BIOLOGIZATION

The Key to Sustainable Agriculture
Catalogue of good practices

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Source: Anna Rosa.

Introduction

1. Introduction

We present you with a **Catalogue of good practices**, developed by the team engaged in the ***Biologization: The Key to Sustainable Agriculture*** project financed by the Erasmus+ National Agency, i.e. the Foundation for the Development of the Education System (FRSE). The project was completed under the ERASMUS+ programme, Action 2: Strategic Partnerships.

The present publication is the effect of theoretical studies as well as the practical experience that the project partners gained in the course of farm visits. The partners learning together – exchanging knowledge and experiences, comparing practices and methods in use, and also comparing the techniques applied in land cultivation, enabled such a catalogue of biological farming best practices to be developed (biologization sometimes call biological farming, regenerative farming). Best practice is understood to mean a procedure that has been shown to lead to desirable results.

With the development of civilisation, the Earth is coming under growing pressure from humans. The degradation and devastation of the natural environment involves the atmosphere as well as anthropogenic changes in the hydrographic network and soil layer. **THE SOIL AS A FUNDAMENTAL RESOURCE FOR FOOD PRODUCTION IS OF KEY VALUE TO HUMANS.**

This becomes obvious when you consider that around half the land in the European Union is land that is being farmed. At a time of climate change and its consequences and frequent food crises (e.g. caused by the COVID-19 pandemic), it is extremely important, even essential to propagate an idea of agriculture that promotes a sustainable farming system (Dudek, Śpiewak, 2022). This involves the rational use of natural resources and taking advantage of the latest technological solutions enabling the use of artificial fertilisers and pesticides to be reduced (Kalinowski, Komorowski, Rosa, 2021). Farming practices that are environment- and climate-friendly prevent the depletion of organic matter in the soil, but also affect production volume and costs.

Biological farming issues are an inherent part of the current discussion on the European Green Deal (EGD), the EU's new strategy for supporting sustainable development. The idea behind it is a climate-neutral economy in the EU, which is to be achieved by 2050 and applies to all areas of the economy, i.e. including the energy sector, transport, industry, and agriculture. From the viewpoint of the agricultural sector, two EU strategies are the most important for implementing the EGD:

- **The Farm to Fork Strategy**, which focuses on creating a fair, healthy and friendly environment for the food system. This strategy assumes reducing the use of pesticides, antibiotics and fertilisers and boosting organic farming.
- **The Biodiversity Strategy**, which assumes the protection and restoration of ecosystems and biodiversity in agriculture and forests as well as the aquatic environment (Commission, 2020). In the light of this document, farming practices should counteract climate change, protect the natural environment, and not reduce biodiversity (Heinrich Böll Stiftung, 2020).

Soil is one of those natural resources that degrade easily, while also being the main factor of production in agriculture. That is precisely why the partners in the Biologization: The Key to Sustainable Agriculture project focused their attention on this element of the environment. The aim has been to characterise selected best practices related to soil, and their popularisation as useful models for agriculture stakeholders (or various groups with ties to agriculture) to follow.

The authors realise that the catalogue presented here in no way exhausts the list of all solutions that benefit the soil and food consumers, but it offers solid guidelines as well as being an invitation to discuss and use the gathered experience in practice. Readers may and even should modify and improve the best practices that they find here, but above all, they should adjust them to the unique character of their own farms.

The Catalogue comprises six sections, an introduction, and a profile of the partners taking part in the project. The authors start by introducing the idea of sustainable development, with a special focus on agriculture. The next segment discusses the importance of this sector in maintaining and increasing food, environment and climate security. From there, the catalogue becomes more practical, presenting the innovative 5C Code for biological farming developed by the Top Farms company, characterising the soil, and outlining selected biological farming practices. The next segment presents some recommendations, one of the effects of the project's implementation, addressed to different groups: entities implementing agricultural policy, agricultural advisers, the scientific research sector and, finally, local self-governments and the public. The publication concludes with a brief presentation of the partners taking part in the Biologization: The Key to Sustainable Agriculture project.

The project involved research workers from scientific research units dealing with agricultural and rural development issues. They included specialists in economics, sociology, and agronomy. Business practitioners also took part in the project; they included employees of large-scale farms from three countries, i.e. Poland, the Czech Republic and Slovakia, who were responsible for company and human resources management, supply chains and crop production, as well as agronomists and mechanisation specialists. The scientists taking part in the project are employed at the Institute of Rural and Agricultural Development of the Polish Academy of Sciences and the Poznań University of Life Sciences. The biological farming practitioners are employees of the Top Farms Group.

This composition of the project group enabled the expected effects to be achieved, those effects being the development of a catalogue of biological farming best practices and the dissemination of this idea and the attendant experiences among a wide prospective audience in Poland, the Czech Republic and Slovakia as well as other EU countries.

The authors would like to thank everyone involved in the Biologization: The Key to Sustainable Agriculture project, especially the participants of the international meetings, who gave us their time and kind attention as we gathered the information we needed to produce this study. Our thanks also go to Prof. Walenty Poczta, PhD hab., for his review and valuable remarks.

Source: Anna Rosa.

Source: Anna Rosa.

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Source: Anna Rosa.

Sustainable agricultural development

2. Sustainable agricultural development

2.1. Sustainable development – definition

The concept of sustainable development originates from international politics and was first used in 1987 in a report by the U.N. World Commission on Environment and Development: *Our Common Future* (the Brundtland Commission). It was defined as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs". The concept slowly gained in popularity, which was followed by successive, more and more complex definitions. At the Earth Summit in Rio de Janeiro in 1992, sustainable development was described as "the preservation of natural resources for future generations combined with the necessity to improve the quality of life stemming, among other things, from enormous and growing poverty in countries of the so-called Third World and in poverty areas in developed countries as well as the steady increase of the Earth's population". Other authors have indicated that it is "such a course of inevitable economic development that would not significantly or irrevocably undermine human beings' lives, would not lead to the degradation of the biosphere, and would reconcile the laws of nature, economics and culture" or "the integration of the social, economic and environmental aspects of human activity to ensure a better standard of living".

The (selected) definitions quoted above show that sustainable development can be considered in two fundamental approaches:

- **temporal**, manifested in intergenerational solidarity and a long-term perspective,
- **based on "deals" (economic, social, and environmental)**, above all understood in terms of the need for their mutual integration.

2.2. Sustainable development – potential conflicts

In principle, both approaches are right, although for sustainable development not to remain a purely theoretical concept but to be effectively implemented, it is essential to become aware of potential conflicts that occur but are possible to prevent, at least partially.

First of all, it needs noting that it is difficult today to accurately judge the needs of future generations. The rapid development of science and technology gives successive generations new opportunities, possibilities and challenges unknown to past generations and often impossible to predict. People from the post-war baby boom, who grew up in the 1960s and became fully active professionally in the 1970s, were unable to predict the opportunities and dangers caused by mass-scale use of the internet, mobile phones and satellite navigation. Nevertheless, today it might be assumed that, similarly to the present day, aspects such as political and economic stability, environment quality acceptable to living organisms, and appropriate social relations will be necessary for normal development also in the future. Hence, action that is being taken to achieve, for example, the economy's lower energy-intensiveness and reduced emissions of harmful substances, coupled with the creation of new jobs, seems to be an obvious path.

Similarly, in the case of the integration of the three fundamental deals, possible conflicts at their junction should be expected. Without exhausting the subject, a few basic ones include:

- **the environment and business**: companies strive for profit maximisation, while environmental protection measures often require capital outlays, which generates costs and reduces profits,
- **business and society**: companies' natural goal of maximising their economic results stands in contradiction to employees' equally natural need for maximally high wages,
- **the environment and society**: contemporary civilisation (which is increasingly becoming "urban") benefits from the "artificial" environment formed by housing, public infrastructure, and other attributes of modernity. Many of them require a lot of space, thus limiting the possibility for wild nature to function freely.

However, the aforementioned conflicts and dilemmas (and many others not mentioned here) have to be prevented, or at least diminished. As pointed out earlier, human existence (both individual and social) requires appropriate (i.e. at least minimally acceptable) environmental, social and economic parameters. Humans are biological as well as social beings.

At this point, we need to consider the importance of political and economic instruments in resolving conflicts occurring along the economy–society–environment line. The fact is, businesses' natural (and, in principle, from the point of view of economic and civilisational development, also healthy) drive to maximise their economic results does not allow them to voluntarily undertake some actions for the benefit of the environment and society. In this case the intervention of public institutions (i.e. politics) is essential, because external costs are involved. In the most general terms, these appear when they are incurred, but not by the entity taking part in a sale and purchase transaction. For example, a rubbish dump is built near a hotel, substantially reducing the hotel's income even though the hotel does not share in the profit generated by the dump. A similar situation occurs when harmful substances discharged by an industrial plant cause diseases among the local population (thus generating costs in the form of medical treatment and sick leave), even though these people are not employed at the factory and do not benefit from it financially in any way. It needs noting that in both these examples, the environment is the "transmission belt" of the external costs. Even though such occurrences are seen to be obviously unfair, the entities in question actually cannot undertake measures to change the situation. Any voluntary actions would contribute to increased costs of production, and thus to a lessened competitive edge, and ultimately to bankruptcy. In the final outcome, it would be those entities that refrained from trying to achieve justice voluntarily that would remain on the market. Hence, the intervention of public institutions, in the form of unified norms to be followed by everyone, is a necessity.

However, there are areas in which the natural activity of business is compatible with the social interest as well as environmental needs. This happens when certain actions contribute to reducing a company's internal costs. In such situations, the company's profits do not decrease but grow.

An issue that future generations are very likely to face might be the depletion of non-renewable energy resources. Regardless of the actual volume, their amount is limited by definition. However, reducing the energy intensity of production (and its material intensity, too) lies in a company's microeconomic interest. In addition, capitalism is strictly connected with generating numerous innovations, while large global corporations have sufficient research and development potential to steadily increase the energy efficiency of equipment used in the economy. In this case, the intervention of public authorities is either unnecessary or should be limited to educating staff for business as well as financing and supporting fundamental research.

2.3. Implementation of the sustainable development principles – critical conditions

Based on what has been said so far, we can identify a number of key necessary conditions for real-term implementation of sustainable development principles:

- **economic development and scientific and technological progress**: fulfilling basic individual and social needs (e.g. food security) and developing technical instruments of environmental protection,
- **political stability**: essential for the effective performance of the three deals, i.e. ensuring economic security, social stability and environmental protection law,
- **social acceptance**: necessary especially for implementing the environmental deal (ecological awareness).

Sustainable development in its guidelines constitutes a global concept, both in terms of actually undertaken measures and as a scientific concept. Nevertheless, it may cover individual countries or regions as well as sectors of the economy.

2.4. Agriculture and its role in implementing the concept of sustainable development

Agriculture plays a special role in the implementation of the sustainable development concept. First of all, it provides basic and strategic foodstuffs essential for individuals as well as entire societies to function. Secondly, it generates income for a significant group, comprising farmers as well as employees of businesses with ties to agriculture (mainly food processing, farming supplies, and institutional and business services for farms). Thirdly, agricultural production takes place on large areas and uses up environmental resources. Fourthly, agriculture itself has an impact on the environment's condition. Different aspects related to agricultural production, mutually intertwined, thus affect social, economic and environmental issues. The time factor is equally important, including intergenerational solidarity. Agriculture is founded on soil, whose quality determines both the type of production and its technical efficiency. The production technologies currently in use can both worsen and improve its production capacity in future. Intergenerational solidarity requires the latter approach, especially if we consider that on a global scale, the possibilities of obtaining land for farming purposes are very limited, and that global population growth is to be expected.

The following definitions of sustainable agricultural development are related to the issues outlined above:

- "Sustainable agriculture means the production of quality goods and services in the long term, taking into account the economic and social structure in such a way that the base of renewable and non-renewable resources is preserved."
- "The orientation of agriculture towards a sustainable system is increasingly widely accepted ... This creates chances for reconciling the necessary growth of agricultural production to feed the world ... without increasing the pressure on the environment."
- "Such management of agricultural resources that makes it possible to satisfy changing needs while preserving the basic natural resources."
- "Such protection of the agricultural production space that will ensure, now and in the future, the production of agricultural raw materials in the amount necessary to feed the human population and of quality corresponding to human health needs, at the same time giving farmers and their families opportunities to achieve their life goals."

Special attention needs to be given to the relations between agriculture and the environment, which – as mentioned earlier – are mutual in character. On the one hand, appropriate soil quality parameters and weather are necessary for agricultural production, while on the other, agricultural operations themselves have a strong impact on the soil and climate. It also needs mentioning that this may be a positive or negative impact, depending on the type of production and, above all, the production techniques used. The very essence of agriculture is connected with transforming extensive areas into artificial agroecosystems that are very different in character from natural ecosystems. For example, almost half of Poland's area is taken up by arable land, whereas without human interference these would mainly be forests. However, change does not always have to mean degradation. The biodiversity of artificial meadows is usually greater than that of natural forests. Of course, the biodiversity of farmland is relatively small, but even this does not have to lead to the soil's degradation. What is important is that farmers follow appropriate agrotechnology procedures, such as rational crop rotation, fertilisation (including using natural fertilisers) and agricultural practices. **PROPERLY CONDUCTED FARMING CAN NOT ONLY PREVENT THE SOIL'S DEGRADATION, BUT MIGHT EVEN IMPROVE ITS BIOLOGICAL ACTIVITY COMPARED TO ITS NATURAL STATE.**

Similar correlations occur between agriculture and the climate. Here, too, production depends on the climate zone, while greenhouse gas emissions are one of the causes of climate change. The difference in relation to the soil is that the farmer is unable to change the existing state. Farmers have to adjust to a given climate, and their individual practices have a negligible impact on its global changes. That is why in this case, the measures that are needed are those based on agricultural and environmental policy instruments, supported by scientific research.

Source: Anna Rosa.

2.5. The need for environmental protection and the food-supply function of agriculture

The feeding function of agriculture in conjunction with environmental protection needs, including the soil and climate, can be considered at the level of the whole sector in individual countries or at the level of individual farms and farm groups.

At the global level, research exists in which the volume of agricultural production is defined by the amount of energy produced during the production process (Sadowski, 2017). This approach results from the fact that the amount of energy produced is the most objective measure, its significance being the same regardless of place and time. The value of money changes in successive years, while natural measures of individual products (e.g. tonnes of meat and tonnes of sugar) are unsuitable for comparison. In the aforementioned research, the amount of energy produced was compared with the amount of greenhouse gases emitted.

Alongside these basic parameters, other important aspects related to agricultural production were analysed as well. Five countries were chosen for the comparison, one from each continent: Brazil, China, the United States, Zimbabwe, and France. The analysis covered the years 1961–2010, i.e. the period for which the relevant FAOSTAT data were available. (Figure 1.–Figure 4.).

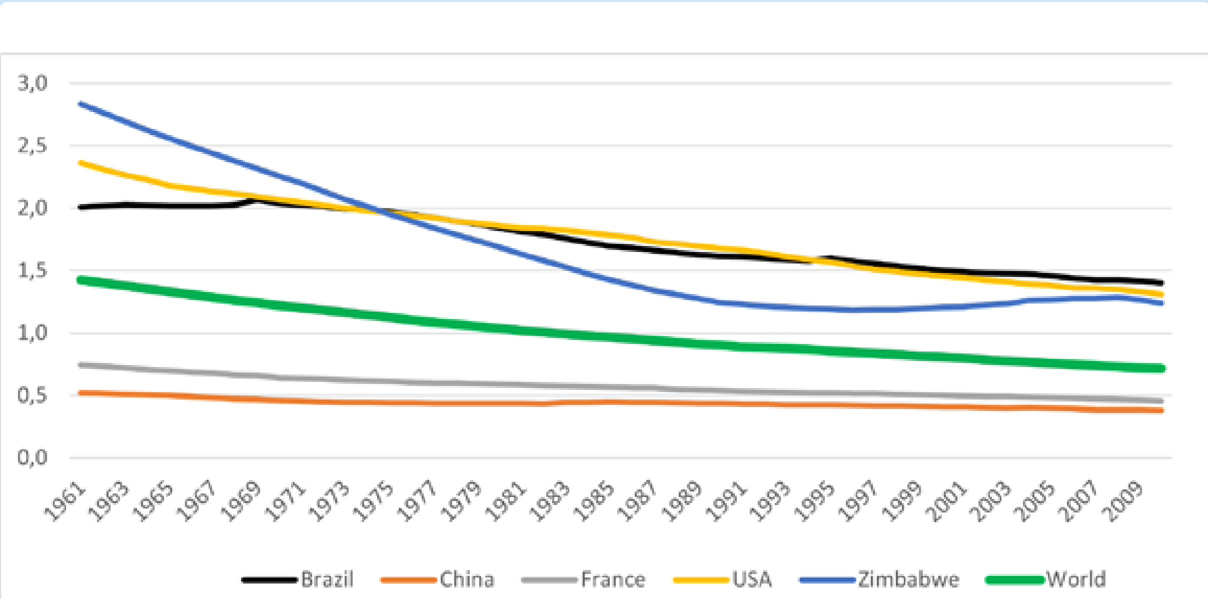


Figure 1. Arable land per capita in selected countries in the years 1961–2010 (ha/person)

Source: own study.

You can see that the amount of arable land per capita decreased in the whole world and in the individual countries (Figure 1.). This was caused by the almost doubled world population coupled with limited possibilities to obtain new farmland. Among the countries in the study, this trend was the most noticeable in Zimbabwe.

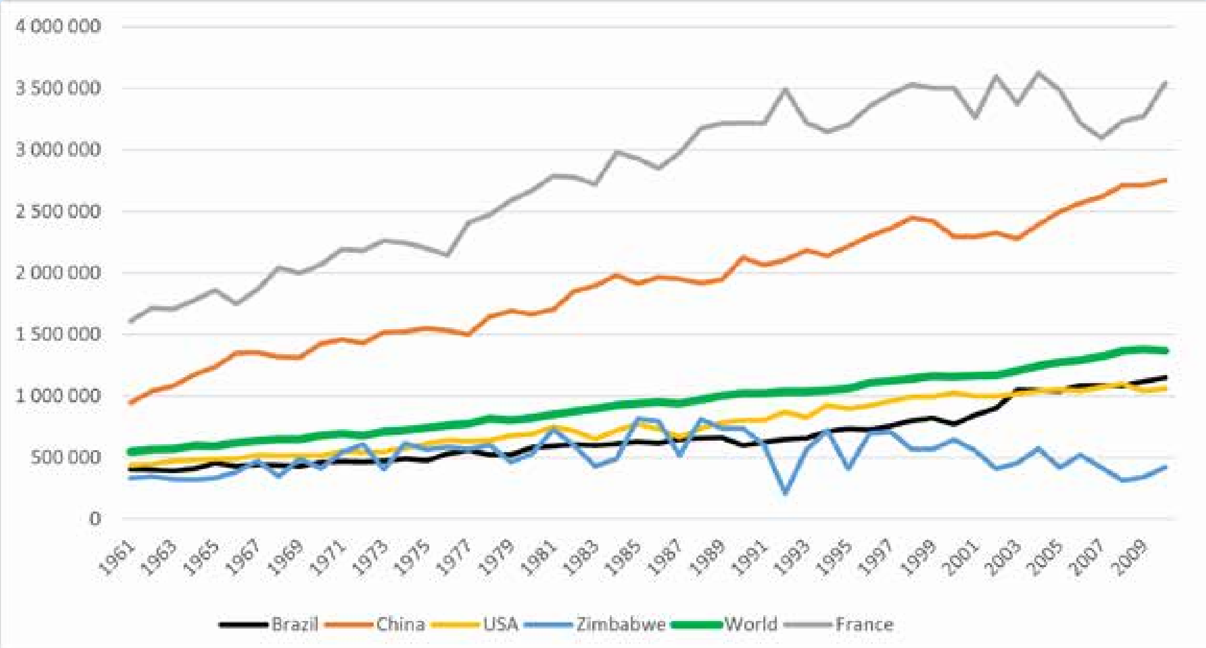


Figure 2. Production of agricultural energy in selected countries in the years 1961-2010 (kcal/ha)

Source: own study.

Nevertheless, the amount of energy produced grew in almost all the countries in the study and globally, which in practice means an improvement in soil productivity (Figure 2.). This was the effect of multifaceted progress in agriculture (mechanisation-related, chemical, biological, and organisational). On the other hand, it was also a response to the demographic explosion in the second half of the 20th century. The smallest increase (or virtually stagnation) can be observed in Zimbabwe, where such progress was the smallest.

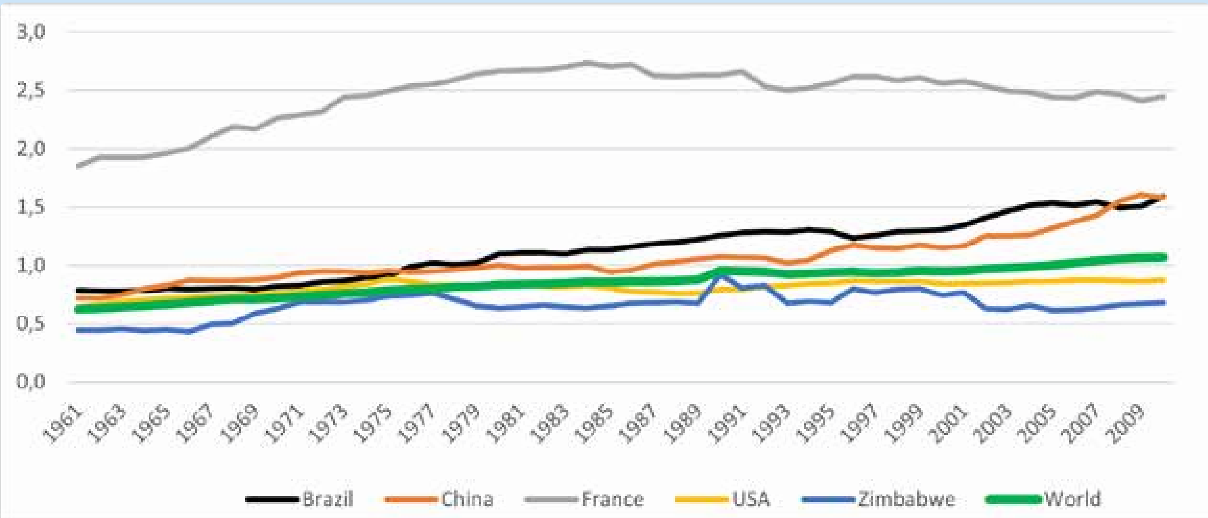


Figure 3. Emission of agricultural greenhouse gases in selected countries in the years 1961-2010 (t CO_2 eq/ha)

Source: own study.

The environmental cost of agricultural energy production was the emission of agricultural greenhouse gases from every hectare of cultivated farmland (Figure 3.). Its levels vary from country to country, though growth is observed everywhere – the result of necessary production growth. By far the highest level of greenhouse gas emissions is seen in Europe's France, due to favourable natural conditions conducive to intensive farming as well as the use of industrial means of production. Nevertheless, starting in the 1990s there is a noticeable stagnation in emissions, and even a slight drop. This period is concurrent with changes in the Common Agricultural Policy, which became increasingly focused on solving environmental and climate problems.

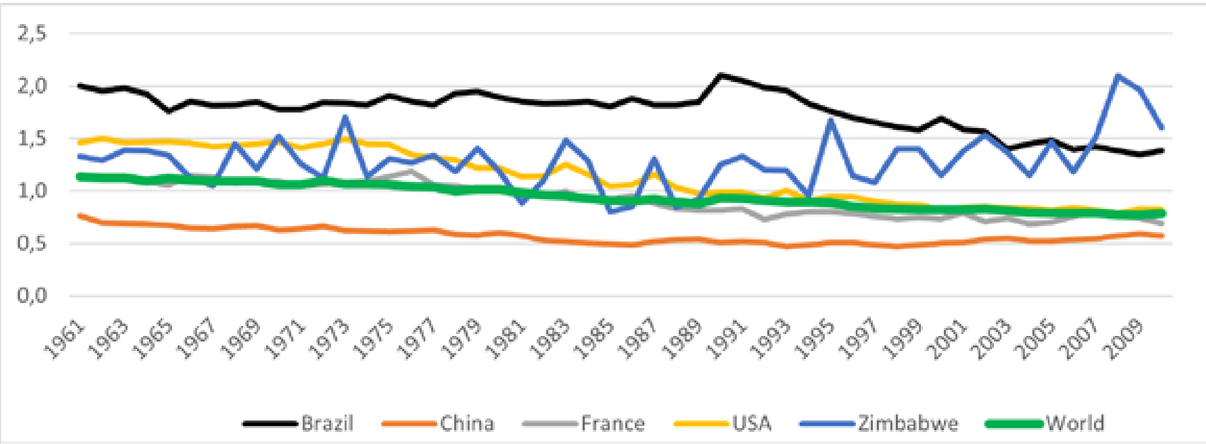


Figure 4. Environmental cost intensity of agricultural production in selected countries in the years 1961-2010 (kg CO_2 /thousand kcal)

Source: own study.

The situation is different when we analyse the environmental cost intensity of agricultural production as the ratio of greenhouse gas emissions to the amount of energy produced (Figure 4.). This decreases in most countries, which is a kind of "side effect" of progress in agriculture. The improved technical effectiveness of machinery, higher effectiveness of chemicals increasing crop yields, and genetically better plants and animals translate into less greenhouse gases in relation to production. In this respect, China has the lowest environmental cost intensity, but also France, i.e. countries with a high level of production and emissions. On the other hand, Zimbabwe, where innovative production methods are less widely used, is characterised by high variability (which also applies to other parameters discussed here) as well as a growing level of environmental cost intensity.

Ultimately, this means that intensive production based on innovative solutions is linked to high but decreasing overall environmental costs, but at the same time enables food security to be achieved and results in relatively low and decreasing production cost intensity.

As mentioned above, issues of agriculture's feeding function in conjunction with soil issues can also be considered at the farm level. Research conducted by A. Sadowski (2012) shows that long-lasting and sustainable farms are the largest in terms of area and report the highest production results (mainly crop harvests), and achieve environmental "friendliness" despite the relatively high use of chemical means of production (fertilisers and pesticides). **INSOFAR AS THE BEST PRODUCTION AND ECONOMIC RESULTS OF THE LARGEST FARMS SEEM OBVIOUS, THEIR FULFILMENT OF THE DEMANDS OF ENVIRONMENTAL SUSTAINABILITY DOES NOT.**

According to popular understanding, small farms, which do not use chemicals increasing crop yields, are the most "environment-friendly". In reality, this is not true, and the explanation lies in several mutually linked causes. Firstly, large farms have appropriate technical equipment that enables them to use chemicals not only in large amounts, but above all rationally. This affects the production volume. At this point, one might note a certain analogy to the countries described earlier that use intensive production methods and at the same time report low environmental cost intensity. Secondly, large farm operators usually have the skills and training to use the right agrotechnology. Thirdly, in the case of large farms, agriculture is the family's main source of income, so concern for soil quality is a social and economic imperative. Among other things, this is why long-lasting and sustainable farms are characterised by the highest ratio of organic matter in the soil.

Studies conducted at the level of countries and farms lead to the main conclusion that rational (sustainable) intensification of production and the use of advanced solutions not only does not stand in contradiction to the principles of sustainable development, but is in fact essential for its achievement. Extensive production not only does not ensure food security, it also – contrary to popular opinion – generates high environmental costs.

3.

Source: Anna Rosa.

Agriculture vs. food and environmental security

3. Agriculture vs. food and environmental security

Issues of food security and concern for the natural environment in European countries have been the focus of lively interest in many societies “since time immemorial”. Suffice it to say that the ultimate reason why the Common Agricultural Policy (CAP) was established at the turn of the 1950s and 1960s was the lack of food self-sufficiency among the countries forming the European Economic Community and now its legal successor, i.e. the European Union. Looking back, one might say that perhaps the most important of the CAP’s goals was the improvement of productivity in the agriculture of the time, i.e. on farms, because in consecutive years this had a direct impact on increasing the supply of agricultural raw materials to the market, and thus also the supply of food for consumers, which meant improved food self-sufficiency in the population.

Even though more than six decades have passed since action was first taken to shape the supply and demand situation on agricultural markets in the EU member states as part of the CAP, problems of food security continue to be relevant. Despite the fact that the EU countries have managed to achieve one of the highest production efficiencies under the CAP goal of “improving agriculture’s productivity”, the food security of consumers is increasingly coming under threat from changing, often worsening environmental conditions in which agricultural raw materials are produced. Moreover, consumer food security is increasingly being affected by emerging armed conflicts (or other unpredictable crises such as the COVID-19 pandemic), which contribute to breaking supply chains involving food raw materials and products, but also means of agricultural production (Dudek, Śpiewak, 2022). This is confirmed by the European Commission’s communication dated 23 March 2022 – COM [2022] 133, entitled “Safeguarding food security and reinforcing the resilience of food systems”. It suggests that the EU’s agricultural sector is in need of continued support, but should also pay special attention to the environmental transformation, because environmental conditions ultimately decide about the volume and quality of agricultural production (Commission, 2022).

Measures aimed at increasing the resilience and stability of food systems will grow in importance in successive years. At the same time, **A SUSTAINABLE FOOD ECONOMY FORMS AN INTEGRAL PART OF FOOD SECURITY, WHICH WILL BE DEVELOPED THROUGH MEASURES IN THE FARM TO FORK STRATEGY AND THE BIODIVERSITY STRATEGY.**

Among other things, the Farm to Fork Strategy is meant to promote more sustainable food consumption and healthy eating. From the point of view of crop production, the expectation is that pesticide and fertiliser use will be cut by half while maintaining the same soil fertility. Moreover, the amount of land used for organic farming is to grow (to a minimum of 25% of EU farmland). Then, since biodiversity ensures food, water and clean air, and is essential for the environment and to counteract climate change, the EU countries have agreed to form a network of properly managed protected areas. These are to occupy at least 30% of the EU’s land and sea areas. Moreover, the

Biodiversity Strategy assumes the necessity to maintain at least 10% of farmland containing landscape elements with high diversity. These include fallow land, ponds, non-production trees as well as areas subject or not subject to crop rotation.


Source: Anna Rosa.

Source: Anna Rosa.

Although the above strategies highlight issues related to reducing production outlays in the form of industrial means of agricultural production, reducing the productivity of the EU's agriculture is not their purpose. The essence of implementing these changes in EU agriculture as part of the above-mentioned development strategies lies in increasing the use of innovations that contribute to sustainably increasing crop harvests and animal productivity.

4

Source: Anna Rosa.

The idea of biologization

4. The idea of biologization

4.1. Biologization as a unique approach to soil treatment

Topics connected with biological farming are garnering a lot of interest these days. One reason is people's growing awareness: they expect quality food. One might say that biological farming responds to new consumer trends. Today the point is not to produce a lot at low cost, but to produce healthy food and, above all, to produce it without harming the environment. In this, promoting biological (natural) solutions in place of synthetic chemicals (e.g. pesticides) is extremely important.

BIOLOGICAL FARMING MEANS A UNIQUE APPROACH TO THE SOIL. IT INVOLVES A NUMBER OF PRINCIPLES AND ACTIONS AIMED AT IMPROVING SOIL FERTILITY.

Biological soil management is "an agricultural approach which, generally speaking, involves processes, methods and practices aimed at improving soil health, enhancing its fertility by increasing the content of organic matter (humus), measures promoting biodiversity, pursuit of balance in soil composition and choice of appropriate agricultural inputs and practices – to reduce the use of synthetic agrochemicals down to the necessary minimum in favour of natural agents". (https://biologizacja.com.pl/en/).

4.2. 5C Code – project partner practices

The farms involved in the project take an innovative approach to crop growing. The Biological Production Standard followed by the project's partners divides the practices into five areas. These are described in the 5C Code, the five Cs being calcium, carbon, cover crops, cultivation, and culture. The 5C Code lists the five main principles of biological farming; it is not a new regulation or a new standard. It is a tailor-made, unique approach to soil.

Figure 5. The 5C Code

Source: https://biologizacja.com.pl/.

All measures aimed at fertilising the soil start from improving its pH. As one of the project participants underlines, regulating the pH is the foundation of biological farming. The aim is to achieve a slightly acidic or neutral pH, and the way to regulate it is by liming.

Calcium is the most important soil nutrient, the key to building soil fertility. Calcium is a macronutrient taken up in the largest amounts, i.e. its primary role is to nourish plants as the element building cell walls. Also, calcium affects pH, which directly determines the composition of soil microflora. Indirectly through pH, calcium decides about the assimilability and uptake of minerals, and by its proportion to magnesium, potassium and sodium, it affects the soil's structural properties. Using calcium and magnesium is key for improving soil fertility, maintaining soil aggregates, preventing caking and water pooling. A calcium deficit affects the condition of crops. Biological farming at Top Farms requires a balanced and, above all, individual approach to liming to make sure that the soil has the best possible composition.

Carbon, i.e. organic matter, is considered a currency by experts, or the heart of the soil. It is one of the most important components in the circulation of nutrients, because there is no life without it! It is responsible for forming nutritional networks for plants and other organisms, it is the building material of all living organisms and a constituent of humus, which in turn is a source of numerous minerals. With proper soil management, farmers can restore the organic matter content to levels from the time of primeval forests and thus limit the negative impact on the carbon footprint.

Source: Anna Rosa.

Cover crops are understood to mean crops that cover the soil outside the main crop's growth period, contributing to the increase of organic matter and enriching the soil.

Cover crop mixtures are a source of biodiversity and can fulfil many roles simultaneously, which makes them more productive than individual species; for example, they ensure biological nitrogen fixation, at the same time restricting the development of pests by creating conditions for the development of natural enemies; they are a source of sugar for soil microorganisms, thus improving the soil structure; they attract beneficial insects, prevent erosion and inhibit weed growth, while the long roots of cover crops loosen the soil. By supplying the soil with sugar, cover crops provide bacteria with necessary energy and take part in the circulation of matter and the continuation of mycorrhizal processes that are a source of very beneficial glomalin. The widespread use of cover crops is a fundamental practice in biological farming.

Applying the right cultivation methods is yet another way of maintaining soil quality. **Cultivation** – intensive tilling interferes with the soil's biological life. That is why the main premise in soil cultivation should be minimal influence on the soil and maximal elimination of ploughing, while maintaining loosening essential for growth and root development. Deep loosening should be performed without turning, while shallow mixing promotes humification, i.e. the formation of humus, thanks to which soil becomes absorbent like a sponge and can soak up any rainfall, however heavy. One of the more important mottos in the Top Farms Group is: "Till as little as possible, and as much as necessary".

Culture focuses on protecting the environment around the field as a site of production. The main idea here is crop rotation as the most important tool serving to improve soil fertility. It also involves working to reduce the use of crop protection chemicals, landscaping, protecting wildlife, especially bees which are important in the ecosystem, revitalising water features, building retention basins, planting and maintaining tree-covered belts between fields. Thanks to such measures undertaken together, fields covered by biological farming and their surroundings see a significant increase in biodiversity. According to the guidelines of biological farming, which should be understood as regard for the soil, it involves, first and foremost, the choice of biological production methods and, as a last resort and if there is no alternative, the use of chemical methods, leading to minimal interference with the environment.

The characterized 5C Code is a proprietary development of the Top Farms Group, reserved in the Patent Office.

5

Soil: the foundation of biologization

5. Soil: the foundation of biologization

5.1. Soil – a complex ecosystem

The results achieved by any operating farm depend, first and foremost, on the quality and condition of the main natural resource used in agricultural production, namely soil. Many scientists and a large group of practitioners, i.e. farmers, suggest that soil is the most complicated, vibrant ecosystem on Earth. This is proven by the many organisms living in the soil, forming its rich flora and fauna. These organisms also influence one another through interactions in biological, chemical as well as physical processes, making soil a dynamic ecosystem that changes over time. The changes can be desirable as well as undesirable. Undesirable changes occurring in the soil in consecutive years will accumulate, leading to the soil's degradation, due to which the farmer will achieve increasingly worse production results. Such negative effects are not inevitable, as they can be prevented by farmers' appropriate and deliberate procedures involving the soil.

The widespread opinion among farmers is that "the fundamental duty of any true farmer is making sure to maintain the soil in proper agricultural condition". Farmers were aware for many decades that they needed to care for the soil, especially by ensuring the high quality of any agrotechnological procedures, in order to develop the best possible habitat conditions for plant growth and development, as this is what has always and still largely determines production results. Unfortunately, this awareness gradually diminished as time passed, among some farmers and even more so among the general public. To some extent, this was the effect of the past century's economic progress and its widespread implementation in agriculture. The growing use of industrial means of agricultural production, including mineral fertilisers and chemical pesticides, coupled with the implementation of biological progress together with the popularisation of mechanisation of farming jobs, meant that production results in successive years were higher compared to previous years, while the work of the farmers themselves became much easier, or even more enjoyable. This situation led successive groups of farmers to attach less and less importance to deliberately shaping the condition of the soil environment, some even taking the view that providing nutrients to the crops and protecting them with chemicals would fulfil all the needs of the production process.

It is clear from the perspective of the past few decades that this approach to farming and agricultural production at farms was inadequate; problems of soil degradation accumulated and intensified, and today have become very noticeable under conditions of progressing climate and environmental change.

That is why from the start of the 21st century we are seeing a renaissance in basic issues related to shaping the conditions for farm production processes, because mineral fertilising and chemical protection alone, even in combination with biological progress in agriculture, do not guarantee the desired production and economic effects. **IT IS STILL VERY IMPORTANT FOR EVERY FARMER TO RETURN TO THE FUNDAMENTAL PRINCIPLES OF RUNNING A FARM, FOR THEM**

TO ORGANISE EVERY PRODUCTION PROCESS IN THE BEST POSSIBLE WAY AND WITH RESPECT FOR THE NATURAL ENVIRONMENT, IN THE KNOWLEDGE THAT THE RIGHT SOIL ENVIRONMENT IS THE BEGINNING OF ALL FUTURE EFFECTS – PRODUCTION-RELATED AS WELL AS ECONOMIC.

Source: Anna Rosa.


Source: Anna Rosa.

5.2. Ancestral experiences as quidance for farmers

Already a few centuries ago, progressive farmers (today we call them innovative) realised that natural processes determined the volume and quality of agricultural production, and thus also the economic situation of every entity involved in production. It is not an exaggeration to say that historically speaking, farmers from the Wielkopolska region have many glorious achievements in this area.

A prime example of this is the life and work of August Cieszkowski (1814–1894), born in the Podlasie region but a Wielkopolska resident by choice, whom we might call a founding father of the Poznań University of Life Sciences in Poland. As a landowner, at first he managed the Surhów estate in Krasnystaw county (1,500 ha), and later in life was also the owner of manor farms near Poznań (Wierzenica, Żabikowo). He popularised a system in which farm labourers were given a share of the farm's profits, which simultaneously aimed to protect estates from being divided up as the granting of freehold to peasants progressed. Personally, he was not against these freehold processes, but he was aware of the negative consequences of increasing farm fragmentation for the future of agriculture. He propagated the idea of agricultural education in Polish lands under Prussian rule. When the circumstances allowed, he did not hesitate to offer part of his estate to set up an agricultural secondary school in Wierzenica, and later the Higher School of Agriculture in Żabikowo, which became a great source of agronomists and stewards for Wielkopolska's landowners. (http://cieszkowski.parafia-wierzenica.pl)

Other famous landowners, to mention Count Dezydery Chłapowski of Turwia and Count Jan Działyński of Kórnik, were also active in the development of agriculture and agricultural education in Polish lands under Prussian rule. Being owners of manor farms themselves, they showed on their own example how to improve agrarian culture in Wielkopolska's agriculture.

Today the experience of our ancestors can serve as a road sign for farmers on the path to innovative, effective and consumer- and environment-friendly agriculture. Every farmer without exception can take advantage of agricultural know-how and advanced production solutions, thus working towards effective cooperation with nature in the process of producing agricultural goods.

5.3. Soil and its maintenance in good agricultural condition

The soil type in a given area primarily depends on the soil formation process as well as the climate and vegetation. Soil formation is the outcome of various factors that influence one another, the most important being the parent rock, water, animals and other organisms, and also the land relief and anthropogenic activity. From the farmer's point of view, soil quality is a leading functional factor; it is affected significantly by humus content, the assumption being that the more humus, the better the soil. Soils with the highest humus content include black earth (chernozem), fen soil and black soils, which potentially enable farmers to achieve high harvests. By digging a soil test pit, farmers can see the soil profile and obtain more detailed information on the quality of their soil, which will help them adjust any agrotechnological and cultivation procedures accordingly.

Source: Kacper Łata.

As mentioned earlier, "the fundamental duty of any true farmer is making sure to maintain the soil in proper agricultural condition". The condition of soil is not its natural quality, it is developed over many years of farmers' deliberate and rational activity, which translates into its capacity for high crop yields. **WHEN CULTIVATION PROCEEDS ACCORDING TO THE PRINCIPLES OF PROPER AGRARIAN CULTURE, THE TOPSOIL USUALLY CONTAINS EVEN UP TO 20 TONNES OF LIVING ORGANISMS PER HECTARE, WHICH DECIDES ABOUT ITS BIOLOGICAL RICHNESS.** These organisms are predominantly bacteria, but topsoil also includes fungi, mites, algae and protozoa as well as higher organisms like insects and their larvae and, above all, earthworms. The presence of all these living organisms in the soil affects the intensity of soil life. An especially important role is played by microorganisms in the soil, both aerobes and anaerobes.

Aerobic microorganisms living in topsoil decompose the organic matter in the soil into particles accessible to plants, i.e. they supply the plants with nutrients. Anaerobic microorganisms, which live in the soil's deeper layer, also support the decomposition of organic matter, through the formation of organic and organic-mineral soil colloids. It is soil colloids that largely determine the effects of the farmer's work, because they have a significant impact on the physicochemical properties of soil, especially its sorption capacity, regulate the soil pH, and help maintain its agrophysical condition, i.e. they are responsible for facilitating the formation of the soil's aggregate structure, also known as its fine-clod structure, which indicates that the soil is in good agricultural condition. Farmers can influence this feature of the soil by appropriate agrotechnological procedures. The factors facilitating the formation of clods include a sufficiently high content of humus as well as calcium and magnesium ions, which bind soil particles together into larger aggregates. The soil fauna plays a major role as well; in particular, the presence of earthworms in the soil has a positive impact on the formation of a fine-clod structure, as their excretions are an excellent binding agent, and they are also resistant to water and crushing, i.e. they limit the negative effects of physical processes. Earthworms living in the soil feed on plant remains, bore corridors in the soil, at the same time scarifying it and enabling water and air to get in – including into its deeper layers, which is especially important in no-till farming.

Source: Anna Rosa.

The decomposition of organic matter by both aerobic and anaerobic microorganisms provides plants with basic as well as essential nutrients. Considering that the humus content in soil is not high, and that the mineralisation of organic matter usually predominates in Poland, farmers need to undertake measures supporting humus formation in the soil they cultivate. At the same time, farmers should strive to maintain a balanced amount of organic matter in the soil and, among other things, ensure that harvest residues, root remnants are supplied to the soil. They should also fertilise the soil with natural, organic fertilisers and cover crops as much as possible. It is best for the amounts of components to be balanced and not to be smaller than the mineralisation of organic matter in the soil caused by crop growing.

One major factor contributing to the degradation of soil, especially light soils, is erosion. Wind erosion causes the depletion of the soil's upper layer as a result of washing away, cutting into the soil or blowing it out, while the soil particles themselves may also cause mechanical damage to plants, especially in the early stages of their development, which leads to crop losses. Water erosion removes valuable substances from the soil's surface layer, but often also from deeper layers as a result of the movement of minerals contained in the soil to surface waters. The physical degradation of soil involves partial loss of soil mass as a result of water and wind erosion, and the deterioration of the soil's structure and air-water properties, e.g. from soil clumping, crusting or dispersion.

Liming is important for maintaining soil in good agricultural condition, and is best done regularly – every four years. If liming is neglected or done sporadically, successive years will see an increasing negative effect, namely progressing soil acidification. Liming is an essential cultivation procedure because acidified soil steadily loses its crop-growing capacity, which is largely the effect of the loss of the beneficial clod structure in calcium-poor soil. A lack or shortage of calcium in the soil has other negative production effects as well. Especially in the case of light soils, intensive powdering of the soil takes place, the soil loses its buffering capacity, the biological activity of living organisms in the soil decreases noticeably, unfavourable wind and water erosion processes intensify, and, as a result, crops receive much less macro- and microelements. The crops become poorly nourished, their growth and development slows down, some of them wither, and consequently the farmer obtains a much smaller harvest compared to a given crop's potential yield, leading to poorer economic results of production processes, i.e. a general decrease in the farm's profitability. A lack or shortage of calcium also has unfavourable production effects in heavy soils, which become "confluent" – they undergo silting, the share of the soil air fraction drops, and large amounts of exchangeable aluminium and manganese appear, which are toxic for plants. These processes reduce soil fertility, i.e. its capacity to produce large crop harvests of the desired quality. Therefore, protecting the soil and taking care of it should be the most important consideration for farmers, as this is their workplace and the source of the farmer family's livelihood.

A farmer's level of care for the soil is expressed in the way that soil is farmed. There is no single absolutely best way of farming the soil. Farming undergoes certain evolutionary changes with the passage of time. Regardless of this fact, however, the essence of farming lies in creating favourable soil conditions for the growth and development of crops. This can be achieved in various ways, i.e. as part of often very different modes of cultivation, and through a varying number of agrotechnical procedures. The essence of contemporary farming lies in altering the soil with the help of agrotechnical procedures, the aim being to create the best possible conditions for growing field crops. Agronomists point out that these measures may come in many different forms (Figure 6.). Farmers working in given environmental conditions always have the possibility of choosing their farming method, but they need to be aware of the consequences of the choice they make, for their decisions will affect soil properties in different ways. A given farming method might affect the soil's physical properties, and those properties will have an impact on the soil's chemical and biological properties. Moreover, the chosen farming method will also affect production costs and the final economic results that the farmer achieves.

Figure 6. Modern-day farming systems and methods

Source: Jaskulski, D., Jaskulska, I. (2018). *Współczesne sposoby i systemy uprawy roli w teorii i praktyce rolniczej.* Poznań.

Once chosen, the farming method and the way it affects the soil will act as a catalyst of chemical and biological processes in the soil. Physical alteration of the soil, i.e. shaping its air-water relations, has a significant impact on the organic matter, where a higher air content in the soil inevitably leads to the consumption of humus, i.e. to the loss of a natural store of nutrients and thus to the deterioration of habitat conditions for crops. This feature is spatially diverse, and also depends on the type of arable land. Permanent grasslands are characterised by a much higher content of organic matter than arable land, by ten times on average.


Source: Anna Rosa.


Source: Anna Rosa.

It should be remembered that only biologically undegraded soil will ensure optimal environmental conditions for proper crop growth and development. Undegraded soil is characterised by greater biological activity, mainly the predominance of useful organisms over those that are harmful for crops, and this activity also determines its higher fertility. Farmers can alter the soil's properties in a desirable direction through their choice of cultivation procedures, the intensity of such procedures, or rational crop rotation. It is a desirable practice to make sure that approx. 2/3 of farmland in flatlands and at least 3/4 of farmland in areas under threat of erosion is covered with vegetation. This practice, or "green field concept", prevents soil erosion as well as protecting the soil against losing its nutrients, especially mineral nitrogen. Proper crop rotation is a precondition of making sure that a positive balance of organic matter is maintained on the farm.

Good biological farming practices

6. Good biological farming practices

6.1. GOOD BIOLOGICAL FARMING PRACTICE

Thorough soil analysis

Soil is the most important resource of any farm. It is a living, dynamic and complex system inextricably linked with the whole ecosystem. As the surface layer of the earth's crust comprising three phases – solid, liquid and gas, it undergoes constant change due to soil formation processes and human activity. Soil is the site of the synthesis and decomposition of mineral and organic compounds, their aggregation and migration, energy transfer, circulation of elements and water (Ingold, 2016). It contains chemical substances essential for living organisms, including crops, namely macronutrients (nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, sodium) and microelements (e.g. iron, copper, cobalt, manganese, zinc, boron).

Grounds for application

Knowledge on the soil environment – its structure, properties and ongoing processes – is the foundation of economically profitable and environment-friendly farming. Proper management of this resource results in its improved condition and fertility, which consequently translates directly into harvest quality and quantity. However, the first step towards improving the quality of soil and increasing its potential (fertility), which will contribute to a farm's greater production and better economic results, is a thorough diagnosis of the situation. The key and the main method for identifying the situation is **to conduct comprehensive, systematic soil analyses**.

Source: Anna Rosa.


Source: Anna Rosa.

Biological farming practice at the Top Farms group's farms

In biological farming – understood as a set of agrotechnology measures – pursued at farms belonging to the Top Farms group, soil is the most important goal and object of agricultural operations. According to Top Farms employees, the implementation of the 5C Code, i.e. the concept of biological farming developed and practised at the company, is based on soil analyses and evaluations of the soil's richness in nutrients. A Top Farms specialist on precision farming and new technologies highlights the fundamental role of such measures as follows:

There is nothing better than hard evidence that what we are doing makes sense. Soil analyses are fundamentally important, as they can tell us literally and in depth what is happening in our soil. It is on the basis of our analyses that we are able to determine the richness of the soil on which we work, and to review the correctness of our operations based on comparing and analysing soil results over a period of years. [K.Ł., 2021-09-28]

The employees agree that before the approach to farming at Top Farms changed towards biological farming, such in-depth studies of the soil were not conducted, among other things due to the lack of awareness of how important they might be. Today, with the shift to regenerative agriculture, **a standard soil analysis comprises as many as 17 elements (1)**. (The figure in parentheses indicates selected activities that make up the biological practice.)

Detailed maps of the soil's richness in macronutrients (phosphorus, potassium, magnesium, calcium) and its pH values reflect the varied demand for nutrients in different locations, thus determining the necessity for a varied approach to agrotechnology measures such as fertilisation. For several years now, the farms of the Top Farms group **use soil analysis with the Mehlich-3 method (2)**. This type of analysis tells us about the elements potentially available to crops. The results obtained with this method are an objective assessment of what the soil contains. The higher level of detail in the Mehlich-3 method compared to other methods (e.g. the Egner-Riehm or Schachtschabel methods) is better adapted to the needs of the farms, e.g. Top Farms Głubczyce where the soil is heavy, clayey. Another benefit of analysing soil using the Mehlich-3 method, besides the precise determination of calcium levels, is its relatively lower cost.

At Spearhead Czech, also part of the Top Farms group, **soil samples are collected from a 3-hectare area once every three years**. Alongside detailed laboratory analyses, **the company also uses visual analysis (3)** – satellite-based maps that are superimposed on maps of the soil (temperature, moisture, dew point). Satellite images are used to calculate the soil fertility index, and then mineral fertiliser and crop protection chemical doses are adjusted to specific areas in the fields. Potential crop performance is also determined for individual fields. An in-depth analysis is performed for plots with a relatively lower yield in a given season. This shows what agricultural production means are required, in what amount and in which part of a field. For example, nitrogen fertilisers are not applied in spring if the soil temperature drops below 10 degrees Celsius beneath the surface, because it does not produce any effect then. Information is sent electronically to field workers, who either apply fertiliser or not, depending on the situation. This system, in the form of a phone app, is used by agronomists, who pass on the information to machinery operators. The aim of these measures is to optimise outlays and costs.

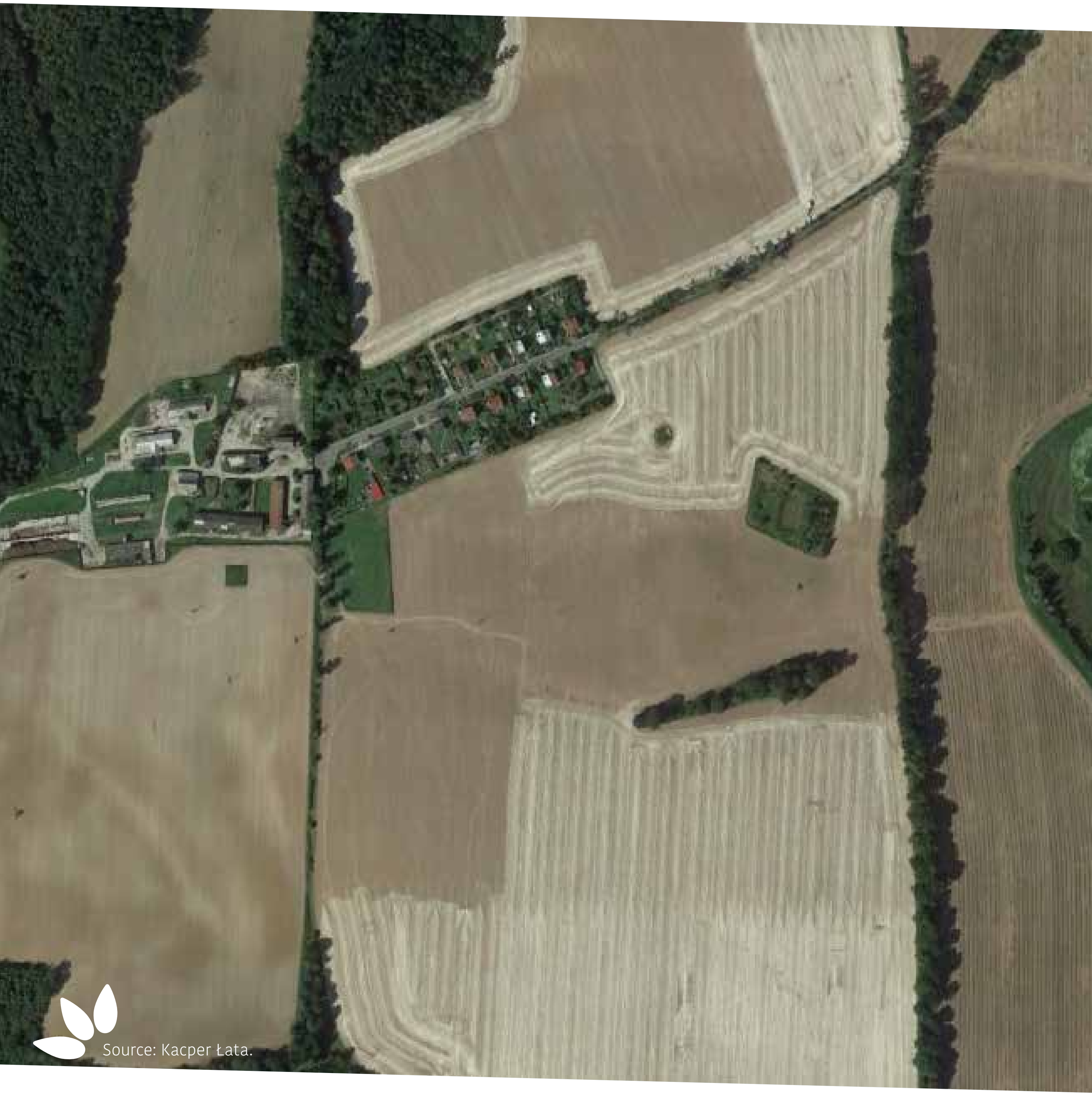
In-depth soil analyses are also fundamentally important in another company from the Top Farms group, Spearhead Slovakia. The company attaches special importance to **soil microbiological parameters**, especially **in terms of the presence of bacteria, protozoa and fungi (4)**. According to an agricultural adviser working with Spearhead Slovakia, the respective amounts of the aforementioned organisms are 135 micrograms of bacteria per gram of soil and 135 micrograms of fungi per gram of soil. Fungi form a network of various fibres that is damaged by tilling. That is why the regeneration of fungi in the soil is a very time-consuming and complicated process. The proportion of the number of bacteria to fungi is important. It should range between 0.3 and 0.8. Active bacteria are an important factor as well: there should be less than 10 micrograms per gram of soil.

6.2. GOOD BIOLOGICAL FARMING PRACTICE – Ensuring appropriate calcium levels in the soil

The property of a soil solution expressed as pH shows the ratio of hydrogen ions to hydroxide ions. For most crops, the optimal pH is around 6.0–7.0, i.e. a neutral reaction. Almost two-thirds of the soil in Poland is characterised by high or very high acidity, which is related to low biological activity and poor fertility. In addition, higher acidity of soil means higher absorptivity of heavy metals by plants. Soil deacidification and the improvement of the soil's physical, chemical and biological properties is achieved by the use of calcium-based fertilisers.

Grounds for application

In terms of plant needs, calcium is one of the most important macronutrients found in soil. This element supports the normal development of plant tissue, makes plants resistant to fungi and viruses, regulates their water relations and cell divisions. Moreover, it improves the soil structure, affects soil fertility and determines pH by reducing soil acidity. A properly balanced liming procedure improves air-water and heat relations, and has a positive impact on the distribution of organic substances and on the development of beneficial microorganisms.



Source: Kacper Łata.

Source: Kacper Łata.

Biological farming practice at the Top Farms group's farms

The importance of drawing attention to calcium at farms of the Top Farms group stems from calcium's fundamental role for physicochemical processes in the soil and its influence on soil properties. **The right proportion of calcium to magnesium, potassium and sodium (1)** (i.e. the level of calcium in the sum of exchangeable cations) is particularly important, as it determines the soil's structure and the conditions for the development of biological life within it. According to US biological farming specialists, as quoted by the company's employees, the optimal ratio of these elements is approx. 80% of calcium, approx. 15% of magnesium, approx. 4% of potassium and 1% of sodium. Agroclimatic differences between countries as well as local conditions and experience mean that farms should strive to achieve the appropriate proportions of exchangeable cations in the soil.

One important factor in plant nutrition is cation exchange sorption occurring between the soil solution and the sorption complex. That is why an important place in the biological farming practice at Top Farms is given to the analysis of soil sorption properties, based on in-depth studies, especially readings of pH in potassium chloride (KCl) and pH in the soil sorption complex. The way to achieve the **optimal proportion of calcium to the other elements and the desirable pH level of 6.5 – slightly acidic (2)** is to apply the right amount of calcium and magnesium with calcium- and magnesium-based fertilisers, e.g. calcium nitrate or magnesium sulphate. The rule adopted at the company is that the pH in KCl has to be about 0.5 lower than the pH in the water suspension, as that is when – according to Top Farms employees – biological activity in the soil is optimal.

Another important indicator facilitating the right choice of the approach to calcium at farms from the Top Farms group is the calcium content in a water solution, obtained by means of the Mehlich-3 test. This indicator shows the amount of the macronutrient that is available to plants. Calcium is an element that plants consume in very large amounts because it is their building material. When the soil pH is beneficial (neutral) and there is a simultaneous calcium deficit, the company **uses a different calcium carrier than calcium nitrate, namely gypsum (3)**, which helps maintain a beneficial

The farms of the Top Farms group achieve the appropriate approach to liming and the right composition of soil components with the help of precision farming technologies, which limit calcium losses. Calcium-based fertilisers are applied directly to the field surface. Alongside **precise dosages of this element, Top Farms puts emphasis on its variable application (4)**, adjusted to the needs of a specific section of a given field. Such an approach is needed because the company operates on soil with different properties (the pH is optimal in some places and very acidic in others). Consequently, calcium in the appropriate dose is applied individually for each location (improving the pH in those segments of a field where it is unsatisfactory and not increasing it in those that do not require liming), which – besides improving or not impairing the biological relations in the soil – brings financial savings (the amount and therefore the cost of fertiliser is significantly reduced). The introduction of variable liming with the help of precision farming solutions is described by an employee of Top Farms Głubczyce as follows:

... in 2018 we started variable liming in all the fields instead of liming their entire surface ... In the variable option, a field is divided into sectors. Each sector has its specific assigned pH, and therefore also the appropriate calcium dose. If the pH is below 6, we apply 3 tonnes over that whole area. For 6.2, we apply 2.5 tonnes, for 6.3 it's 2 tonnes per hectare per sector. And if the pH ranges between 6.4 and 6.8, we apply 1 tonne to maintain that pH. But if the pH is over 6.9, there is no liming. As an example: in the fixed option and based on the average of all the sectors within a given field, 352 tonnes of lime should be applied on 176 hectares. In the variable option, when we apply a specific dose of calcium over a specific sector of the field, the amount of lime is reduced to 207 tonnes, and the area of application is also smaller, 147 hectares. If we [applied] 352 tonnes over 176 hectares in the other [fixed] option, in the variable option we only apply 207 tonnes over 147 hectares. [K.Ł., 2021-05-25]

Variable liming brings benefits to the farms of the Top Farms group, including improved pH values in field sections where the soil was diagnosed as acidic. For example, analyses conducted at Top Farms Głubczyce showed that in the period when this practice was implemented (2017-2020), the area of field sections requiring liming decreased significantly. The share of sections with a pH of 7.0 and more, where no liming was done, grew from 351 ha in 2017 to 802 ha in 2020. The area of sections with pH between 6.6 and 6.9 increased from 1,361 ha in 2017 to 2,140 ha in 2020. The area of sections with pH below 6.5 decreased from 1,817 ha in 2017 to 587 ha in 2020. Places in the field with pH below 6.0 were eliminated. This approach brought measurable savings (financial benefits). Following variable liming of the fields in 2018 and an analysis of the soil results in 2020, the company received hard evidence that it was the right approach. In 2021, thanks to the accurate identification of soil properties based on soil analysis and the application of variable liming, liming costs dropped by approx. PLN 400,000 compared to the fixed option.

6.3. GOOD BIOLOGICAL FARMING PRACTICE — Ensuring the appropriate level of microelements in the soil

Besides macronutrients, soil also contains a number of microelements, i.e. chemical elements found in plants in small amounts. They include boron, manganese, zinc, copper, iron and molybdenum.

Grounds for application

Microelements are essential for plants to live and develop properly. These elements have a beneficial role when their balance is right. An excess or deficiency is unfavourable for plants and manifests itself in diseases, unsatisfactory harvests or low quality of crops (Zimny, 2003).

Source: Anna Rosa.

Biological farming practice at the Top Farms group's farms

One of the biological farming practices implemented at the farms of the Top Farms group involves maintaining **the proper content of microelements in the soil (1), including iron,** a microelement of which crops need relatively the most, since plants take up the biggest amounts of iron among all the microelements. Iron is involved in many biochemical processes in plants, mainly in redox reactions, but it is also essential for chlorophyll synthesis (replacing magnesium in protochlorophyll). Soil studies at the company show that the levels of iron as well as other microelements have been too low. That is why fertilisation with iron, but also with other microelements such as **boron and zinc**, has been practiced for a number of years. Another substance used to improve the micro- and macronutrient content as well as the amount of nutrients like sugars and amino acids in the soil is **beet molasses (its main purpose being to feed bacteria)**. It binds together grains of soil and works well as a herbicide booster. The application of molasses has enabled some dosages of crop protection chemicals to be reduced by about 25%.

Another example of good biological farming practice is the use of microelements in rapeseed growing. Observation of the field at a farm belonging to the Top Farms Wielkopolska company in May showed poor rooting, cracked stems, yellow buds and a small number of flowers. The possible causes were believed to be too much nitrogen in the soil and zinc deficiency. The company decided to apply various microelements on a wide scale.

Among microelements, of course it is our standard practice to apply boron, which is very important for cell division and whose content is very low in most of the soil we cultivate. We will continue working on the boron [content]. At present we are applying 2,500 grams of boron to our rapeseed. These are relatively large amounts. Even so, we still see plants with a deficit. We apply about 250 grams of manganese, and up to 100 grams of copper. In recent years we have increased the use of zinc, because we think the rapeseed stalk cracking might be related to it – we apply 250 grams. The importance of iron fertilisation has also grown substantially, at present we apply about 300 grams, but we'll apply more. Iron has one drawback. It's the most expensive microelement. ... However, we see some very positive effects of applying it. Of course, regardless of the choice of fertiliser types and dosages, we have to remember the farm's capacity for spending money, which is why we have adopted the principle of maintaining the overall costs of fertilisation at a fixed level. As a result, we no longer fertilise with 300 kg of nitrogen – I remember a time when this was the standard dose... Today we have 130 kg of nitrogen here, and the cost difference from its reduction is the basis for increasing fertilisation with other minerals. [P.K., 2021-05-25]

The application of microelements, e.g. iron in rapeseed growing, thus brings positive and measurable effects. These include satisfactory yields of the crop coupled with lower use of mineral fertilisers.

6.4. GOOD BIOLOGICAL FARMING PRACTICE

Increasing the amount of organic matter and carbon in the soil

Organic matter, or matter from which living organisms originate, is formed by the remains of plants and animals as well as soil humus. Carbon is the most important component of organic matter. Soil is an enormous store of carbon, twice bigger than the atmosphere and three times greater than vegetation. Humus as an organic component of soil is the complex product of the decomposition (humification) of plant- and animal-based substances. During this process, carbon dioxide is released into the atmosphere. Almost half the soil in Europe, especially in the south and the central parts of the continent, has a low organic matter content (Institute for Environment and Sustainability, 2009).

Grounds for application

Organic matter and the carbon it contains is essential for the existence of life in soil. It also has a positive impact on soil structure and fertility and on the capacity for storing water, which is essential for the development of plants, especially crops grown in naturally dry and sandy soil. Plants owe a great many nutrients to organic matter. In connection with the drive to limit livestock production and the spread of crop monoculture in the world, arable land is being depleted of organic matter. According to specialists working for Spearhead Slovakia, a conventional instead of, for example, a regenerative approach to crop production causes an average annual loss of about 700 kg of carbon per hectare.

Source: Anna Rosa.

Biological farming practice at the Top Farms group's farms

According to the 5C Code drawn up and developed in the Top Farms group, carbon, and especially the organic matter content of soil, is a key element from the point of view of biological farming. Many of the farms belonging to the group **aim to achieve the highest possible level of organic matter in the soil (1)**, at least 3%. Measures undertaken to reach this level include **limiting the level of soil oxidation by not ploughing (1a)** and **leaving harvest waste (straw) in the fields (on the entire cereal acreage) (1b)**. These practices enable the soil to receive nutrients (glucose) that feed microorganisms. Another practice is **to grow soil-building crops (1c)** like leguminous plants (peas, alfalfa) and fagopyrum, which of all plant species provide relatively the greatest support for the development of biological life in soil. An agronomy specialist working at Top Farms Głubczyce describes this approach as follows:

We try to treat nourishing our soil like the stomach of a cow, where plant matter is broken down into simple sugars by bacteria. In the same way, our soil needs complete nourishment in order to produce organic matter and subsequently supply many beneficial substances to plants. [M.M., 2021-09-28]

When straw is left in the field, the good practice of farms from the Top Farms group includes **its appropriate cutting, spreading as well as maintaining the proper amount of harvest waste**. This enables the farms to avoid problems caused by self-sown plants, rodents or seed drill operation.

Another practice followed by farms in the Top Farms group to increase the amount of organic matter in the soil is **using organic fertilisers (1d)**. The organic fertiliser (mainly manure and slurry) comes from the farms' own cattle and pigs. For example, Spearhead Czech produces about 165,000 tonnes of organic fertiliser per year (about 6-7 tonnes per hectare). At farms without livestock production, organic fertiliser is purchased. It can include chicken droppings as well as molasses and defecation lime from the sugar industry. The carbon level in soil is also increased by **appropriate crop rotation and sowing suitable cover crop mixtures (1e)**.

According to studies conducted in the Top Farms group, the aforementioned regenerative farming practices (mainly organic fertilisation, leaving harvest waste in the field and growing cover crops) **contributed to increasing the average organic matter content of the soil in various farm locations**. For example, at Spearhead Czech the organic matter content grew by 2-2.5 percentage points (from 2% to 4.5%), while at Top Farms Głubczyce the amount of organic matter increased by 0.16 pp in the period between 2016 and 2019.

6.5. GOOD BIOLOGICAL FARMING PRACTICE

Increasing the diversity of crops through broad crop rotation

The choice and rotation of crops planned over a longer period on the basis of specific rules depends on various factors, the aim being to obtain high crop yields while maintaining the agro-ecosystem's bioenergy balance. Depending on the structure of crops and the planned effects, one can distinguish different types of crop rotation (e.g. cereal, seed, root, anti-erosion, alternating, industrial).

Grounds for application

Appropriate rotation of crops protects soil from erosion, excessive evaporation, loss of nutrients and carbon dioxide emission into the atmosphere. Varied and appropriate crop rotation and well-chosen crop combinations can be beneficial for soil microorganisms and help combat weeds and diseases. Crop rotation also supports the formation of organic matter in the soil and prevents a reduction in biological diversity. The most important thing for farmers is that it helps maintain long-term soil fertility.

Source: Anna Rosa.

Biological farming practice at the Top Farms group's farms

Ever since production at farms in the Top Farms group switched to regenerative farming, great importance has been given to a diverse crop structure. The emphasis is on **a variety of crops and broad crop rotation (1)**. The production of winter wheat and rapeseed is diminishing, while the production of leguminous plants, soy, poppy seeds and flax is growing. The approach to crop diversification that distinguishes Top Farms' farming operations from traditional agriculture in Poland is described as follows by one of the company's employees:

> *Most farms in Poland pursue cereal crop rotation, i.e. cereals follow cereals at almost 70% or it even reaches 90%. At our company [Top Farms Głubczyce], cereals take up 35%, or in some years 50% maximum, so we have very big biotype diversity here.* [M.M., 2021-09-28]

The biological farming guidelines have also led to changes in the choice of crops and their succession at Spearhead Czech. A few years ago, the company only grew the three most important crops. However, in order to meet the requirements of regenerative farming (or, as the employees put it, of "being a good farmer"), crops are being diversified systematically. The acreage of crops such as **soy, oats and leguminous plants (2)** is being increased at the company's farms. This is happening particularly at locations where the soil conditions are good. Expanding crop rotation is beneficial due, among other things, to the relatively lower use of resources in production. Increasing the level of crop diversification also fulfils an anti-erosion role. Many of the company's fields in Czechia lie in areas of upland. Storms accompanied by heavy rainfall are frequent at the company's farms. Even up to 50 mm of rain per square metre can fall in 30 minutes. That is why all the entities that are part of Spearhead Czech have been mapped for water erosion risk. Crops requiring sparse sowing, e.g. maize, are not grown in areas at risk of erosion, in favour of e.g. poppy seed or oats. **In addition, the area designated for a single crop has been limited to a maximum of 30 ha (3)**. For example, a 150-ha field is divided into five 30-ha sections. Also, **green belts preventing erosion, in the form of grass mixtures (4)**, are formed on individual plots.

Top Farms sees **soy production (2a)** as an important biological farming practice, although it is still a unique one in Poland, Czechia and Slovakia. For example, the company based in Głubczyce was one of the first entities to initiate and implement this crop production in Poland, with support from various units from the research sector. It was a difficult process that was experimental in character, because when the decision to develop soy production was made, there were no technologies or means for it in Poland. Knowledge about this crop was also modest.

> *A few years ago there were no technologies, no crop protection products in Poland. We as a company joined the PolSoja consortium, a consortium tasked with developing a soybean production technology. We conducted experiments with fertilisers, varieties, preceding crops, tilling and herbicides. Thanks to those four years of experiments, we were able to develop a complete, comprehensive crop technology... And currently every farmer who would like to start growing soybeans has this booklet, has a knowledge base they can consult at any time and learn a lot of interesting things.* [M.M., 2021-09-28]

Source: Anna Rosa.

Top Farms Głubczyce currently grows soybeans on 330 ha. Nitrogen fertilisation is not applied on this acreage. This is possible thanks to using seeds treated with Nitragin. Certified and treated seed is purchased. A further treatment is applied at the company before sowing. Nitragin is made up of live cultures. According to the company's employees, Austrian research results have shown that double treatment of seed with Nitragin before sowing is conducive to the plants' symbiosis with rhizobia, as a result of which free atmospheric nitrogen (which plants cannot access in this form) is fixed in the soil. To avoid damage to the seed during the second treatment, the company has developed a special technique. The seeds are sprayed on a potato conveyor from a sprayer before being transferred to a trailer. From the trailer, the treated seed is transferred directly to a seed drill. According to Top Farms' employees, once you control weeds and pests, soy will become a crop that does not require much labour and will bring savings. To grow soybeans, you do not have to use any mineral fertilisers, and you can additionally obtain nitrogen because this plant fixes it in its root nodules. The soy plant has a root system that also loosens and breaks up the entire soil profile. It reaches down to a depth of 1.8 metres, thanks to which the plants efficiently use up nutrients that are out of the reach of cereal crops. The company's experience shows that soy is one of the best preceding crops for winter wheat, even despite later sowing, because depending on the season, its growth usually takes place at a different time (the harvest is in October). Another benefit of growing soybeans is the price, which has been very high in recent seasons (on 23 September 2021, 1 tonne of soybeans cost PLN 2,400).

6.6. **GOOD BIOLOGICAL FARMING PRACTICE**

Increasing the diversity of main crops by growing cover crops

Cover crops (catch crops) are crops that yield an additional harvest besides the main crop and comprise green mass, hay, silage or green manure for incorporation. Depending on the place in crop rotation and the time of sowing and harvesting, one can distinguish stubble catch crops, companion crops and winter catch crops.

Grounds for application

Cover crops play an important role in livestock production (as feed), but are also important for increasing biological activity in the soil and for soil fertility. Cover crops have a role in plant building and enriching soil with nitrogen (especially leguminous plants). Moreover, cover crops affect the amount of organic matter in the soil, and fulfil other functions related to protection from water and air erosion (increasing water absorption levels, which is especially important in view of the growing frequency of rainstorms, and storing water during periods of drought) as well as preventing the spread of weeds. Cover crops, in which solar energy is stored, are decomposed by living organisms and end up in the soil. Having a developed root system, cover crops increase the absorption of elements by the soil thanks to the mycorrhiza process. At the same time, they help transfer nutrients from lower layers of the soil to its upper level. This enables valuable nutrients to be supplied to the main crop.

Source: Anna Rosa.

Source: Anna Rosa.

Source: Anna Rosa.

Biological farming practice at the Top Farms group's farms

Cover crops play a leading role in the biological farming practices of the Top Farms group. The company's employees say this is the cheapest and most effective regenerative farming method. Ever since regenerative farming started being implemented at farms from the Top Farms group, the aim has been to ensure that cover crops cover **about a fifth of a farm's overall acreage (1a)**. The fact that this method is usually only effective in the long term is a bit of a drawback. With **cover crops, soil processes stretch over a long period of time and have to be adapted (often by trial and error) to the local context of farming operations (different agroclimatic conditions) (1b)**. For this reason, each company in the Top Farms group has developed its own optimal approach to cover crops.

Discussing the advantages and specificity of growing these crops, an agricultural adviser collaborating with Spearhead Slovakia described them as follows:

Applying cover crops is a question of proper thinking. Everyone has to adjust cover crops to their particular conditions. People often act upon information from the United States or Australia which is incompatible with local conditions. Why should we grow them? Every plant is unique, it has its own secretions. It forms a specific spectrum of microorganisms around its roots. The aim is to grow as many of them as possible. Then we obtain greater biological diversity in the soil. Cover crops are the most important source of organic mass in the soil. Nothing else can replace them. And there is also the fact that they fix carbon dioxide in the soil. [M.S., 2021-07-21]

According to this Spearhead Slovakia adviser, one should not be afraid to experiment with cover crops. As the Slovak agronomist points out, applying cover crops is difficult, farmers need to stick to certain rules, show long-term commitment, identify the soil and local agroclimatic conditions, learn about crop mixtures and take advantage of new technologies.

... Good production effects cannot be achieved without making mistakes ... There's no better way of improving the organic matter content of soil. You also have to invest in new technologies. Machinery is very expensive, but you have to invest in it ... Cover crops are new plants we have to teach ourselves. With cover crops, you have to be patient because success is not achieved instantly with them. [M.S., 2021-07-21]

Based on past experience and the knowledge utilised in the farming operations of Top Farms, one can formulate **a number of detailed guidelines on growing cover crops (1c)**:

1. A cover crop should be left in the field for as long as possible. One of its main functions is the action of its roots. There has to be order between the plant's root and the soil. Crops with short and deep root systems should be grown. The issue here is to stabilise the soil. Roots of different lengths form a whole. For example, radishes, mustard and lupin will grow deeper down. On the other hand, clover and phacelia will stabilise the soil structure in the upper layer.
2. Cover crops should not be sown when it is dry. We sow cover crops where there is straw. The straw has to be finely ground down and spread evenly along the combine's entire working width; if the amount of straw is large enough or the combine has not spread it evenly, it is worth using a special harrow.
3. Large-seed cover crops are sown in the first half of August. The second half of the month is the time to sow clover or phacelia mixtures (small-seed leguminous plants). The mixtures used depend on the soil and the main crop. If the day is longer, the plant produces more biomass. The day grows radically shorter in late September and intensive growth becomes impossible.
4. The appropriate choice of mixtures is very important. The plants' growth schedules have to be respected.
5. The plant density in the field is important; there should be a maximum of 200-350 plants per square metre.
6. Attention should also be paid to the remains of chemical substances from previous seasons, which could damage the cover crop.

Source: Anna Rosa.

Source: Anna Rosa.

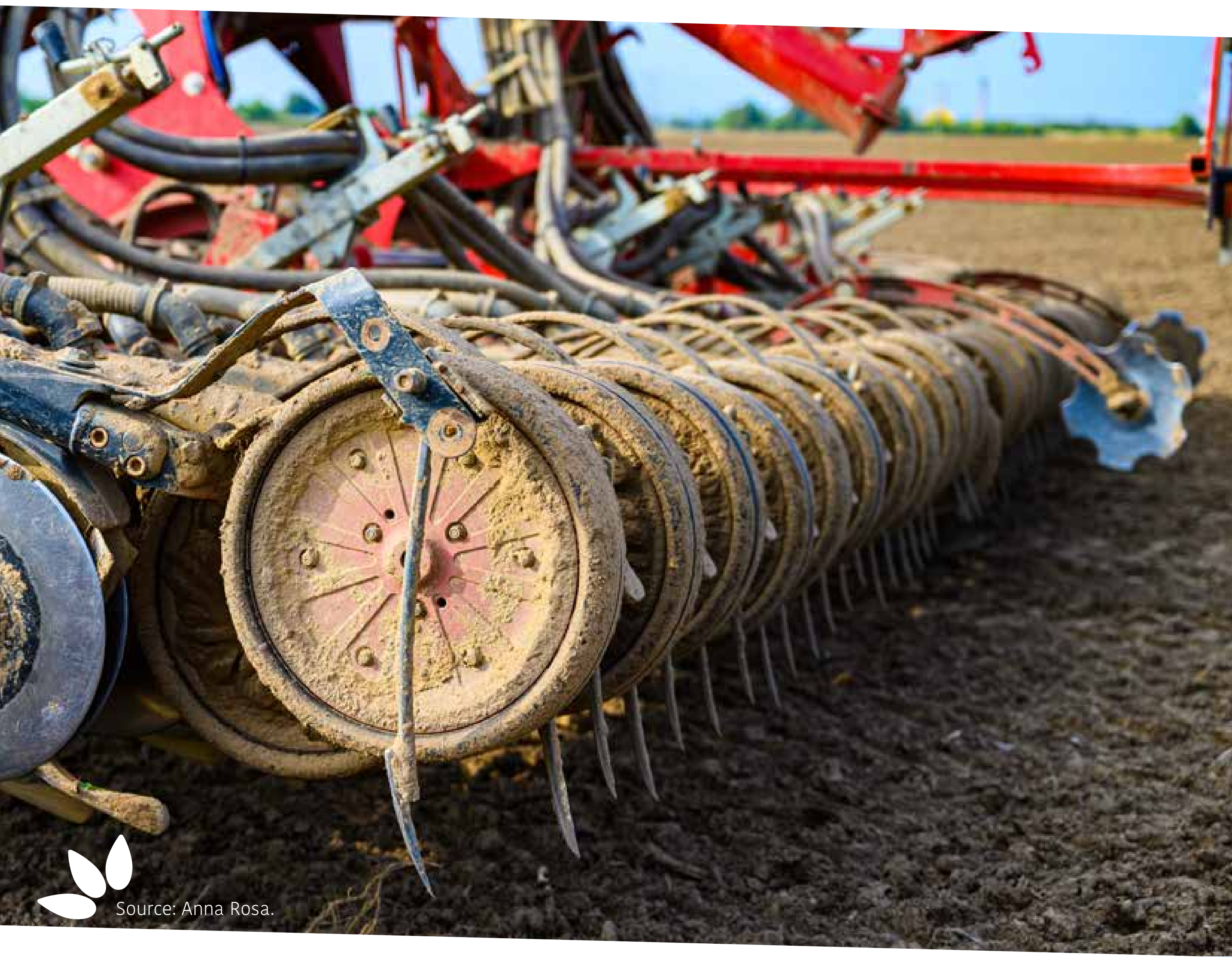
Top Farms Wielkopolska (sandy soil) uses cover crop mixtures comprising **buckwheat, oats and sunflowers**. The decomposition of buckwheat harvest waste increases the amount of phosphorus available to plants from the soil. Another practice related to cover crops involves using cutters to mow the plants down at an appropriate height (10 cm) and leaving the cut stems over the winter (less often, the cover crop is chopped with mulchers). In spring, when beets are sown, for example, there is a lot of cover crop waste in the field. The farms belonging to Top Farms Wielkopolska aim to ensure that cover crops are sown in autumn in about 90% of the fields where sugar beets and potatoes are grown.

At another company of the group, Top Farms Głubczyce, cover crops are sown on 20% of a farm's total arable area. One hectare of cover crops yields an average 30 tonnes of green mass. At present, this company sows cover crops on 1,700 ha, **mainly after the main crops of cereals, potatoes, sugar beets and soybeans**. The mixtures comprise **oil radish, phacelia, Egyptian clover, clover and peas. These crops are sown using a seed drill with two containers (1d)**. This prevents uneven sowing of different-sized seeds, as the seed drill sows light small-seed plants (especially leguminous plants) and relatively heavier large-seed plants (peas, broad beans) separately. This machine is also fitted with a special "fin" that makes wide cuts in the soil from behind instead of in front, thus avoiding resistance from harvest waste.

6.7. GOOD BIOLOGICAL FARMING PRACTICE

Limited-till, minimal-till, no-till and no-plough farming

Limited-till, minimal-till, no-till and no-plough farming are reduced-tillage farming systems whose aim is to ensure optimal conditions for crop growth and development. They involve reducing farmers' negative impact on soil (halting its degradation), among other things by abandoning some tillage procedures in the field or replacing deeper procedures with shallower ones. Reduced-tillage farming requires special machinery, e.g. disc, tooth or rotary harrows; no-plough farming involves machinery other than a mould-board or disc plough and direct-sowing seed drills. No-till farming involves preparing a field for sowing by applying herbicides to the stubble and then sowing seeds directly. It is most often used for growing maize, rapeseed, sugar beets and winter cereals. To increase the positive production and economic effects, reduced-tillage farming systems are usually implemented in an integrated way and in stages spread over a number of years.



Source: Anna Rosa.


Source: Anna Rosa.

Grounds for application

The downsides of traditional farming (plough farming carried out with farming tools and involving numerous procedures that supplement one another) include disturbing the natural soil system by damaging its structure, reducing the population of beneficial organisms living there (such as bacteria, protozoa, algae and roundworms), destroying the natural protective layer (plants and organic waste) that prevents water and wind erosion, and disturbing underground nutrient circulation. Frequent procedures enable oxygen to get into the soil, causing its average temperature to rise. Consequently, organic matter – the main component of healthy soil, encompassing all the organisms living there – undergoes more rapid decomposition.

Reduced-tillage methods aim to preserve as much as possible of the natural soil by reduced disturbance of its structure. In place of mechanical mixing of soil, a biological variant of this process is launched. It progresses thanks to microorganisms, roots and soil fauna, which take over the tillage functions and balance the amount of nutrients.

All the farming types that constitute reduced-tillage systems make farmers' lives easier and speed up work in the field. Special aggregates and tillage sets enable several actions to be performed during one tractor run, which reduces energy consumption and labour. Other benefits of reduced tillage include smaller carbon dioxide emissions due to the increased accumulation of organic matter in the soil as well as reduced use of farming machinery. However, sometimes in the initial period of implementing these technologies, crop yields and thus income may drop. This can be the effect of the farm manager's inadequate knowledge, a lack of the necessary equipment, or mistakes. This practice is also relatively less suitable for dense soils that need scarifying. It requires substantial knowledge and experience, appropriate machinery, and the proper choice of the preceding crop and the main crop. Reduced tillage could be an attractive option for larger farms as they increase their area or if water becomes scarce and means of agricultural production grow more expensive.

Biological farming practice at the Top Farms group's farms

One of the key biological farming practices implemented at farms from the Top Farms group involves carrying out agrotechnological procedures with the smallest possible interference in processes taking place in the soil. This is done by reducing tillage (no-plough farming or limited ploughing) to disturb the soil as little as possible. Why? According to the Top Farms group's employees, soil aeration leads to the decline of organic matter in the soil.

At Top Farms, they also break down the soil without turning it, by covering the ground with harvest waste. This supports the production of humus in the soil (humification). Another widely used procedure (in at least half the cases) is to withhold ploughing up until the moment of sowing. Both procedures (ploughing and sowing) are carried out in one run of the machinery. One of the company's employees describes the advantages of this solution as follows, highlighting the benefits of preventing erosion and storing excess water in the process:

Thanks to this [limited ploughing and leaving harvest waste in the field], we do not see a scouring effect. A rainstorm of 50 or 60 litres will not harm the soil structure. The soil starts building its structure by itself when it isn't ploughed, when it isn't disturbed. The water is soaked up really well. Of course, this protects against frost, against wind, against rainstorms, it has a great many benefits... [P.K., 2021-05-25]

Top Farms employees are guided by the principle of "tilling as little as possible, and as much as necessary". Translating this into practice, it means that ploughing is not practised on most of the total acreage of cereals (combine-harvested crops), sugar beets and fodder crops. Traditional ploughing is only performed in fields where potatoes are planted, for example at Top Farms Głubczyce. It is estimated that ploughing is practised on one-fifth of all the tilled land. In addition, wherever potatoes are grown, in successive seasons the company sows plants that do not require ploughing and improve soil fertility and structure as well as supporting increased biological life in the soil. Soil condition is also improved by the use of appropriate farming techniques, such as mixing harvest waste (to accelerate decomposition), deep breaking up of the soil without turning, shallow mixing, sowing and tilling during one run of the machinery (reducing fuel consumption and limiting soil compaction).

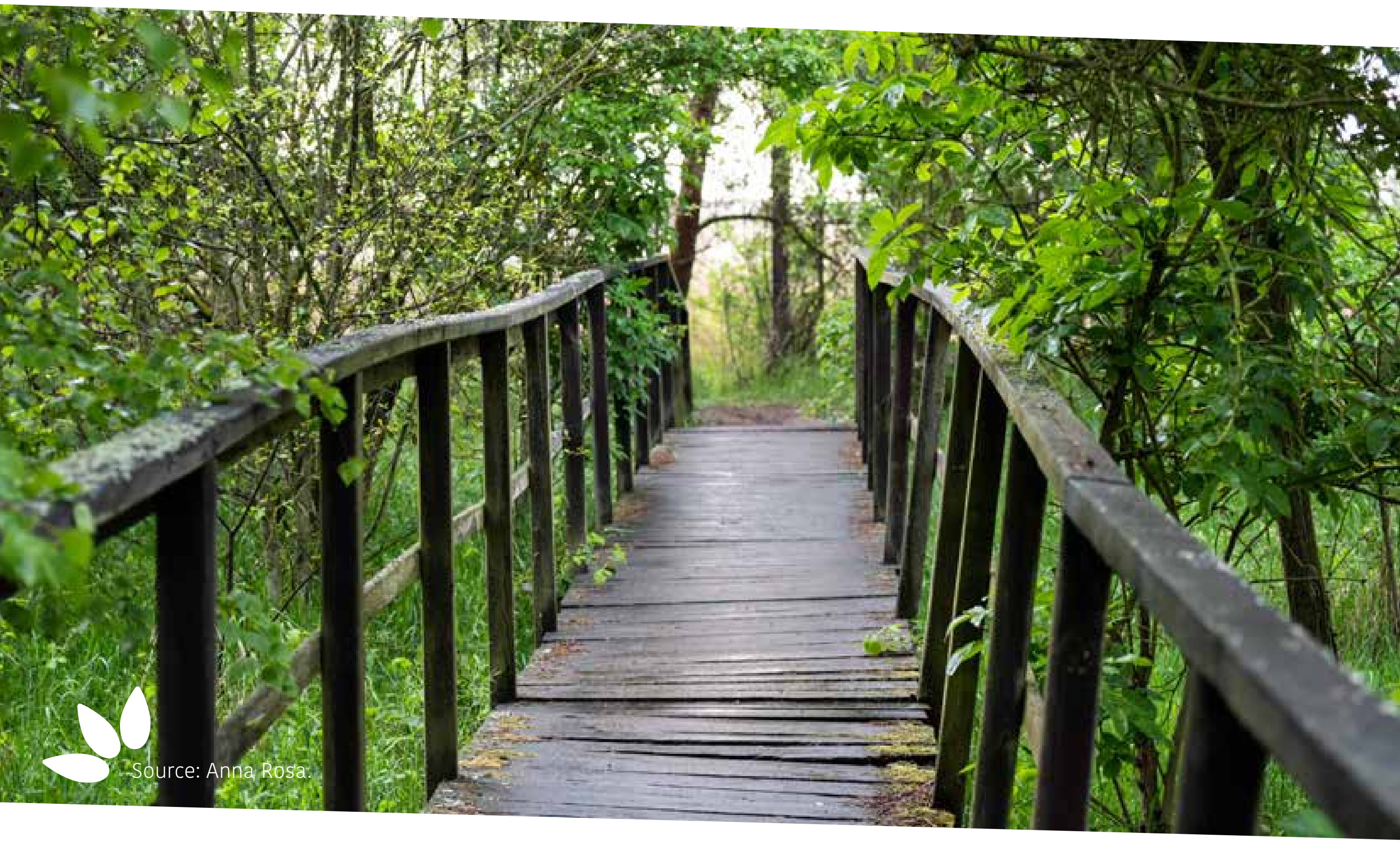
6.8. GOOD BIOLOGICAL FARMING PRACTICE — Culture

In relation to farming, culture usually means a wide range of practices, standards and values connected with this area of human activity. It can include very diverse elements, from the way certain procedures are carried out in the field or activities linked to animal husbandry, all the way to farmers' attitudes and values related to farming and stemming from it. In the narrow sense related to biological farming, culture means conducting agricultural operations in such a way as to generate public goods and contribute to the production of tangible and intangible benefits that are valued by society and are desirable from the point of view of the natural environment and climate. In this sense, it can be considered as one of the elements of farming culture.

Grounds for application

An approach to farming which is based on respecting and maintaining the good condition of natural resources (especially soil, water, air, landscape, plants and animals), and which takes into account the needs and values of non-farming communities functioning in a farm's surroundings (e.g. neighbours, tourists, food consumers), is conducive to establishing, upholding and developing positive and comprehensive relations between the different actors of the environment, the economy and society. Farming culture coupled with biological farming thus contributes to the creation of many natural and social benefits. At the level of farmers basing their activity on this type of culture, it might also mean achieving many individual benefits. Biological farming practices can lead to increased yields, but also to the development of mutually beneficial relations with the market environment, serving as an example of socially responsible business activity that is valued on the market.

Source: Anna Rosa.



Source: Anna Rosa.

Biological farming practice at the Top Farms group's farms

The 5C rules followed in the Top Farms group are based on the premise that farming should bring benefits to the company's environment in a broad sense. As the employees underline, farming is conducted in symbiosis with the farms' entire environment. The company works with local units in all areas of activity involving a natural/environmental aspect. One example of this kind of farming involves creating conditions for the development of pollinators (bees) by sowing cover crops (mixtures) that produce fruit and seeds. Cover crops increase local biodiversity while also bringing financial benefits for local beekeepers.

Another example of farming culture with a positive impact on the surroundings is activity related to small-scale water retention and the construction of embankments to support crop irrigation at locations where the company operates that have relatively little rainfall. These are simple embankments of clay or marl, covered with soil and fitted with furrows and sluices. These sites are also an oasis for many beneficial species, including rare birds.

Apart from building small-scale water retention systems, especially in winter and spring, the Top Farms group plants and maintains tree-covered belts, which have a positive impact on the natural environment and local landscape, and serve as protection against wind erosion. Planting broad-leaved and coniferous trees has another benefit: the trees form a natural buffer restricting the spread of the smell of organic fertiliser as it is stored and used. They also serve as a sanctuary for many useful plant and animal species.

Moreover, Top Farms is also involved in renovating elements of local cultural heritage such as roadside crosses, chapels and statues.

As regards the 5C Code and farming culture, Top Farms employees believe that being the best possible farmer is not limited to implementing appropriate practices of regenerative farming, but also includes passing on knowledge and information about the true image of this activity to other farmers and the socio-economic environment. To increase the awareness of customers, society, consumers and public opinion, and to adjust to the demands of the buyers of the company's products, businesses belonging to the group participate in agricultural production quality systems such as the Harmony integrated crop production system or the LEAF and Global Gap programmes.

6.9. GOOD BIOLOGICAL FARMING PRACTICE — Precision farming

Precision farming is a type of farming based on digital technologies and devices. It uses data from production operations to appropriately adjust all the agrotechnology elements to variable conditions in different areas of the fields under cultivation (Dominik 2010; Kowalczyk, Krzyżanowski, Kwasek, 2018). The main purpose of this system is to increase the scale of production and improve its quality, although it also helps reduce agriculture's negative impact on the natural environment and climate. The range of technologies and devices used in precision farming is extensive. It includes satellite navigation (GPS – Global Positioning System), computers, drones, cameras, automated soil sampling devices, 3D maps of soil richness and variability, specialist software, and farm machinery (tractors, sprayers). Precision farming is also based on many different kinds of data, including information on soil and plant properties, the presence of agrophages, meteorological parameters, jobs completed in the field, crop harvests and yields, and the state and location of machinery.

Grounds for application

Precision farming technologies and solutions contribute to reduced use of means of agricultural production while also helping achieve a greater scale of production. This means improved productivity of the resources engaged in a farm's operations and improved effectiveness of those operations, which translates into increased profitability of farming. Another major benefit of precision farming lies in reducing the negative impact of farming on the natural environment and climate. Processed and properly interpreted, data gathered from the fields may enable less water to be used, for example, or agrotechnological procedures to be applied selectively (application of fertilisers and pesticides where they are needed and in optimal amounts), thanks to which smaller amounts of environmentally harmful substances are used, such as mineral fertilisers, pesticides and fuel.

Precision farming today is also an important element of the "smart solution" concept, supporting entrepreneurship and thus fostering the socio-economic development of rural areas (Kalinowski, Komorowski, Rosa, 2021).

Biological farming practice at the Top Farms group's farms

At farms belonging to the Top Farms group, precision farming is an important biological farming practice as well as being a key measure enabling the goals of farming operations to be achieved. For example, Spearhead Slovakia limits the use of agricultural chemicals. This is made possible by the use of innovative machines and technologies. Since 2020, the company has been investing in mechanical weed removers, purchasing an interrow cultivator fitted with a camera for active operation management and control. Its advantages include quick operation and the possibility of running close to the sown crop rows. This means that the size of the area not covered by the procedure is small. Another piece of equipment on the farm is a weeder, used for cultivating winter crops and spring crops. The company has modified this machine to enable precision removal of weeds from crop rows. Another solution related to precision farming and helping reduce the use of chemicals at Spearhead Slovakia involves satellites and drones for photographing the fields. Data from the drone are not sent directly to the sprayer, they first undergo specialist processing. Special software produces crop-spraying maps adjusted to the current situation and specific parts of a field. The pictures are so detailed that it is clear precisely where weeds grow, and that is where the spraying is done. This approach enables precision spraying that reduces the amount of weedkiller at the farm by about 25%.

The main aim of these applications is financial savings due to using smaller amounts of pesticides, mineral and natural fertilisers. Thanks to such tools, we can have a positive impact on the farm's profits, because [we use] herbicides selectively, where only the weeds are sprayed and not the crops. [K.S., 2021-07-21]

The next example of precision farming is liming at Top Farms Głubczyce. This has been performed as precisely as possible for the past five years, using specialist machines and devices reducing lime losses. Alongside precision application of lime, Top Farms Głubczyce attaches importance to the varied (changing) amount applied, adjusted to the needs of a specific section of a given field. Special equipment is used for this: instead of an ordinary spreader, which applies lime inaccurately, a lance-type spreader is used, which evenly applies a specific and variable dose of lime along a working width of 12 metres, within a defined range.

Source: Kacper Łata.

Source: Kacper Łata.

7.

Source: Anna Rosa.

Recommendations and conclusions

7. Recommendations and conclusions

7.1. For agricultural policy and agricultural advisers

1.

Conclusion

Many farmers lack funding to implement biological farming methods at their farms.

Explanation

Besides knowledge, some biological farming practices also require advanced farming machinery and equipment as well as precision farming solutions. This is very expensive equipment and technology that few agricultural producers in Poland can afford. Farmers often do not have enough funding to modernise their farms and invest in innovations because their main efforts focus on ensuring simple replacement of assets.

Recommendation

Increase the availability of non-repayable and repayable financial support instruments for agricultural investments serving to make agricultural production more environment-friendly and helping improve production and economic results, as part of agricultural policy (e.g. CAP second pillar, preferential loans for farmers). Strengthen the farming services sector offering the implementation of regenerative farming practices.

2.

Conclusion

Farmers often come to accept certain solutions after observing the positive experience of other farmers.

Explanation

Studies conducted around the world and the experience of partners in the Biologization: The Key to Sustainable Agriculture project suggest that biological farming is profitable (e.g. by reducing the cost of fertilisers, fuel, crop protection chemicals, or thanks to increased yields) and contributes to positive effects for the natural environment and society. However, some agricultural producers are mistrustful of new agricultural practices, which are usually passed on from the top down and in traditional ways (lectures, printed materials). Studies show that the popularisation of good farming practices is very effective when the methods involve mutual sharing of knowledge, the exchange of experiences, and also new channels of communication (online services with videos) and social media.

Recommendation

Provide organisational and financial support to initiatives aimed at sharing knowledge and experience related to regenerative farming practices (shows, demonstrations at farms, online services and social media).

3. **Conclusion**

Most agricultural advisers and farmers do not have the necessary knowledge about regenerative farming practices and guidelines connected with the European Green Deal and the new Common Agricultural Policy.

Explanation

During the project's implementation and international meetings, we often heard the opinion that agricultural advisers and farmers had insufficient knowledge about farming practices that would be economically profitable while also having a positive impact on the natural environment. These include biological farming practices, some of which will receive support under the eco-schemes foreseen in the Common Agricultural Policy Strategic Plan for the years 2023-2027.

Recommendation

Organise training courses, workshops and demonstrations for agricultural advisers and farmers in order to expand their knowledge on biological farming practices (intensify regenerative farming knowledge transfer to individual links of the Agricultural Knowledge and Innovation System – AKIS).

7.2. For farmers

1. **Conclusion**

Few farmers in Poland test soil for pH levels and macronutrient and microelement content.

Explanation

Studies show that a negligible number of farmers test their soil in Poland. This is an unfavourable situation from the point of view of rational and profitable farming and socially and environmentally responsible business operations. A proper diagnosis of the situation is the first step in biological farming undertaken to improve soil condition and increase its potential (fertility), thus leading to a farm's improved production and economic results. The key to identifying the situation and the basic method for any farm should be a comprehensive and in-depth analysis of the soil.

Recommendation

Conduct systematic, comprehensive and in-depth soil analyses.

2.

Conclusion

Almost two-thirds of the soil in Poland is characterised by high or very high acidity.

Explanation

Excessively high acidity is connected with the low biological activity of soil and its low fertility. It also means higher absorption of heavy metals by plants. The way to deacidifying the soil and improving its physical, chemical and biological properties is to use calcium-based fertilisers. From the point of view of plants' needs, calcium is one of the most important macronutrients in soil.

Recommendation

Strive to maintain an appropriate soil pH – for most crops grown in Poland, this lies within the range of 6.0-7.0 (slightly acidic or neutral). At the same time, the proper ratio of calcium to magnesium, potassium and sodium has to be maintained, as this determines the soil structure and the conditions for the development of biological life within the soil.

3.

Conclusion

Many farmers are mistrustful of sowing cover crops.

Explanation

Growing cover crops is a financial cost for producers, and a difficult practice that has to be developed by trial and error. People often believe that cover crops deprive soil of the water needed for the main crop to grow. However, sowing cover crops is definitely a practice that benefits both the farm and the natural environment. Cover crops help build plant structure and enrich the soil with nitrogen. They have a positive impact on the soil's organic matter content, but also serve as protection against water and air erosion. Thanks to cover crops, valuable nutrients stored deep in the soil are made available to plants from the main crop.

Recommendation

Sow cover crops, especially after cereals, potatoes and sugar beets, in accordance with guidelines developed for biological farming (described further in the Catalogue) and taking into account a given farm's specific situation.

4.

Conclusion

The long prevailing view in conventional farming is that ploughing is a necessity.

Explanation

One of the main principles in the 5C biological farming code followed by the Top Farms group is related to the right approach to agrotechnology procedures. The idea is to interfere as little as possible in processes occurring in the soil – by limiting tilling, which can mean no-plough farming or limited ploughing, according to the principle that you should "disturb the soil as little as possible" and "only till as much as necessary". Coupled with the practice of leaving harvest waste on the soil surface, limiting ploughing contributes to increased organic carbon levels and biological diversity in the soil. Moreover, the above-described practice improves the soil structure. Limiting ploughing also reduces the costs of labour and consumption of means of production (fertilisers, fuel, machinery) as well as reducing carbon dioxide emissions (fixing of organic carbon in the soil, reduced carbon dioxide).

Recommendation

Limit ploughing or switch to no-plough farming.

7.3. For science and research

1.

CONCLUSION

The concepts of biological farming and regenerative farming are relatively poorly recognised, especially in Polish science and research from the fields of economics of agriculture, agronomy, rural sociology, and rural studies in a broad sense.

EXPLANATION

Desk research as well as bibliometric and webometric analyses suggest that, unlike the international research space, studies on biological and regenerative farming are extremely rare in Poland. This translates into low awareness among stakeholders (entities responsible for creating and implementing agricultural policy, agricultural producers, the farming support sector, and consumers) of the existence of farming practices that benefit farmers, food consumers and natural resources.

RECOMMENDATION

Pay relatively more attention to and support interdisciplinary research related to biological and regenerative farming, including research on the economic, environmental and social factors involved as well as the effects.

2.

CONCLUSION

The results of many research projects show that there are long-term negative consequences of conventional farming practices for soil, consumer health and the economic vitality of farms. On the other hand, the number of widely used and well-known farming practices that benefit farmers and the environment is still relatively small.

EXPLANATION

Agricultural producers guided by a justified drive to make a profit from their farms are often convinced that there is no alternative to "old and proven" methods of agricultural production generating satisfactory profits, even though these do not always have a positive impact on soil condition, water resources, biodiversity and the nutritional value of produce.

RECOMMENDATION

Support research in agronomy and the economics of agriculture to study farming practices that benefit farmers, the environment and society (e.g. regenerative, organic, sustainable farming practices).

7.4. For society and local governments

Conclusion

A large part of food is falsified, it does not meet quality standards, and the process of its production does not benefit the environment and climate. Food consumers feel lost on the market.

Explanation

Studies prove that a large part of food does not meet health standards, while its production is connected with a negative impact on valuable natural resources and climate change. At the same time, more and more consumers attach great importance to healthy eating. Their ecological awareness is also growing. However, there is an asymmetry of information between consumers and food producers, while the agri-food market is characterised by limited transparency.

Recommendation

Ensure transparency of the production process at businesses in the agri-food sector as well as communication with customers. In food purchase decisions, take into account certificates confirming a product's quality and appropriate standards followed in its production.

8.


Source: Anna Rosa.

Partners of the project

8. Partners of the project

Partners working on the *Biologization: The Key to Sustainable Agriculture* project:

- Institute of Rural and Agricultural Development, Polish Academy of Sciences (IRWiR PAN)
- Poznań University of Life Sciences (UP Poznań)
- Spearhead International
    - Top Farms Group based in Poznań
    - Spearhead Czech s.r.o.
    - Spearhead Slovakia s.r.o.

IRWIR PAN
Polska Akademia Nauk
Instytut Rozwoju Wsi i Rolnictwa

Source: Anna Rosa.

Staszic Palace, the IRWiR PAN building in Warsaw

Institute of Rural and Agricultural Development, Polish Academy of Sciences

The Institute of Rural and Agricultural Development of the Polish Academy of Sciences (IRWiR PAN) belongs to the Polish Academy of Sciences' Division I – Humanities and Social Sciences. As an opinion-forming and advisory unit, it has conducted scientific research as well as expert and evaluation projects for over 50 years. What distinguishes it from other institutes is an interdisciplinary approach to the subject of its research, i.e. rural areas. Research conducted at the institute covers social and economic changes in rural Poland, taking into account domestic and global trends. The research also aims to diagnose processes occurring in rural areas and in agriculture as well as to predict future directions of change and conceive development scenarios.

In the institute's research work, agriculture has always been an important element of the much broader field of rural development. The interdisciplinary nature of the institute's research is conducive to finding answers to questions, solving problems and identifying issues that are too broad or too complex to be dealt with by a single discipline or specialised group of researchers. For this reason, the institute brings together specialists from different disciplines: economics, sociology, demography, ethnography, education, geography etc., whose common interests are focused on matters related to rural areas and agriculture. This enables them to take an interdisciplinary approach to rural issues and conduct extremely varied studies, in terms of the topics covered as well as the research tools used.

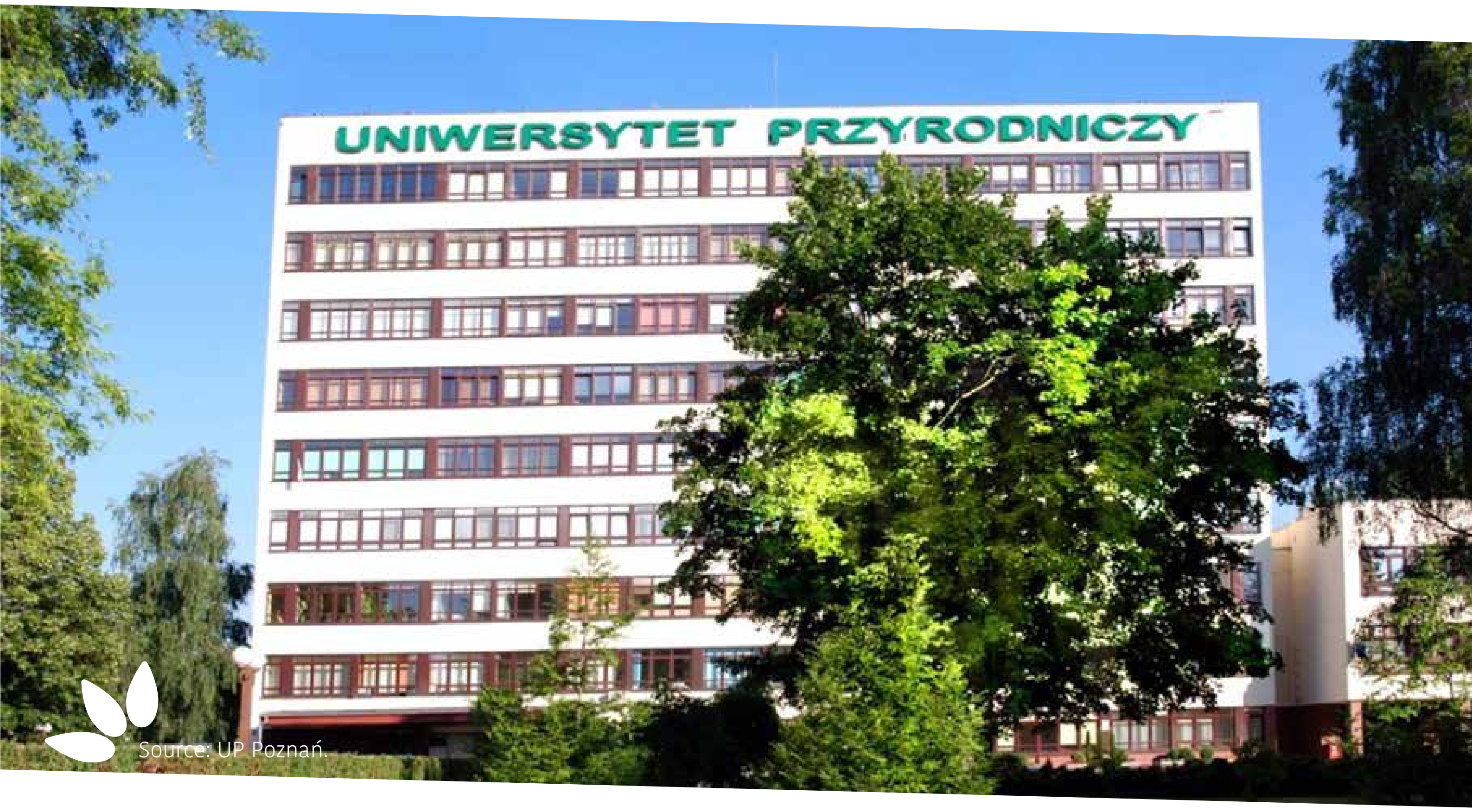
The institute collaborates with many Polish and international research centres as well as organisations and individuals representing the world of business.

The institute has been monitoring the economic aspect of processes occurring in rural areas for many years, which is a necessary condition for formulating any long-term strategy of rural and agricultural development in the process of integration with the EU. The institute has an indisputably significant share in the development of rural policy, agricultural policy being one of its elements.

IRWiR PAN is also a forerunner in research on entrepreneurship in rural areas.

In government documents, the institute is mentioned as a unit that produces independent evaluations and conducts independent monitoring of government policies related to the structural development of agriculture and rural areas.

UNIWERSYTET PRZYRODNICZY W POZNANIU



Poznań University of Life Sciences building

Poznań University of Life Sciences

In its academic activity, the Poznań University of Life Sciences (UP Poznań) combines a rich tradition of education for the needs of agriculture with educating people for other sectors of the economy. Already in 1870, through the efforts of Count August Cieszkowski, the Halina Higher School of Agriculture was set up in Żabikowo near Poznań – at the time, the only school in Polish lands under Prussian rule that trained agronomists and stewards. UP Poznań also draws its intellectual heritage from a university founded in 1919 (initially called the Piast University, later the University of Poznań), whose structure included the Faculty of Agriculture and Forestry. The university's post-war history began in 1951 with the establishment of the Higher School of Agriculture, transformed into the

Agricultural Academy in 1972, which functioned as the August Cieszkowski Agricultural Academy in Poznań in the years 1996-2008, and from 2008 has been called the Poznań University of Life Sciences.

The mission of the Poznań University of Life Sciences is to provide an education and carry out top-standard research within the concept of sustainable socio-economic development. In particular, staff members of the Faculty of Economics conduct original and unique studies involving economic and social issues related to the agri-food sector and rural areas. At the same time, this faculty also carries out research on a macro-, meso- and micro-scale, studying economic and social issues related to economic development processes in an international, national, regional or local approach. Another major segment of research and development work involves issues of competitiveness and sustainable development of agriculture, the food industry, rural areas, the forestry and timber sector, bioeconomics as well as domestic and international food trade and consumption, regional diversity, and the political and institutional environment of agrobusiness.

The Poznań University of Life Sciences is one of Poland's leading life sciences universities. Every year it teaches over 7,000 students in 23 courses, employing over 800 academic teachers, including over 100 professors, and boasting an advanced material base and a wide group of qualified research and teaching staff. At present the university is authorised to confer postdoctoral degrees in the following disciplines: agronomy, forestry, zootechnics, horticulture, wood science, food and nutrition science, agricultural engineering, biotechnology, environmental protection and engineering, and economics.

The high quality of both education and research at the university has been confirmed by many awards in recent years, including the Kuźnia Kadr award and the title of Poland's Best Agricultural University. The university's achievements are mobilising the entire academic community of the Poznań University of Life Sciences to continue working hard and striving to be "THE BEST BY NATURE".

The university's scientific achievements are publicised domestically and internationally, and are also the object of knowledge transfer to socio-economic practice as part of various collaborations with partners at home and abroad, including local-government, governmental and EU institutions.

Source: Kacper Łata.

Spearhead International

Spearhead International is a European agri-food group operating on approx. 90,000 hectares in five European countries (Poland, Czechia, Slovakia, Romania, and the United Kingdom). The company's over 50-year history, coupled with the reputation it owes to the quality, reliability and safety of its products, has enabled it to win the position of a recognised leading supplier for many international food producing and processing businesses as well as retail chains.

The group's greatest value is its team of highly qualified employees who pursue their professional vocation with great passion. The jointly developed and applied code of values that they follow at Top Farms, among other things based on honesty, reliability, trust and commitment, is the foundation of the organisation's development. The group's resources as well as the latest technologies and advanced management systems ensure the company's constant business growth and development. Special concern for the natural environment guides the company in its operations, which involve an integrated crop protection system, environment-friendly farming and processing technologies. At its farms, the group uses biological farming techniques aimed at improving soil fertility and health as part of a model of diverse agriculture, including minimising the use of crop protection chemicals and optimising fertilisation as well as eliminating the negative effects of intensive farming.

The **Top Farms Group** with its head office in Poznań is the biggest producer of quality foodstuffs and raw materials and products for agri-food processing, and a leader in cereal seed production and dairy cattle husbandry. The group's operations cover 32,000 hectares located in the Wielkopolskie, Opolskie and Warmińsko-Mazurskie provinces, where the group's nine companies are also based. Top Farms' resources and state-of-the-art technologies and advanced management systems as well as synergy effects within the group ensure constant business growth and development. Special concern for the natural environment guides the group in its operations, which involve an integrated crop protection system, environment-friendly farming and processing technologies. The group's greatest value is its team of highly qualified employees who pursue their professional vocation with great passion. The jointly developed and applied code of values that they follow at Top Farms, among other things based on honesty, reliability, trust and commitment, is the foundation of the organisation's success and future development.

Spearhead Czech s.r.o. with its head office in the municipality of Horní Moštěnice is part of the Spearhead International Ltd. Group. As a parent company, it comprises a group of six regional agricultural businesses with long-standing traditions: SALIX MORAVA, EUROFARMS JIHLAVA, AGRO-SUMAK, Agro-družstvo MORAVA, EUROFARMS AGRO-B, ROLANA, and the seed business AGROSALES. The group has 320 employees and runs farming operations on approx. 25,000 hectares, supplying quality agricultural produce to the agri-food processing industry. Crop production focuses on cereals, oil plants, fodder plants and root crops as well as energy crops for biomass. In terms of livestock, it specialises in dairy cattle and pigs. Its key products are wheat for food, rapeseed, and cow's milk.

Spearhead Slovakia s.r.o. with its head office in the town of Farná in the south-western part of Slovakia is part of the Spearhead International Ltd. Group. It coordinates the operations of local agricultural businesses with long-standing traditions, such as Green Point, Radar, and Polnohospodárske družstvo Podhorany. The group has 44 employees and operates on approx. 5,300 hectares of land. It supplies quality agricultural produce to the agri-food processing industry, chiefly cereals, root crops and oil plants as well as energy crops for biomass. It also has extensive acreage on which it can successfully use highly productive mechanised production systems.

Information and Literature

Source: Anna Rosa.

Information and Literature

1. International project meetings as part of the *Biologization: The Key to Sustainable Agriculture* project

Poznań – 1 March 2021
Turew – 25 May 2021
Horní Moštěnice – 21 July 2021
Zbehy – 22 July 2021
Głubczyce – 28 September 2021
Wrocław – 20 January 2022
Warszawa – 31 March 2022

Quotations with initials listed in the Catalogue are statements made by participants of international meetings.

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