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THE ROLE OF ORGANIC SOYBEAN IN ENSURING EUROPE'S FOOD SECURITY

JOLANTA PUCZEL, *dr. inż. International Academy of Applied Sciences in Łomża, Poland;*
BRONISŁAW PUCZEL, *dr. inż. International Academy of Applied Sciences in Łomża, Poland*

This article examines the issue of ensuring food security through the use of soybeans, the most widely grown legume crop. This question is increasingly being raised by EU farmers and policymakers: can organic soybeans realistically reduce the European Union's dependence on imported protein? The article presents production trends for this crop from 2017 to 2022, specifically the expansion of organic soybean acreage from 60,000 to 155,000 hectares, a 94% increase in production, yet the EU's self-sufficiency rate did not rise; on the contrary, it fell from 64% to 61%, while the demand grew more rapidly. Key agronomic constraints have been identified – lower yields under rainfed conditions (3.1 vs. 3.5 t/ha compared to North America), a shortage of specialized varieties, and vulnerability to droughts. In conclusion: organic soybeans are of strategic importance for Europe's food security, but realizing this potential without targeted breeding, the development of supply chains, and effective support within the CAP is not possible. The EU regulatory framework is one of the most supportive in the world for the development of organic production. The "Farm to Fork" Strategy, the Organic Action Plan, the CAP 2023–2027, and the EUDR together form a powerful set of incentives and commitments. The question is whether farmers and processors will be able to translate these incentives into concrete production results by 2030. Agronomic challenges are real and will not disappear on their own. Lower yields under rain-fed conditions, the difficulty of weed control, climate instability, and a lack of the specialized varieties – all these problems require targeted scientific and practical solutions. Public funding for breeding programs focused on organic farming is of special attention. Market conditions remain attractive for those willing to invest in quality and supply chain transparency. The premium for organic and non-GM soybeans, coupled with the growth in the food market segment and the EUDR, collectively create a long-term demand capable of offsetting higher production costs.

Keywords: *organic soybeans, food security, European Union, self-sufficiency, protein crops, organic farming, sustainable development.*
Table 1., Fig. 2., Ref. 10.

Statement of the Problem. Soybeans (*Glycine hispida* (Moench) Max), often referred to as the crop of the 21st century, are at the center of global agricultural science and production as a vital source of food and feed resources and a powerful biological fixer of atmospheric nitrogen. It has rapidly become part of global agriculture and plays a strategic role in addressing the global food crisis. By the 1960s, soybean crops occupied approximately 23.8 million hectares of cultivated land. Between 1961 and 2010, global soybean acreage increased 4.28-fold; at that time, soybeans were being grown in more than 90 countries across the world's major agricultural regions. At the same time, yields rose from 1.128 to 2.55 t/ha, and production had increased from 26.9 million tons to 260.8 million tons. Thanks to the use of biotechnology, commercial genetically modified soybean varieties entered production in 1996 and now occupy the majority of the acreage in the leading soybean-producing countries – the United States, Brazil, and Argentina.

Over a long historical period, a robust gene pool for this crop has been established (270,000 genotypes), which is one of the largest among agricultural crops and is maintained in 91 countries [1].

Soybeans are a crop without which it is difficult to imagine the modern agrarian world. Their seeds contain about 35–40% protein and 20% lipids, making them the most efficient plant-based source of the protein in large-scale production [2]. It should be noted that for the European Union, soybeans are primarily an imported commodity: first, the EU consumes 30–35 million tons of soy products annually, while domestic production in 2023 amounted to only 3 million tons [3]. The resulting shortfall of 27–32 million tons is covered by imports from Brazil, the United States, and Argentina. The problem is not new, but in the recent years it has become more acute for several reasons. Since 2022, geopolitical instability has made the issue of food security more pressing and acute than ever. At the same time, pressure from environmental commitments is mounting: imported soybeans are traditionally linked to deforestation in South America – a problem that contradicts the EU’s own stated goals regarding climate neutrality. Finally, consumer demand within the EU for GMO-free and certified organic products is growing significantly faster than production capacity.

All of this together places organic soybeans in an unusual role: not merely an agricultural niche for specialized farmers, but a potential strategic asset in the food security system of an entire region. Whether these expectations will be met depends on the extent to which agronomic realities align with the ambitious goals outlined in EU strategic documents. Therefore, addressing this issue is timely and requires a scientific basis for resolving the problem.

The analysis of recent studies and publications. Today, 79% of global soybean production is genetically modified, meaning soybeans with properties that have been specifically altered through genetic engineering. However, European consumers prefer to consume organic plant-based products, including soybeans, provided that the producer can guarantee certain safety standards for the products.

The most comprehensive analysis of the state of the EU organic soy sector was conducted in a study prepared with the support of the French Agence Bio in 2024 [4]. The document covers data for all the member states for 2017–2022 and allows one to track not only volume trends but also structural shifts: the growth in the share of production intended for human consumption (from ~10% to 15%) and the geographical concentration of production around France and Romania. At the same time, the report notes that the EU’s self-sufficiency rate for organic soybeans has declined from 64% to 61%, indicating an inverse relationship between production growth rates and demand.

The fundamental scientific basis for assessing the potential of soybean production in Europe was established by a large-scale study by Reckling et al. (2024), published in *Scientific Reports* [2]. The authors showed that the average soybean yield under rainfed conditions in the region – from the southern Great Britain to the Mediterranean - is 3.1 ± 1.2 t/ha.

For comparison: in North America, this figure reaches 3.5 t/ha. Thus, the following conclusion can be drawn: without targeted breeding of resilient varieties adapted to the arid conditions of the south and the shorter growing season of northern Europe, no significant breakthrough in yield should be expected.

In its 2024 annual report, Eurostat noted that the area under organic farming in the EU had expanded to 16.9 million hectares in 2022 − representing 10.5% of agricultural land [5]. The leaders in this regard are Austria (27%), Estonia (23%), and Sweden (20%). It is noteworthy that these three countries are among the most active advocates for organic agriculture at the EU level, demonstrating a link between national policy and statistical achievements.

At the molecular-genetic level, the Richel-Bielska group and their co-authors (2024) [6] had investigated the problem of soybean adaptation to Central European conditions. The Polish experience clearly illustrates a broader trend: over the past 50 years, agroclimatic zones have shifted approximately 500 km northward, which theoretically opens up new areas for crop cultivation. However, realizing this potential in practice requires not only warming but also suitable genotypes – ones resistant to spring frosts and capable of maturing within a shorter growing season. Similar conclusions regarding the priority of breeding for stress tolerance and ease of harvesting were reached by Vymislitskyi et al. during a multi-location study of soybean genetic resources (Frontiers in Plant Science, 2025) [7].

The strategic dimension of the issue is documented in two key analytical reports by the European Parliament’s Parliamentary Research Service - on the EU Protein Strategy (2023) [8] and on alternative protein sources (2024) [10]. According to their data, the EU is only 24% of self-sufficient in oilseed and protein meal, and 20 of the 28 approved national CAP strategic plans for 2023–2027 provide for direct support to producers of legumes and protein crops. This is a significant signal: the regulatory framework is gradually adapting to the recognition of the protein deficit as a systemic problem.

The purpose of this article is to assess the actual role of organic soybeans in EU food security based on current statistical data and scientific publications from 2020–2025: to determine to what extent the recorded growth in production meets market needs, what agronomic and structural constraints stand in the way, and what strategic tools are capable of significantly changing the situation.

Results of the Research. It was found that over a six-year period (2017–2022), organic soybeans in the European Union demonstrated one of the highest growth rates among organic crops. The area under cultivation increased from 60,000 to 155,000 hectares (+158%), and production rose from 144,000 to 280,000 tons (+94%). These figures seem impressive. However, if we look at the self-sufficiency rate, it declined from 64% to 61% over the same period because the demand grew even faster (Table 1, Fig. 1).

The geographical landscape of production has also changed. France and Romania have traditionally dominated the sector, accounting for more than half of Europe’s total organic soybean production.

Table 1

Trends in organic soybean production in the EU (2017–2022)

Indicator	2017	2022	Change
Area planted with organic soybeans (thousand hectares)	60	155	+158%
Production volume (thousand tons)	144	280	+94%
Self-sufficiency rate (%)	64	61	−3
Percentage of a person's diet (%)	~10	15	+5

Source: Compiled based on data from Agence Bio (2024) [4]

At the same time, the record harvest of 2023, as reported by Donau Soja [3], spanned a much wider range of countries: Austria (+15%), Hungary, Romania, and Nova, indicating a gradual geographic diversification of the sector. It is noteworthy, however, that the 2022 harvest turned out to be somewhat lower than the previous one - due to an abnormal drought in the summer in Central and Southern Europe. This is not a random glitch, but a harbinger of systemic risk.

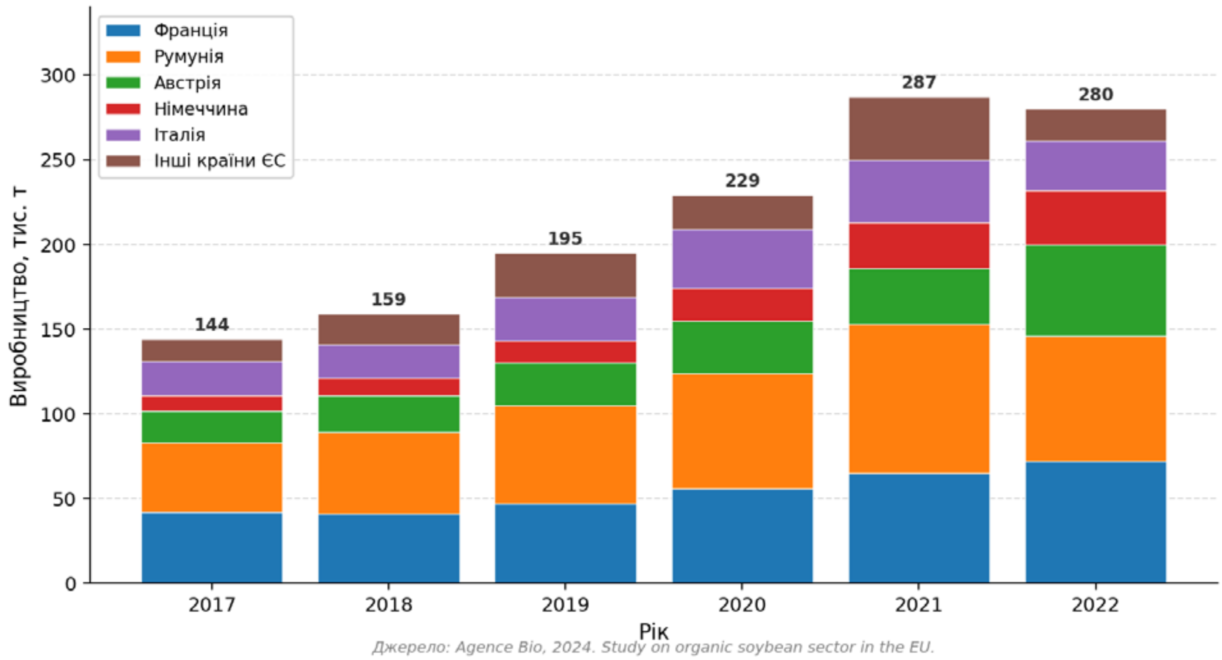

Fig. 1. Trends in organic soybean production in the EU by year, 2017–2022
Source: Compiled from data by Agence Bio (2024) [4]

The past five years have seen a significant overhaul of the regulatory framework directly affecting organic soybean production. The central document remains the “Farm to Fork” Strategy, adopted by the European Commission in May 2020 [9].

It sets three interrelated goals for 2030: to increase the share of organic farming to 25% of agricultural land, to halve the use of chemical pesticides, and to reduce the use of synthetic fertilizers by one-fifth.

If these goals are achieved, conditions for organic soybean production in the EU will improve dramatically − but only if market demand is supported by adequate processing infrastructure.

The EU Organic Action Plan for 2021–2027 (COM(2021)), adopted in March 2021 [10], provides the further details: minimum criteria for organic products in public procurement, and at least 30% of the Horizon Europe budget allocated to organic-related topics. Significantly, the document explicitly mentions for the first time the need for a balance between supply and demand growth – without this, as the plan's authors note, expanding acreage risks collapsing premium prices and undermining farmers' economic motivation.

The Common Agricultural Policy for 2023–2027 supports these strategic objectives with financial instruments. According to EPRS [8], 20 of the 28 approved national strategic plans provide for direct coupled support for producers of legumes and protein crops – with a total increase in support for the protein sector of one-quarter (Fig. 2.). This is not just a number: for an organic farmer growing soybeans, the difference between having and not having such support can mean the difference between profit and loss.

It is worth highlighting the EU Deforestation Regulation (EUDR), adopted by the European Parliament in 2023. It will require companies to prove that their products – particularly soy – have not contributed to deforestation after December 31, 2020. In practice, this will inevitably increase the cost and complexity of importing soybeans, while making local organic products more competitive in the EU market. The effect will likely be gradual, but strategically significant. In general, the regulatory framework creates a favorable environment. But strategic documents alone do not guarantee a bountiful harvest. Standing between ambition and results are agronomic realities, which are the focus of the following section.

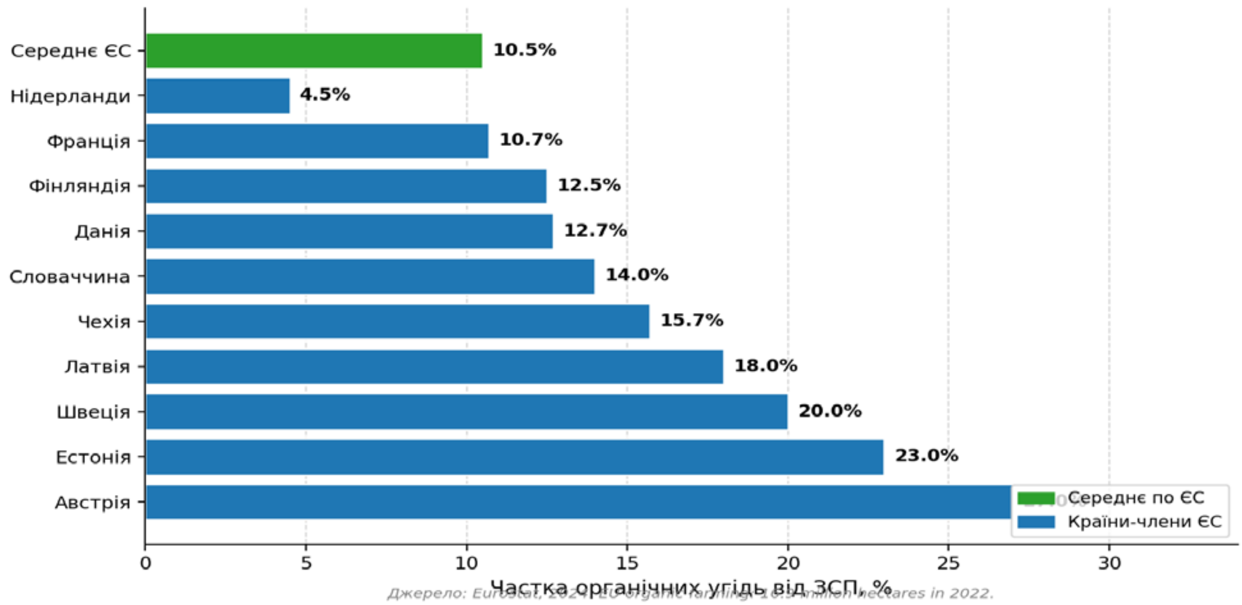

Fig. 2. *Share of organic farming in the total agricultural area of EU countries, 2022 (%) Source: made from Eurostat data (2024) [5]*

The most obvious challenge is yield. The average soybean yield under non-irrigated conditions in Europe is 3.1 ± 1.2 t/ha [2], whereas in North America it is 3.5 t/ha. When transitioning from conventional to organic farming, this gap widens even further: according to various estimates, organic production yields 20–25% less under controlled conditions and up to 50% less in production settings [9]. These figures do not mean that organic soybeans are inefficient - but they do mean that achieving the same production volumes requires more land, which puts pressure on both the price and availability of land.

Weed management is the second most significant challenge, which farmers often describe as even more problematic than yield. In organic systems, herbicides are not an option, and soybeans are a crop that is slow to close the row spacing. The solution is mechanical inter-row cultivation and the selection of varieties with better foliage and taller stems, which gives the plant a competitive advantage over weeds [7]. However, such varieties are still being developed for Central European conditions.

Climate instability has a twofold effect. On the one hand, global warming opens up new opportunities: over the past 50 years, agroclimatic zones have shifted approximately 500 km northward [6], and crops are now actually being grown in Poland and the Czech Republic in areas where their agronomic potential was in doubt just 20 years ago. On the other hand, droughts in the south and late spring frosts in the north remain just as real risks, and forecasts by Nendel et al. (2023, cited in [7-10] indicate that drought stress will become the dominant limiting factor in the medium term.

The solution of this problem lies in plant breeding. Polish studies [6, 7] have identified promising genotypes with improved adaptability to local conditions, resistance to pod shattering, and indeterminate growth habit. The latter is particularly important for organic production: plants with determinate growth are prone to uneven ripening, which complicates harvesting without chemical desiccation − which, again, is prohibited in organic systems.

The premium price is what keeps organic soybean producers in the game. According to Donau Soja [3], in 2023, non-GM soybean meal in Northern Germany traded at a premium of 30–35 euros/ton over the price of its GM counterpart. For organically certified soybeans intended for food products, the premium is even higher, though more volatile. Notably, in 2023, this premium declined slightly- due to rising non-GM imports from Brazil and Ukraine-but demand remains structurally stable.

It is important to understand that organic soy in the EU is increasingly being used for human consumption rather than animal feed. The share of production destined for human consumption has risen from ~10% to 15% in just six years [3]. Behind this lies a broader trend: the EU market for plant-based proteins – tofu, soy milk, plant-based meat–is projected to grow by over 50% over the next decade [8]. For organic producers, this means higher profit margins and more stable demand than in the feed segment.

Another source of competitive advantage is the EUDR, which has already been mentioned. Once the regulation is fully implemented, importing companies will be required to provide documentary evidence that their soy is not linked to deforestation. This will increase administrative costs for imports and strengthen the position of local producers – those who can already ensure a transparent supply chain today.

The case for organic soybeans goes beyond food security in the narrow sense. Symbiotic nitrogen fixation, facilitated by the nodule-forming microorganism Bradyrhizobium japonicum, makes soybeans a natural “restorer” of soil nitrogen in crop rotation. For organic farms, where synthetic fertilizers are prohibited, this is not just an agronomic bonus – it is a prerequisite for an effective farming system. In some four-field organic crop rotation models, the inclusion of soybeans significantly reduces the need for subsequent crops to rely on additional nitrogen sources.

A systematic review of organic farming in the EU (2000–2023), published in Frontiers in Sustainable Food Systems, confirms that organic farming systems are consistently associated with higher biodiversity, better soil structure, and lower pesticide use. For soybeans, this also has practical implications − less pressure from diseases and pests in the fields with documented agrochemical “purity,” which meets the demands of the processors.

Finally, we cannot fail to mention the climate aspect. According to researchers’ estimates, over 30% of the land needed to meet the EU’s food needs is located outside its borders [9]. Every ton of soybeans grown in Europe instead of being imported from Brazil not only reduces the carbon footprint of transportation but also lessens the indirect pressure on tropical forests.

Conclusions and Prospects for Further Research. The analysis which was conducted allows us to draw several key conclusions.

1. Organic soybean production in the EU is growing rapidly – but not fast enough. Between 2017 and 2022, acreage increased by 158% and production by 94%, yet the self-sufficiency rate fell from 64% to 61%. This means that in order to truly reduce import dependence, production growth must outpace demand growth; for now, the opposite is true.

2. Agronomic challenges are real and will not disappear on their own. Lower yields under rain-fed conditions, the difficulty of weed control, climate instability, and a lack of specialized varieties - all these problems require targeted scientific and practical solutions. Public funding for breeding programs focused on organic farming is of particular importance.

3. Market conditions remain attractive for those willing to invest in quality and supply chain transparency. The premium for organic and non-GM soybeans, the growth of the food market segment, and the EUDR together create long-term demand capable of offsetting higher production costs.

4. Organic soybeans are part of the solution to the EU’s protein dependency problem, but not the entire solution. Their contribution will only be meaningful if breeding science, agricultural policy, and market infrastructure develop in a coordinated manner, rather than through separate, isolated efforts.

Areas for further research include a comparative assessment of the economic efficiency of organic soybean production in various agroclimatic zones of the EU, an analysis of the barriers to scaling up organic supply chains, as well as – a separate and highly relevant topic – Ukraine's potential as a supplier of GMO-free to EU markets in the context of post-war reconstruction and European integration processes.

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АНОТАЦІЯ
РОЛЬ ОРГАНІЧНОЇ СОЇ У ЗАБЕЗПЕЧЕННІ ПРОДОВОЛЬЧОЇ БЕЗПЕКИ ЄВРОПИ

У статті висвітлено питання щодо забезпечення продовольчої безпеки за рахунок використання найбільш поширеної зернобобової культури сої. Це питання, все частіше постає перед аграрниками та урядовцями ЄС: чи здатна органічна соя реально зменшити залежність Євросоюзу від імпортованого білка? Наводиться динаміка виробництва цієї культури із 2017 по 2022-й, а саме зростання площ посіву під органічною соєю з 60 до 155 тис. га, збільшення виробництва на 94%, проте рівень самозабезпечення ЄС не підвищився, а навпаки – знизився з 64 до 61%, але швидше зріс попит. Виявлено ключові агрономічні обмеження - нижча врожайність у богарних умовах (3,1 проти 3,5 т/га порівняно з Північною Америкою), дефіцит спеціалізованих сортів, уразливість до посух. Ринкові умови залишаються привабливими для тих, хто готовий інвестувати в якість і прозорість ланцюга постачання. Преміум-надбавка для органічної та non-GM сої, зростання харчового сегменту ринку і EUDR разом створюють довгостроковий попит, здатний окупити вищі виробничі витрати. Органічна соя – частина вирішення проблеми білкової залежності ЄС, але не все вирішення. Її внесок буде реальним лише якщо селекційна наука, аграрна політика та ринкова інфраструктура розвиватимуться скоординовано, а не окремими ізольованими зусиллями.

Перспективами подальших досліджень є порівняльна оцінка економічної ефективності органічного соєвого виробництва в різних агрокліматичних зонах ЄС, аналіз бар'єрів для масштабування органічних ланцюгів постачання, а також – окрема і надзвичайно актуальна тема – потенціал України як постачальника органічної ГМО-вільної сої на ринки ЄС в умовах повоєнної відбудови та євроінтеграційних процесів.

Ключові слова: *органічна соя, продовольча безпека, Європейський Союз, самозабезпечення, білкові культури, органічне землеробство, сталий розвиток.*

Табл. 1., Рис. 2., Літ. 10.

Інформація про автора

Jolanta Puczel, dr inż. International Academy of Applied Sciences in Łomża, Poland, jolanta.puczel@wp.pl, ORCID: https://orcid.org/0009-0009-1713-7058.

Bronisław Puczel, dr inż. International Academy of Applied Sciences in Łomża, Poland, bronekpuczel@gmail.com, ORCID: https://orcid.org/0009-0008-5097-9639.

Йоланта Пуцель, доктор інж. Міжнародна академія прикладних наук у Ломжі, Польща, bronekpuczel@gmail.com, ORCID: https://orcid.org/0009-0009-1713-7058.

Броніслав Пуцель, доктор інж. Міжнародна академія прикладних наук у Ломжі, Польща, bronekpuczel@gmail.com, ORCID: https://orcid.org/0009-0008-5097-9639.

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