiotic and biotic stressors. For that purpose, breeders through their dedicated work need to create more tolerant genotypes capable to overcome the negative effects of high temperature and lack of precipitation.
- **Local adaptation:** Selecting and breeding crops that perform well under local environmental, climatic and soil conditions are of key importance.
- **Farmer involvement:** Farmers play a central role essential to PPB. When choosing varieties that are best suited for their particular local contexts, their understanding of the requirements and conditions in the area is valuable.

Benefits of PPB in organic agriculture

- **Local:** Varieties developed through PPB are often more resilient to local pests, diseases and climatic stresses. Varieties are tailored for specific pedo-climatic conditions.
- **Local/global:** By developing varieties that perform better and meet market demands, PPB can enhance the economic viability of organic farms.
- **Global:** PPB supports the broader goals of organic agriculture, such as biodiversity, soil health and reduced dependence on external inputs.

Implementing PPB in organic agriculture

1. Be in line with local environmental conditions and farmer needs.
2. Selecting and breeding soybean varieties with identified traits of interests.
3. Establish field trials on organic farms.
4. Evaluate material and collect data prior to selection decisions.



Getting started with PPB

Field trials and farmer assessments are the main activity of PPB. Here are following steps:

- Establish plots for each soybean variety, ensuring they are representative of your farming conditions;
- Decide on the traits of interests, such as soybean yield, disease resistance, or grain quality;
- Keep detailed records of planting, growth and any observations throughout the season (e.g. pest, diseases);
- Consult with breeders or experts on collected material.

Data collection and analysis

Accurate data collection is crucial. Keep detailed records of planting, growth, and any observations throughout the season (e.g. pest, diseases). Analyse this data to identify the traits and best-performing varieties. Consult with breeders or experts on analysis or tools that can evaluate variety performances.



Selecting and breeding soybean varieties

Introduction to Selection and Breeding

In Participatory Plant Breeding (PPB) programmes for soybean, a crucial aspect is the selection and breeding of varieties. Suitable soybean varieties for breeding can be obtained by purchasing certified organic seed, directly from breeders, from seedbanks and other sources of seed material.

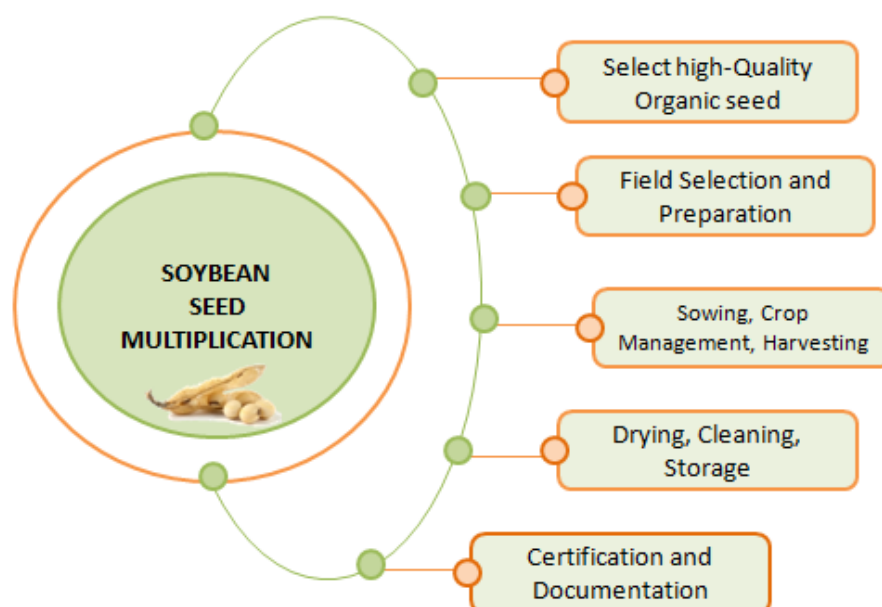
Identifying useful traits

Key traits for soybean variety selection might include:

- **Yield:** Grain production.
- **Disease and pest resistance:** Resistance to local biotic stressors.
- **Drought tolerance:** Resilience in local abiotic stressors.
- **Nutritional quality:** Level of protein and oil.

Soybean seed multiplication

Here are the general steps in organic soybean seed multiplication:



The participatory approach

Continuous engagement between farmers and breeders is vital:

- Continuous feedback helps to align breeding efforts with the actual needs and conditions of organic farmers producing soybean as well as with other supply chain participants.



- Collaborative decisions in the selection and breeding process ensure the development of varieties that are practical and beneficial for farmers as well as the soybean supply chain.

Documentation and record-keeping

Keeping detailed records of breeding activities, plant performance and observations is essential for tracking progress and making informed decisions in future breeding activities.

- **Tools and equipment:** Simple tools like measuring tapes, scales and notebooks are essential. Additionally, digital tools like smartphones or tablets can be used for recording and storing data electronically.
- **Observe soybean growth and development:** Monitor the growth stages of soybean, from germination to flowering and seed maturation. Note the timing of each stage and any deviations from expected patterns for various soybean maturity groups.
- **Perform yield measurements:** By assessing the harvested grain from a specified plot size, you can record yield data. This offers a clear evaluation of production.
- **Monitor disease and pest resistance:** Monitor disease or pest infestation of testplots. Collect data on the severity and impact on the plants, record any resistance observed in particular soybean varieties.
- **Keep track on environmental and soil conditions:** During PPB record rainfall, temperature, extreme events and any specific soil characteristics that can help in understanding how different varieties perform under the specific growing conditions.

Progressing post-breeding activities

- **Wider field testing:** Testing in different conditions and at various scales to ensure stability and performance.
- **Community engagement:** Sharing seeds and knowledge about new varieties within the farming community for broader socio-economic benefit.



Soybean harvesting

Harvesting soybean

Timing of harvest

Soybean is ready for harvesting when plants reach full maturity and the grain moisture is about 13%. Various factors can influence harvest delay whereby the harvest is done at a lower than optimal grain moisture. Harvesting with lower moisture content (below 11%), can cause seed damage and a reduction in quality.

Harvesting methods

Soybean harvesting can be done manually or with machinery. Mechanical harvesting is recommended whereby combine harvesters are used, especially for larger fields.



EU Organic Standards and compliance

Key aspects of EU organic standards

Regulation (EU) 848/2018 active from January 1, 2022, lays down the rules for organic production and labelling, emphasising environmental protection, preservation of natural resources and animal welfare. PPB programmes are aligned with key aspects of the EU Organic Standard.

Prohibition of GMOs

The use of genetically modified organisms (GMOs) is strictly prohibited in organic agriculture. This includes prohibition of the use of GMO seeds or any GMO-derived inputs in the breeding and cultivation processes.

Use of organic seeds

Organic farmers are encouraged to use organic seeds. However, under certain conditions, seeds from conventional production may be used if organic seeds are not available. In the case when seeds from conventional production are used, seed need to be non-treated and supported with documentation on the origin and non-use of synthetic pesticides.



Sharing and learning

In addition to creating new varieties tailored for local production conditions, Participatory Plant Breeding (PPB) for organic soybean aims to establish a community of practice and knowledge sharing platforms.

Networking with other farmers

Make contact with other PPB farmers. Via regional agricultural cooperatives, this can be accomplished via on-line workshops, field days, agricultural/trade fairs or PPB focused groups. Mutual learning and assistance can result from the exchange of experiences and methods.

Collaborating with researchers and breeders

Establish partnerships with soybean breeders and researchers. Their scientific background can help solve challenges and offer insightful information about the PPB process and to provide material for PPB activities.

Social media

Make use of social media channels to establish connections with a larger PPB group. These platforms provide space for exchanging experiences and remaining up to date on the most recent advancements of soybean. In addition, discussion on challenges that farmer faces today.

Webinars, participatory workshops and field days

Participate in or provide on-line training and webinars with a PPB and organic agriculture focus. These digital platforms promote the exchange of knowledge beyond geographical boundaries and open up learning to a larger audience.

Organise or take part in field days and workshops where farmers, scientists, and breeders meet to exchange ideas and discuss the latest developments in PPB and organic farming.



Conclusion

PPB is pathway for increasing involvement and engagement of farmers in plant breeding programmes. The empowerment of farmers through PPB leads to more resilient, sustainable and productive farming systems tailor made for local pedo-climatic conditions, benefiting not just the farmers themselves but also other stakeholders in the soybean supply chain.

Additional resources:

List of resources for further reading and support.

Organic Eprints URL: <http://www.orgprints.org/>

FAO Plant Breeding and Farmers Participation URL:
<https://www.fao.org/3/i1070e/i1070e.pdf>

URL: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018R0848>

Organics at a glance URL: https://agriculture.ec.europa.eu/farming/organic-farming/organics-glance_en

Willer H, Trávníček J, Meier C, Schlatter B (eds.) (2021) The World of Organic Agriculture. Statistics and Emerging Trends 2021. Research Institute of Organic Agriculture FiBL, Frick, and IFOAM – Organics International, Bonn (v20210301). URL: <https://www.fibl.org/fileadmin/documents/shop/1150-organic-world-2021.pdf>

Murphy K, Lammer D, Lyon S, Carter B, Jones SS (2005) Breeding for organic and low-input farming systems: An evolutionary-participatory breeding method for inbred cereal grains. *Renewable Agriculture and Food Systems*, 2005, 20(1): 48-55. doi:10.1079/RAF200486

Witcombe JR, Joshi KD, Gyawali S (2005) Participatory plant breeding is better described as highly client-oriented plant breeding. I. four indicators of client-orientation in plant breeding. *Experimental agriculture*, 41(3): 299-319. doi:10.1017/s0014479705002656

