Banat Green Deal: GreenERDE

Education and Research in the context of the digital and ecological transformation of agriculture in the Banat Region and Baden-Württemberg - towards resource efficiency and resilience

AGRICULTURE IN RESPONSIBILITY FOR OUR COMMON WORLD

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Introduction

The vocational training course program **"Agriculture in Responsibility for our common World"** organised within the frame of the **Banat Green Deal Project "GreenERDE"** (Education and Research in the context of the digital and ecological transformation of agriculture in the Banat Region and Baden-Württemberg - towards resource efficiency and resilience) and delivered between June 2021 and May 2022 targets the knowledge and experience transfer to the farmer community in the Banat Region, Romania and other parts of the world. Current and future challenges, such as the ecological conversion and digital transformation of agricultural production, but also social, economic and cultural aspects haven been addressed transcending prevailing patterns. The innovative and relevant knowledge originating from practice, experiments, research or development projects throughout Europe and other continents is deployed in a training format to the interested participants.

Background

The starting point is the Voiteg Romanian-German Training Center for Agriculture, which has an institutional framework being established and operated by the Banat`s University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" from Timisoara. From Germany, DEULA Baden-Württemberg gGmbH, Nürtingen-Geislingen University of Applied Science, Madora GmbH and the University of Hohenheim are involved as an educational partners. This cooperation seeks to expand the area of topical vocational training, promote education and training in the agricultural and environmental sector, and to improve farmers` skills in responsible farming concerning the challenges of climate change and soil degradation as consequence of the industrialization of the world economy. Drought events in the Banat region of Romania, Hungary and Serbia underline the need for action in this farming region with fertile arable soils. For the agricultural sector as an important socio-economic and cultural factor, questions of holistic education and training with respect to the possible benefits and risks of novel technologies, digitalization and ecological transformation, with a view to the common good and sustainable human development need to be clarified. Measures for soil, water and climate protection as well as care for socio-economic welfare and health are of increasing relevance at regional and global levels. Previous approaches in education and consultation, in applied research or in networking with initiatives in neighbouring countries urgently need to be expanded and established in a long-term framework to meet current and future challenges.

Goal

The overarching goal of the project is to combine Baden-Württemberg's previous involvement in the Voiteg Romanian-German Training Center for Agriculture with a sustainable development strategy for the agricultural sector in the Romanian Banat and neighboring regions by increasing the volume of professional and universal knowledge, diversifying skills with an impact on the career, obtaining perspectives, acquiring a level/status of digital literacy as well as cultural competence, and opening new horizons in the agricultural field with respect to its and soil ecological implications.

The **Objectives** of the project are to:

1. Reach a higher level of awareness and competence regarding current and future challenges for agriculture with emphasis on the adaptation to and mitigation of climate change, ecological conversion, digital transformation,

maintenance of soil fertility and health, water resources, ecosystem services and environmental integrity, as well as socio-economic and cultural aspects.

2. Consolidate and further develop technical, informational and communicational skills to enable the use of high technology, platforms and applications in farming activities as well as to promote the formation and active participation in Agricultural Knowledge, Innovation and Information Systems (AKIS).

3. Practical on-farm demonstration and e-learning supported training.

4. Improved networking with national and international research and education partners to ensure further development stages of the Centre as Professional Training Hub in Western Romania.

Format

The trainings were conducted virtually on an interactive online and e-learning platform ILIAS ("Integrated Learning, Information and Work Cooperation System") and as practical trainings and field demonstrations at the research station and agricultural training center in Voiteg, Romania.

Participants

Course participants include farm owners, farm employers, bachelor, master and Ph.D. students. The number of participants has been limited to 50 participants on face-to-face activities and to 100 participants to the online activities due to the capacity of the online platform. All interested participants are invited to express their interest to attend. To do so, they must submit a pre-registration form. The trainings organizers will send the meeting link as well as the guidelines on engagement to confirmed participants.

Trainers Affiliations

* Banat`s University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" from Timisoara

* BASF-Agrarzentrum Limburgerhof, Germany

* CREA (Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria),

* CZU (Česká zemědělská univerzita, Tschechische Agraruniversität), Czech Republic

* Department of Environmental Science, Policy, & Management, UC Berkeley, California, USA

* IBLA (Institute for Biological Agriculture Luxembourg), Luxemburg

* Institute for science application in agriculture, Belgrade, Serbia

* Julius Kühn-Institut – Bundesforschungsinstitut für Kulturpflanzen (JKI) is the German Federal Research Centre for Cultivated Plants, Germany

* Nürtingen-Geislingen University (German: Hochschule für Wirtschaft und Umwelt Nürtingen-Geislingen), Germany

* ÖMKi (Ökológiai Mezőgazdasági Kutatóintézet, Ungarisches Forschungsinstitut für Organische Landwirtschaft), Hungary

* Ostbayerische Techn. Hochschule Regensburg (OTH Regensburg), Germany

* University of Belgrade, Serbia

* University of Hohenheim, Germany

* University of Veterinary Medicine Budapest, Hungary

* University Prishtina, Republic Kosovo

Languages

Simultaneous translations in English, German and Romanian has been provided for the trainings sessions.

Programme Structure, Content and Timetable

The training sessions have included plenary presentations and breakout groups thereby allowing interactive knowledge exchanges and discussions among the participants. The timing of the sessions has been scheduled to allow for maximum participation of participants in different regions.

Call to Action on Agriculturae Education

The organizers intend to release a Call to Action on Agriculture Education as an outcome of the trainings. This shall serve as a reference point and guide for those wishing to intensify or expand their efforts in agriculture education. The Call to Action shall be prepared and shared with trainings participants and other stakeholders for comments. Participants at the trainings and subsequently, organizations, shall be invited to endorse the Call to Action.

Organizers and Partners

The planning and implementation of this training is a cooperative effort of six members of the Collaborative Partnership on Agriculture, namely the:

* University of Hohenheim
* Banat`s University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" from Timisoara
* University of Nürtingen-Geislingen
* Madora GmbH
* Romanian-German Training Center for Agriculture Voiteg

With financial support by the State Ministry of Baden-Württemberg

Program Description

The Course “Agriculture in Responsibility for our common World” organised within the frame of the BanatGreenDeal Project “GreenERDE” (www.greenerde.eu) and delivered between June 2021 and March 2022 targets the knowledge and experience transfer to the farmer community in the Banat Region, Romania and other parts of the world. Current and future challenges, such as the ecological conversion and digital transformation of agricultural production, but also social, economic and cultural aspects have been addressed transcending prevailing patterns. Innovative and relevant knowledge originating from practice, experiments, research or developmental projects throughout Europe has been deployed in a training format to the interested participants.

The structure of the course comprises eight topical modules, organized as follows:

Module 1&2, delivered online (3rd tier of June 2021), has covered topics of **Current and Future Challenges for a Socially, Ecologically and Economically Sustainable Agriculture**. This comprises sessions providing an overview on Agriculture in Romania, Germany and Baden-Württemberg as well as the Global Situation. Attention will be drawn on the role of Agriculture regarding the Ecological and Cultural Crisis, which requires that solutions are not only expected from technological progress. Resilience and farming under climate change – adapted varieties and crop management, structural issues/evolution and socio-economic perspectives in Romania, Germany and Europe will be addressed. **Soil Fertility and Water Purity are Precious Goods at Risk**. In this context, the Taxonomy of Main Soils in Romania, Climate Change Impact on Soil Fertility, The role of Soil Life for Soil Fertility, Biological Approaches, Responsible Soil and

Water Management, Soil and Water Related Technologies oriented towards Soil (Structure) Preservation, Humus Management, Low Input Technologies), Crop Rotation and Soil Fertility, Microbiology, Agricultural Pollutants and Water Purity/Quality, The Biological Activity of the Soil in Ensuring a Sustainable Agriculture, Compost and Soil Organic Matter, Organic Farming and Soil Fertility has been emphasized.

Module 3, introduces the **Ecological Conversion of Agriculture: Changes and Challenges in Plant Nutrition** and Protection (2nd tier of July 2021) and includes sessions in: Integrated and Biological Plant Protection and Weeds Control, Biological Agents for Crop Protection, Urban Gardening and Plant Protection without Pesticides, Traditional and Innovative Plant Health Maintenance, Field Testing of Chemical and Biological Agents, Plant Protection in Horticultural Production Systems, Plant Protection and Mineral Nutrition in Viticulture, Plant Protection in Viticulture and Horticulture with less Agrochemicals, Plant Nutrition and Resistance of Crop Plants, A Dynamic Fertilization for Sustainable Agriculture, Organic Farming - Actions, Challenges and Perspectives, The Role of Crop Rotations in the Control of Weeds, Diseases and Pests in Agricultural Crops, Agrotechnical Methods of Control of Weeds, Diseases and Pests in Agricultural Crops, Safe Application of Plant Protection Products.

Module 4 on **Soil Cultivation: Connecting Biodiversity and Climate Change Mitigation and Adaptation** (2nd tier of September 2021) covers: Soil Cultivation and Seeding, No Tillage Systems and Technique, Minimum Tillage, Strip Tillage/Target, Adaptation of Crop Plants to Drought, Cold and Inadequate Mineral Nutrient Availability in Soils, Genetic and Epigenetic Adaptation of Crop Plants to Adverse Environmental Conditions, Climate Change and Land, Impact of the Climate Change on Biodiversity, Integrating Climate Change Attenuation and Adaptation in Plant Culture, Specific Crop Technologies with the Role of Reducing the Impact of the Climate Change, The Climate Change Influence of the Crops Physiology. Complementary to the lectures, in this module at 2-days a practical training at the Voiteg Agricultural School with the demonstration of agricultural machinery is offered for plant production managers of large farms, middle sized farm owners, specialists, students and other interested persons: soil cultivation and seeding, no tillage systems and technique, minimum tillage, strip tillage.

Module 5 introduces the **Digitalization of Agriculture: Rationality and Risks** (2nd tier of November 2021) integrating sessions in: Digitalization and Ethics, Basics for Digital Farming: Concept of Smart Farming, Guidance Systems and Farm Management, Field-Robotics for Soil Sampling and Analyses, Digitalisation in Land Cadastre, Optimization of Agricultural Production Processes through Smart Farming, Digitization of Farm and Off-Farm Activities, Best Apps Selection for Farmers.

Module 6 concentrates on the **Global Integration of Agriculture: Social and Geographic Networking** (3rd tier of January 2022) including sessions dealing with: Benefits of Forest Belts in Landscapes regarding Soil Conservation and Crop Protection, Possibilities for Restoration of Degraded Farmland, Information and Elaboration of Application Maps (Site Specific Plant Protection and Fertilisation), Precision Agriculture: Global Positioning System (GPS), Geospatial Methods for Collecting Data, (Mini-)GIS for Agriculture, Monitoring the Crops by using Remote Sensing Images.

Module 7 covers the topic of **School of Agriculture and Life: Sharing Knowledge and Innovations** (2nd tier of February 2022) with insights over: Sharing Knowledge and Innovation - Education and Practical Training in the Context of Digital and Ecological Transformation of Agriculture in the Banat / Digital and Ecological Transformation of Agriculture - Experiences from and for Training and Knowledge Transfer, The Agricultural Knowledge and Innovation System (AKIS): Inspirational Ideas to Adequately meet Local and Global needs, Romanian AKIS and Knowledge Brokerage in the Romanian Rural. Equally it delivers a vocational training seminar and experience exchange (input and workshops).

Module 8 introduces the **Integrated Crop Management and Digitalization** (2nd tier of March 2022) with machines and equipment for organic farming, delivering a wide selection of applications validated by the Wisefarmer (wisefarmer.eu) and Landsupport (landsupport.eu) projects, and the impact of paired online learning as blended form of training.

The participants will receive Training Certificate for each Module issued by the BUAS Timisoara; Voiteg Schoala Agricola, DEULA, University Nürtingen-Geislingen and University of Hohenheim. The participants acquire top-of-the-state of art knowledge in all the domains covered by the modules and sessions enabling them to develop and project new perspectives and approaches in their farming activities and in the interactions with the wider farming community with accent on current trends and threads proving higher awareness as result of the received training and information.

Involved Institutions and Countries of Origin:

- Banat`s University of Agricultural Sciences and Veterinary Medicine ”King Michael I of Romania” from Timisoara and the Romanian-German Training Center and Professional Development in Agriculture (Scoala Agricola Voiteg), Romania
- Universităţii de Ştiinţe Agricole şi Medicină Veterinară Cluj-Napoca, RO
- Nürtingen-Geislingen University (German: Hochschule für Wirtschaft und Umwelt Nürtingen-Geislingen), Germany
- University of Hohenheim, Germany
- Ostbayerische Technische Hochschule Regensburg (OTH Regensburg) G.
- ÖMKi (Ökológiai Mezőgazdasági Kutatóintézet, Research Institute of Organic Agriculture), Hungary
- IBLA (Institute for Biological Agriculture Luxembourg), Luxemburg
- CREA (Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria), Italy
- CZU (Česká zemědělská univerzita), Czech Republic
- University Prishtina, Republic Kosovo
- University Belgrad, Serbia
- Institute for Science Application in Agriculture, Belgrade, Serbia
- University of Veterinary Medicine Budapest, Hungary
- Julius Kühn-Institut – Bundesforschungsinstitut für Kulturpflanzen (JKI) is the German Federal Research Centre for Cultivated Plants, Germany
- BASF-Agrarzentrum Limburgerhof, Germany
- Department of Environmental Science, Policy, & Management, UC Berkeley, California, USA

Course publications

Agriculture in Responsibility for our common World:

Introductory note

Dr. Markus Weinmann: Agriculture in Responsibility for our common World

Science, technical progress, industrial development, digitization and globalization of the economy are accelerating each other like never before and are changing living conditions on earth to a very complex and hitherto unknown extent. This offers humans a wide range of opportunities to shape the world in which we live for the better. However, concerns are growing as these processes are increasingly accompanied by negative side effects that affect both social interaction and the stability of ecological systems in regional and global contexts. These include distribution injustices, poverty and human rights violations as well as the loss of biological diversity, soil and water degeneration and climate change. With regard to overcoming these global challenges, agricultural science is considered to play a key role in the development of sustainable production systems and the care for the natural basis of life. Simply looking for technical solutions to the growing environmental problems, however, seems to hide the root causes of the ecological crisis. This is indeed a dramatic consequence of the ruthless exploitation of nature as a result of an irresponsible superiority of technical rationality over the order inherent in nature without the reasonable inclusion of ethical aspects.

A main objective of this course program is to better understand the cultural context of the current ecological crisis and to discover holistic solutions for a more ecological design of agriculture that goes beyond a one-sided scientific-technical approach.

In the interdisciplinary dialogue, awareness of the importance of environmental problems should not only be sharpened, but by understanding the situation as a challenge for rethinking, this should be actively used as an opportunity for intellectual and spiritual growth in order to release creative energies in finding a proper way out of the ecological crisis.

I. Current and future challenges for a socially, ecologically and economically sustainable agriculture

Assoc. Prof. Dr. Cosmin Sălășan: Overview of the Romanian Agriculture

With over 3.4 million farms and little over 12.5 million ha the (statistical) average farm in Romania places at 3.63 ha/farm. These figures speak about the fragmented structure of the farms with many small operations, including the agricultural households. In this respect, the total registered economic agricultural operations, as legal entity, only amounts 15328 units in 2019. However, the employed population across all these structures include 1.74 million people. In terms of structure and size coupled with the share of production designated for market, respectively for self-consumption, most small farms (2.95 million units) are basically producing for self-consumption in shares larger than 50% of total production out of which 1.7 million have an area inferior to 1 ha and another 1 million have 1-5 ha. Worth adding that over 230000 farms under 5 ha use direct sales for more than 50% of their productions. In terms of area, the farms under 5 ha self-consumption-oriented cover 3 million ha, representing 40% of the arable land, while the same category of size oriented towards the market covers less than 0.7 mil ha. The evolution of the agricultural area has recorded certain changes over the past three decades; in terms of total agricultural area 138956 ha were lost between 1990-2014 out of which 55092 ha were arable land. The mechanical endowment of the farms changed consistently, certain regions such as North-West multiplied the number of tractors three times while the West region doubled them until 2020. These figures do not highlight the replacement over the 30 years period yet only the number of active units each year. The agricultural labour also decreased, only during the last two decades dropping from 3.46 million down to 1.33 million people. The acreage of main crops had evolved using different patterns or no patterns at all, with significant variations over time even from a year to the next where an important factor could be represented by the dependency to the weather factors, notably the water. That also speaks for the relative low endowment and use of irrigations with direct impact on both winter and spring crops. Still the large oscillations recorded until the accession to the EU (2007) were reasonably reduced in amplitude after, linked to the important investments sustained by the European Fund for Agriculture and Rural Development and national funds via National Rural Development Programme for modernisation and increase of competitiveness in agriculture. If the earlier comment is valid for the cereals (mainly wheat and maize), for the sunflower the evolution hasn't improved visibly with large variations even of relatively short time periods. Surprisingly, the vegetable production, with a considerably higher added value, still output at the level of the '90s. All field crops undergo a cyclic variation in terms of yield record, yet these figures comprise all farms involved, and the level and variations are strongly affected by the results of the many small farms. While still affected by the statistical effect the crop production reports a positive evolution with particular emphasis for the medium and large farms well connected to the market. In return the animal production performs considerably worse. The total bovine herd reduced from 5.38 mil heads in 1990 to 1.92 mil heads in 2019; this drop was recorded back in 2010 and remained relatively stable since. Given the time period when it reached the lower-most level and the financial crisis of that time it is factor with the largest influence and the recovery seems uncertain even after a decade. In the case of the swine meat production, the evolution and the reduction were even more severe. Starting with a total of 12 mil heads back in 1990 reaches only 3.83 mil heads in 2019 practically only one third and further decreasing in most regions on the country except for the West region. This production although highly demanded by the local market and yet not self-sufficient was placed under a constant pressure over the past two decades and more by the systematic ban for the EU market as result of sanitary veterinary events and incidents. The sheep herds also lost in volume decreasing by the beginning of the 2000s to almost half from 14 mil heads to 7.2 mil heads in 2001 and then recovered well returning to 10.35 mil heads in 2019. Positive records are also seen in beekeeping where the bee families doubled over the same time-period. The product of the main agricultural products per inhabitant over the observed period (1990-2019) has doubled for the cereals with the most notable result for maize where it practically tripled, for sunflower it multiplied by factor six while the growth for fruits and vegetables was rather insignificant and explained by the large areas of disaffected orchards and the collapse of the large glass-house system. On the side of the animal production the meat (all types included) decreased by ¼ and increased by 25% for milk and derivates. In terms of economic accounts, the cereals multiplied by factor eight, from 2.8 billion ROL in 1990 to 22.7 billion ROL in 2019 where the maize moved-up from 1.3 billion ROL to 13.6 billion ROL; sunflower started at 0.2 billion ROL and reached the level of 4 billion ROL in 2019; although with important herd decrease the cattle accounts multiplied by factor three with a similar evolution in the case of swine meat. The transition period started in the early 90s was followed by a favourable period where structural adjustments and pre-accession funding expressed in highly visible results; those last ones were subsequently moderated by the financial crisis at the end of 2010s setting the grounds for a sustained growth after it and during the second programming period (for Romania) of the EU budget to get shocked again in 2020 by the pandemic crisis. The observations indicate a high resilience for the small farms and agricultural households paralleled by an important shock absorption capacity for the medium and large farms.

Prof. Dr. Manfred G. Raupp: Agriculture in Europe, Germany and Baden-Wuerttemberg

The problem of feeding the world has become dramatically acute over the past 200 years. For millennia there were fewer than a billion people in the world who had to be fed, but since 1804 this figure has quadrupled. In 1970 there were 3.9 billion people to be fed from 3700 m² per person, but by 2018 there were already 7.0 billion, each to be fed from 2200 m². At the moment there are three more births than deaths per second, so we must expect that in 2050 there will be 9.8 billion who must make do with 1700 m² each.

Up to now increasing food requirements could be met by technical advances in breeding, plant nutrition, plant protection and management of farming, but traditional agriculture has now been drawn in discussions about the exploitation of nature. Maximising agricultural yields has in some cases caused a significant stress for the environment, in particular in soil degradation and impoverishment of soil life.

Since the industrialisation of Europe the importance of agriculture for national productivity has been drastically reduced. Within two centuries the proportion of agriculture‘s contribution to the economy dropped from 90 % to 2 %.

There has been a dramatic structural change in the structure of agriculture in Germany since the end of the Second World War. While 4.9 million people worked on the land in 1949, in 2019 this figure was under 600,000, which represents less than 12%. In the same period the number of agricultural operations sank from 1.6 million to 266,000. In 1949 a farmer supported 30 others with nourishment, but in 2019 this rose to 134.

Spending on foodstuffs in Germany has sunk from 55% to around 12-14% (of a household budget) since 1900, with a concurrent rise in the number of production stages involved.

Increasing prosperity in Germany has led to a considerable change in how money is spent. In 1950 people spent almost 50% of their budget on food, but today 50% is spent on accommodation, travel and communication.

The importance of agricultural production in Europe differs greatly y between countries, depending on their size. France produces foodstuffs to the value of 75 billion euro, while in Germany the figure is 57 billion, in Italy 56, in Spain 50 and in Rumania 19 billion. It should be remembered, however, that on average only 25% of the production cost of agricultural goods reaches the farmer. With a further increase in the degree of processing and production of ready meals this proportion will further decrease.

The foodstuff industry is bound by the balance between supply and demand, and has become increasingly important over the past decades. In 2019 agricultural exports to the value of 74 billion euro and imports of 87 billion were recorded. The degree of self-sufficiency in the case of numerous products is greater than 100%. Thus cheese, pork, milk, butter, beef and veal, potatoes, wheat and sugar are exported, and vegetables and fruit (particularly tropical fruit) are imported.

The USA and China are the most important trade partners of the EU in the import and export of foodstuffs.

Since the start of debates about near-natural agriculture and environmental protection, and their combination with a reliable food supply, the number of „bio"-operations has increased to a total of almost 15%. The leading countries in this area are Spain, France, Italy and Germany.

In Germany it is mostly the southern states that have become noted for ecological agricultural operations. Bavaria leads the way in the eco-movement with 370, 000 hectares (11.9% of its agricultural land), followed by Baden-Wuerttemberg with 187,000 ha (13.2%).

The clear goal of the EU to feed the population ever more in harmony with nature requires a transition to near-natural agriculture. Reliable provision of food has up to now been achieved through traditional farming methods, and the transition would require technical and financial support. In particular, farmers would need digital support to achieve an annual balance between ecology and economics. The new methodologies are based on new scientific knowledge which must be converted by computational modelling into recommendations for action by farmers.

The tentative application developed by a consortium under the leadership of Hohenheim University, with the goal of making the results of the BioFector Project (Fig. 1) useful for agriculture in actual practice, has been set up by EU bodies under the name „BeyondSoil".

Fig. 1: Geographical distribution of experimental sites within the International Field-Testing Network of the BioFector Project (2012-2017; www.biofector.info).

One goal of another initiative, the „Green Earth Project“, is also to ensure reliable food supply and quality of nutrition in these times of climate change. Furthermore, farmers and politicians should be shown ways how climate change can be faced by agriculture.

Dipl. Eng. Hervé Vantieghem: Agriculture in the Ecological and Cultural Crisis - Our Contribution, BASF SE

The prime target of agriculture remains to feed the world. To achieve this target several challenges need to be faced in the coming decade. These challenges deal with the higher demand and constraints in the global production, changing and more demanding societal demand and last but not least tougher requirements and hurdles to the agricultural production. Feeding 9 billion people by 2030 with a higher demand for calories and protein rich diet needs to be realized with less available arable land and in an environment with high volatility in crop production and farmer income due to climate changes. The society by 2030 is characterized by increased urbanization and increasing demand for healthy sustainable food, produced from local production and imposed more stringent regulatory requirements. To face this, agricultural production by 2030 requires a 50% higher productivity and increased farm professionalism to successfully produce under increasing sustainability requirements and increasing pest and disease resistance.

Looking closer to the above-described macroeconomic trends, there are multiple challenges in the ecological, economical and societal area that become transparent, bearing conflicts and vicious circles which need to be understood, addressed and brought into the right perspective.

Such a vicious circle is described hereafter as example. Producing more food and feed on less arable land and with more restrictions requires increased efficiency, higher professionalism, more know-how and the use of innovation. Putting this against increasing cultural demands for CO2 neutral, gmo free farming and the high demand for meat neutralizes the chance to benefit from the higher efficiency and professionalism. Moreover, the claim for local production with a transparent origin removes the benefit to achieve economy of scale and a better cost position. To assure continued viable farming within such an environment, the higher societal needs imply a compensation by a higher price or more subsidies. However, who will pay for it, the consumer through a higher price or the state by more subsidies?

Facing the above environment, BASF, a global player with ca. 59 billion € total turnover in 2020 of which ca. 13% of it in agricultural sets on offering agricultural solutions. BASF is investing ca. 40% of its total R&D budget in agriculture. These agricultural solutions comprise a complete portfolio covering key production input factors such as seeds & traits and crop protection combined with farming solutions beyond crop protection such as soil management, integrated pest management, public health and digital farming.

BASF´s strategic focus worldwide comprises four major crop systems. The crop “system wheat, oil seed rape and sunflower” and “fruit and vegetables” are the main crop systems in Europe.

In such a crop system, continuous innovation in crop protection is brought in and its usage is endorsed by digitalization tools to fulfil best possible the perspective of modern sustainable agriculture. BASF´s crop systems embrace long year experience in agricultural production and feedback of profound dialogues with the farming community.

Some examples are described hereafter.

BASF´s fungicidal active ingredient **Revysol®** is an example of sustainable crop protection in cereals. Revysol®, was introduced in European cereals in 2019. The 10-year approval in Europe will allow to sustainably secure the farmer income from cereals following the reliable control of the key winter wheat disease *Septoria tritici*, including all stems and at all weather conditions. Moreover, the protective and curative control reduces the need for correction treatment and gives a cost benefit.

BASF´s seed treatment **Systiva®** in winter barley is an example of efficient production with more outcome per hectare and with lower input. Systiva® stands for improved crop development, less winter kill and yield increase. The additional control of early foliar diseases allows to skip the first fungicide treatment in the spring and to reduce the foliar fungicide usage in winter barley.

BASF´s growth regulator **Prodax®** in cereals offers in top of the better stand, additional positive effects on the root development and enhanced plant vigour. This results in a better uptake, a higher yield and increased nitrogen efficiency. This also supports the effort to maintain the yield in areas with imposed reduced nitrogen rates per hectare.

BASF´s **Clearfield®** production system in sunflower widens the scope of growing sunflower by the efficacy on the parasitic weed *Orobanche cumana* and assures a viable income to farmers, located in areas infested with this parasitic weed such as for instance in Romania.

BASF´s digital farming solutions **Xarvio**® allow to tailor the crop protection usage, product choice, application time and use rate, according to the situation of the individual field and assure a more sustainable usage.

Side along to the measures upgrading the agricultural production, BASF is making big efforts to motivate the farming community to stay positive and to continue farming, despite the more challenging environment. Such an example is BASF´s campaign "Farming the biggest job on Earth",

However, to motivate BASF to maintain its current effort in agriculture, the return on investment, challenged by the low success quote in finding a new crop protection active ingredient, the high development cost associated with a new active ingredient and the short remaining patent protection after launching the new product, needs to be fulfilled.

Bottom line, current agricultural production is trapped in a tough battle to satisfy increasing ecological, economical and societal requirements. BASF as global player is committed to agriculture and supports farmers to fulfil these requirements and to remain viable. However, this is not a home run and requires an ongoing 360° balanced approach from all involved players.

Let's join forces in finding the right balance in future agricultural production!

® = registered trade mark of the BASF

II. Soil Fertility and Water purity: precious goods at risk

Dr. Thorsten Ruf: Biological Agriculture in Luxemburg: Crop rotation and Soil Fertility with Examples from Current Research at the IBLA

The „Institut fir biologësch Landwirtschaft an Agrarkultur Luxemburg“ (IBLA) is the competence centre for research and consulting in the field of organic agriculture and viticulture in Luxembourg. According to the motto "research for the practice", IBLA aims to have rapid transfer of their research results and knowledge into the practice through extension services, seminars, field visits of trials and various information brochures and leaflets. The focus areas are inter alia protection of natural resources (water, soil, and climate) and biodiversity, sustainability assessment, preservation and improvement of soil fertility, variety testing, animal welfare and optimization of crop rotation. IBLA is also an important contact point in Luxembourg for the cultivation and utilization of legumes.

We envision a world where we can produce high quality food while protecting the natural environment through farming in respect with nature. We believe that we can achieve such a sustainable farming system through organic agriculture. Improving organic agriculture with research, advisory, dissemination and support activities, thus making agriculture more performant and resilient. This will empower farmers to implement sustainable farming practices in Luxembourg.

Prof. Dr. Isidora Radulov: Climate change impact on soil fertility

Climate change is a major challenge for the agricultural sector and ensuring water resources and crop stability are major priorities in developing policies to prevent and mitigate the impact of extreme weather events.

Soils are important for food security, and climate change has the potential to threaten food security through its effects on soil properties and processes. Understanding these effects and what we can do to adapt to them requires an understanding of how climate and soils interact and how climate change will change soil fertility.

Soil is the main source of nutrition for plants, but also for the application of fertilisers and amendments. A fertile soil is defined by the combination of physical properties (texture, structure, profile, water retention, etc.) and physico-chemical properties (pH, nutrient content, organic matter content, cationic and anion exchange capacity, sum of bases exchangeable).

Maintaining soil fertility requires a permanent exchange of nutrients between organic matter, mineral colloids and soil solution. Changes in average temperatures and rainfall will affect soil organic matter. This, in turn, will affect important soil properties, such as aggregate formation and stability, water retention capacity, cation exchange capacity and soil nutrient content. Exactly how soil fertility will be affected by climate change involves extremely complex and interconnected systems. Identifying a single variable that influences fertility, such as temperature or precipitation level, is difficult and it is hard to determine how a change in that single variable affects this essential property of the soil.

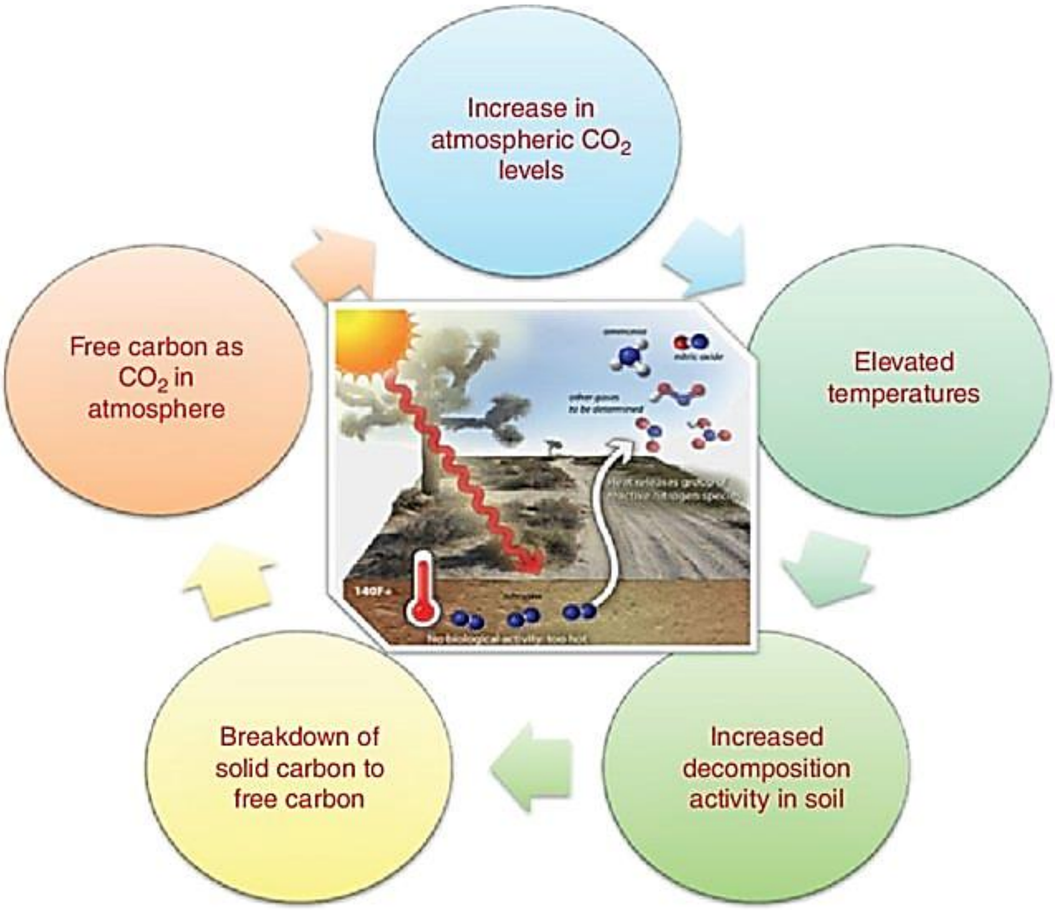

Fig 1. Increasing CO2 concentration effect upon soil organic matter (Meena and Jha, 2017)

Various studies show that soil and plants retain about 30% of CO2 released from various human activities in a year. According to Pareek (2017), increasing CO2 concentration will lead to:

- Increase in soil organic matter
- Increase in water use efficiency
- More availability of C to soil microorganisms
- Accelerated nutrient cycling

The effects of climate change on soils leads to increase in soil temperature, which will determine:

- reduction in moisture content
- reduction in labile pool of Soil organic matter,

- Increase in mineralization rate
- Loss of soil structure
- Increase in soil respiration rate
- Loss of soil organic matter

The increase in the amount of precipitation due to climate change, determines the following changes in agricultural soils:

- Increase in soil moisture or soil wetness
- Enhance surface runoff and erosion
- Increase in soil organic matter
- Nutrient leaching
- Increase reduction of Fe and nitrates
- Increased volatilization loss of nitrogen

On the other hand, the decrease in the amount of precipitation leads to:

- Reduction in soil organic matter
- Soil salinization
- Reduction in nutrient availability

The effect of climate change on soil fertility are complex processes that require multidisciplinary approaches to better understand and improve soil productivity. Good agricultural practices are recommended to improve soil health and to mitigate and adapt to climate change.

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Dr. Anna Abrahão: Global importance of soils in Brazil: The Cerrado soils

Text translated from Abrahão et al. (2022)

Characterization of the Cerrado

The Cerrado is a phytogeographic domain in Central Brazil composed of a mosaic of vegetation types, from open grasslands to forests. The distribution of the different vegetation types is the result of the interplay between climate, soil, and fire (Eiten 1972). The soils are usually deep, aluminium-rich, acidic, and well-weathered, which means they are nutrient-poor and have been long considered wasteland for agricultural purposes. The Cerrado flora is very characteristic, with short, thick-barked trees, with a crooked appearance, interspersed in a very diverse matrix of grasses and herbs.

Agricultural expansion

Since the 1960's, with the change of the capital from Rio de Janeiro (at the coast) to Brasilia (in Central Brazil), and the will to develop the region, the Cerrado has been turned into the agricultural frontier in Brazil. In the 1970's, the Brazilian government judged that it was necessary to establish an organization dedicated to fostering technological innovations and founded the Brazilian Agricultural Research Corporation (EMBRAPA) in 1973. The discovery that liming practices allowed for the regulation of the acidity of the soils, decreasing aluminium toxicity and increasing nutrient availability, allowed for the establishment of large-scale monoculture (Hosono and Hongo 2016). Other factors that contributed to the success of the expansion of the agriculture in the Cerrado region were the rainy season, the flat land, which was suited to large-scale mechanized farming and the shrub vegetation, which was easy to clear so that land could be reclaimed, thereby reducing initial cultivation costs.

The agricultural expansion into the Cerrado is seen by many as one of the "greatest achievements of worldwide agricultural science in the 20th century" (Lopes and Guimarães Guilherme 2016). As a result, the soybean production in 2006 increased more than 5000% compared to 1976 (Faleiro and Sousa 2007). The establishment of arable soils in the Cerrado opened new horizons for corn, cotton, sunflower, sugarcane, wheat, and beans used in rotation cultures in the Cerrado soils (Faleiro & Sousa, 2007). The soybean production for commodity exports has brought Brazil to economic superavit in the last two decades, as this sector accounted for 25% of the country's gross domestic product (GDP), with great economic benefits for landowners (Lapola et al. 2013).

Effects of the agricultural expansion on the water cycle

Water in the atmosphere precipitates from clouds in the form of rain, which percolates in the soil or flows on the surface. This water can be taken up by plants that absorb it in the roots, and release it through the leaves in the atmosphere, in a passive process, following a difference in water potential (Oliveira et al. 2014). This means that plants do not require any energy to transport water, and that water flows from wetter to drier areas. Once back in the atmosphere, the water can move towards other regions, according to differences in atmospheric pressure and precipitate in other regions. Therefore, the vegetation cover in one region can strongly influence the precipitation in other regions, depending on atmospheric circulation patterns. This is the case, for example, in the Amazon region, where one single tree can pump 1,500 litres of water into the atmosphere per day (Oliveira et al. 2014). The dominant atmospheric circulation in South America comes from the Atlantic Ocean and blows the clouds westward, where they are impeded by the Andes Mountains, and are diverted south (Pearce 2020), toward the Cerrado region. As such, the rain in the Cerrado comes mainly from the Amazon region. After precipitating in the Cerrado, the water is absorbed by plants, and percolates into the soil, or is pumped into the atmosphere; only a small portion being lost by runoff. The balance between runoff, percolation and evapotranspiration is driven by land cover and determines groundwater recharge and land surface cooling.

The changes in land cover, from native vegetation to crops or pastures, change the amount of water that the plants transport from the soil to the atmosphere, called transpiration. By adding the plant-transported water, and the water that evaporates directly from the soil, we obtain what we call evapotranspiration. The evapotranspiration of the native vegetation is higher than the pasture, which cools down the area. On a regional basis for clear-sky daytime conditions, conversion of natural vegetation to a crop/pasture mosaic warms the Cerrado by an average of 1.55°C (Loarie et al. 2011). In addition, the water percolation into deeper soil layers is decreased by land conversion to pastures or crops. This happens because plants have much deeper roots in the Cerrado. The deep roots help conduct water to the deeper soil layers in a process called hydraulic redistribution (Oliveira et al. 2005a, b). Plants not only absorb water from the deeper soil layers and release it in the atmosphere, but also take it up from the atmosphere or shallow soil layers and transport it into deeper soil layers. This process only happens when the deep soils are drier than the atmosphere or shallow soils, following the gradient of water potential. Hence, Cerrado plants are very good at intercepting water. For example, in a study comparing wooded Cerrado and pasture, the surface runoff was 30 times higher in the pasture (Anache et al. 2019). As a result, the recharge of groundwater decreases with land use changes from Cerrado to pastures (Oliveira et al. 2014). However, if we compare different Cerrado vegetation types, we observe that more open systems such as grasslands contribute more to recharging underground water as forested systems (Oliveira et al. 2017). Therefore, the protection of open grasslands is imperative not only to protect the biodiversity, but to secure the recharge of groundwater, and consequently, supply water to 8 out of the 12 hydrographic basins in Brazil (Lahsen et al. 2016).

The energetic matrix in Brazil is mainly based on hydroelectric energy, which is responsible for 50-65% of the energy production (ONS 2021), of which the Cerrado accounts for 19% (Latrubesse et al. 2019). In very dry years, such as 2021, Brazil relied on thermoelectric generation for half of the energy production, which severely increased the generation costs, and was reflected in the electricity bills of the consumers (Getirana et al. 2021).

In addition to the use in producing electricity, half of the water captured in the Cerrado is used for irrigation, which secures crop production during the dry season, but decreases the water flow and volume in rivers (Latrubesse et al. 2019) affecting the provision of ecosystem services that support human well-being. Unfortunately, water uptake is poorly regulated in Brazil. Uncounted pivots of surface water uptake for irrigation continue to be installed, and the extraction of surface water for irrigation is devastating swamps, creeks, small lakes, and rivers. The number of irrigation pivots in operation illegally in the whole Cerrado is unknown but is likely to be a relevant amount. For example, just in the Goiás state, more than 2,600 pivots are operating without environmental licenses (Latrubesse et al. 2019). Therefore, although Brazil has adequate legislation and regulations, they are not accompanied by law enforcement. A recent modelling study found that the present scenario of land clearing already altered the weather patterns with negative consequences on maize yields due to the higher frequency of hot and dry days (Spera et al. 2020). This finding undermines one of the main reasons for land clearing: rain-fed crop production.

Alternatives to land conversion

Ample evidence shows that it is possible to increase agricultural production without any further clearing and establish a zero-clearing policy (Lapola et al. 2013). In the early 2000's, a decrease in land clearing was accompanied by an increase in production. Cattle ranchers, especially in the south, invested in managing degraded pastures to increase productivity, or converted pastures to crops (Spera 2017). However, it is also possible that agricultural intensification will favour agricultural expansion (Lapola et al. 2013). In the MATOPIBA (states of Maranhão, Tocantins, Piauí and Bahia) region only, there were 21.5 Mha of native vegetation in 2017, of which 75% (17.2 Mha) can be legally cleared (Polizel et al. 2021). Therefore, new policies need to be put in place to prevent further land clearing in the Cerrado. One of these policies could be for example the extension of the soy moratorium to the Cerrado, whereby no new lands can be cleared for soy plantation and soybeans can only be planted in land cleared before 2008 (Nepstad et al. 2019). There could also be economic incentives to keep a larger portion of the negative vegetation standing, such as voluntary sustainability credits (Ninni 2011; Kreibich and Hermwille 2021). However, these solutions remain poorly regulated and will require technological innovations, new regulations, and appropriate law enforcement if they are to work.

Additional land valuation includes the use by traditional communities for agro-extractivism and investments in bioeconomy. The Cerrado provides an incredible variety of fruits and nuts that could reach the markets with greater profits for those who collect and process the products. It is essential to publicize and consolidate attractive markets for a diverse range of native products, such as those with regionally or internationally consolidated markets in the Amazon region, such as Brazil nuts (*Bertholletia excelsa*), açaí (*Euterpe oleraceae* or *precatoria*), babassu (*Attalea speciosa*) if the management is not intensified to the point of creating monocultures (Freitas et al. 2021). In the Cerrado, gabiroba (*Campomanesia pubescens*), passion fruit (*Passiflora* sp.), baru (*Dipteryx allata*), cagaita (*Eugenia dysenterica*), buriti (*Mauritia flexuosa*) and pequi (*Caryiocar brasiliense*) all have a potential to conquer the national market and have medicinal properties that could be further exploited (Alves et al. 2000; Melo e Silva et al. 2009).

Finally, areas of Cerrado native cover provide sources for seed collection for much needed restoration projects. Successful seed collection initiatives involve local communities that organize themselves into associations that sell native seeds for environmental compensation projects (Schmidt et al. 2019). The "Cerrado de Pé" association, in northern Goiás state and the "rede de sementes do Xingu" in Mato Grosso are examples of initiatives to restore Cerrado savannas and the Amazon forests via direct seeding, without any need for investing in expensive plant nurseries, and less losses due to sapling transplantations into the field (Sampaio et al. 2019). It is a cost-effective technique with a large potential to restore large-scale areas. The species choice must be carefully evaluated to recover not only aboveground biomass, but also the belowground biomass, which provides greater resilience against disturbances such as fire (Giles et al. 2021).

In conclusion, it is imperative to create policies and law enforcement strategies to protect the remaining native vegetation cover in the Cerrado. The native cover is essential not only for maintaining biodiversity, which has great medicinal and economic values, but also the water and carbon balances, which provide essential ecosystem services for the human population both in urban and in rural areas.

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Dr. Adina Berbecea: Agricultural pollutants and water quality

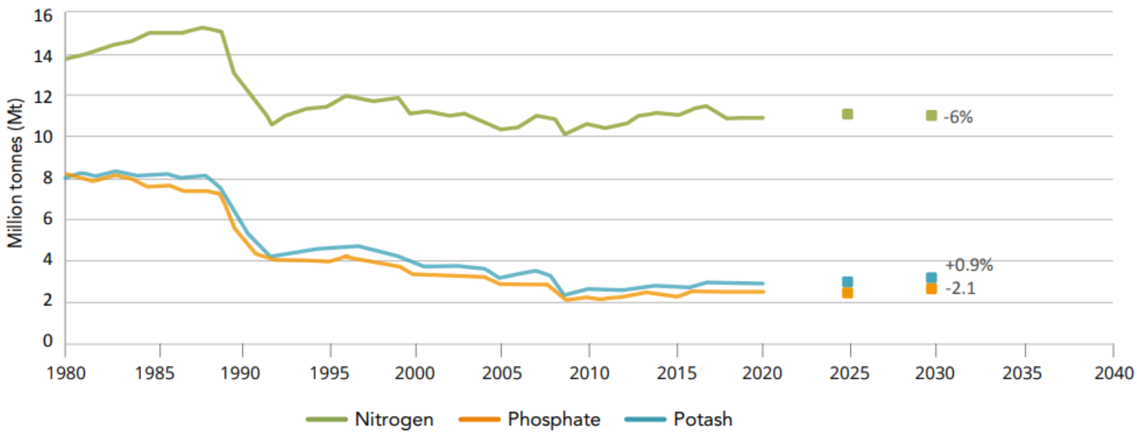
Water pollution is a global problem, both for developed and developing countries, affecting the pace of economic development and the health of billions of people.

Human settlements, industry and agriculture are the 3 major factors that determine water pollution. Globally, more than 80% of domestic wastewater is discharged untreated into water bodies, industry dumps millions of tons of solvents, heavy metals, toxic waste, and agriculture, which consumes more than 70% of global water catchments, discharges large amounts. Quantities of fertilisers, pesticides, organic matter, drug residues, sediments, etc. In countries with developed economies, pollution of water from agricultural sources has exceeded pollution from domestic sources and industrial pollution. Plant cultivation, animal husbandry and aquaculture put great pressure on both surface and groundwater.

The most important pollutants from agricultural sources are: fertilisers, pesticides, salts, sediments, organic matter, pathogens, metals and drugs.

Fertilisers

In the European Union, for an area of 133.7 million ha of agricultural fertilized land, was used per season, amounting to 11.2 million tons of N fertiliser, 2.7 million tons of phosphate and 3.1 million tons of potash. (Forecast of food, farming and fertilisers use in the European Union 2020 – 2030).

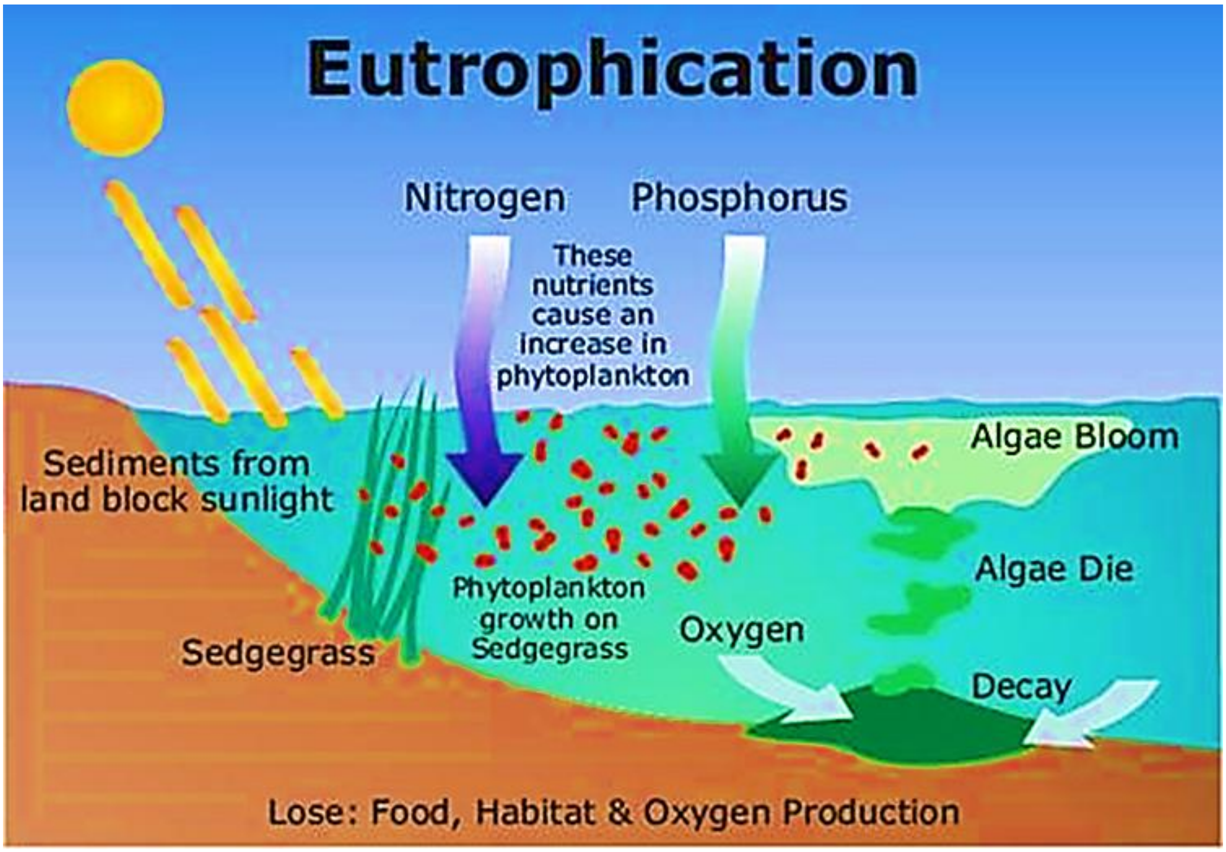


Fertiliser consumption in the EU

Water pollution with fertilisers used in the cultivation of field plants results from their irrational application, at a higher rate than can be fixed by soil colloids or used by plants. Excess nitrogen and phosphorus can be leached into deep water or runoff into surface water. Phosphates with a lower solubility than nitrates and ammonium tend to be adsorbed by soil particles and reach watercourses by erosion. Large livestock farms produce significant amounts of nitrogen- and phosphorus-rich waste, which, if improperly handled and stored, end up polluting both groundwater and surface water. Manure, often improperly collected, applied in unfounded doses and at inappropriate times, leads to diffuse water pollution.

On the other hand, the fodder consumed in intensive feeding in aquaculture, contributes significantly to the increase of nutrient content in the water.

Due to the high content of nutrients in the water, algae proliferate rapidly. After the end of the vegetation cycle, the algae decompose, consuming in this process a large part of the dissolved oxygen. As a result, mass mortality of aquatic organisms occurs.

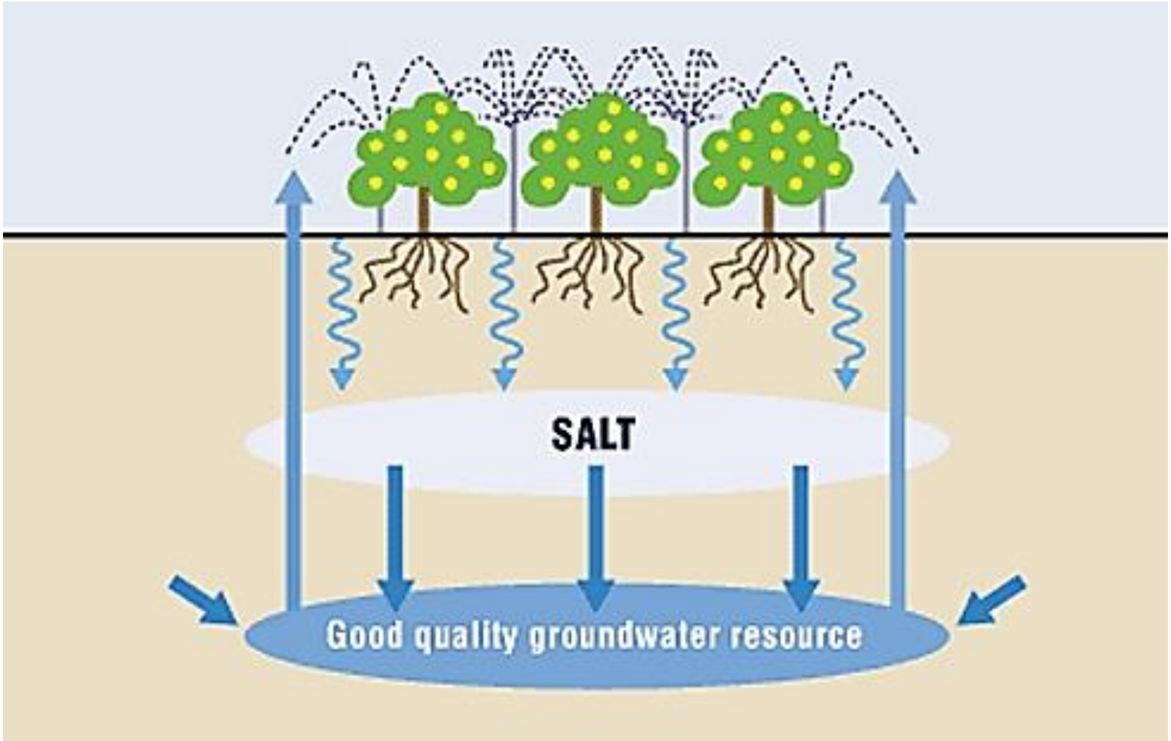


Source: https://onlinesciencenotes.com/

Nitrates, leached into drinking water sources, have serious, sometimes even fatal, consequences for human health. In the body, nitrates are reduced to nitrites, which, with haemoglobin (responsible for transporting oxygen in the body) form methaemoglobin, thus blocking the transport of oxygen in organism.

Irrigation

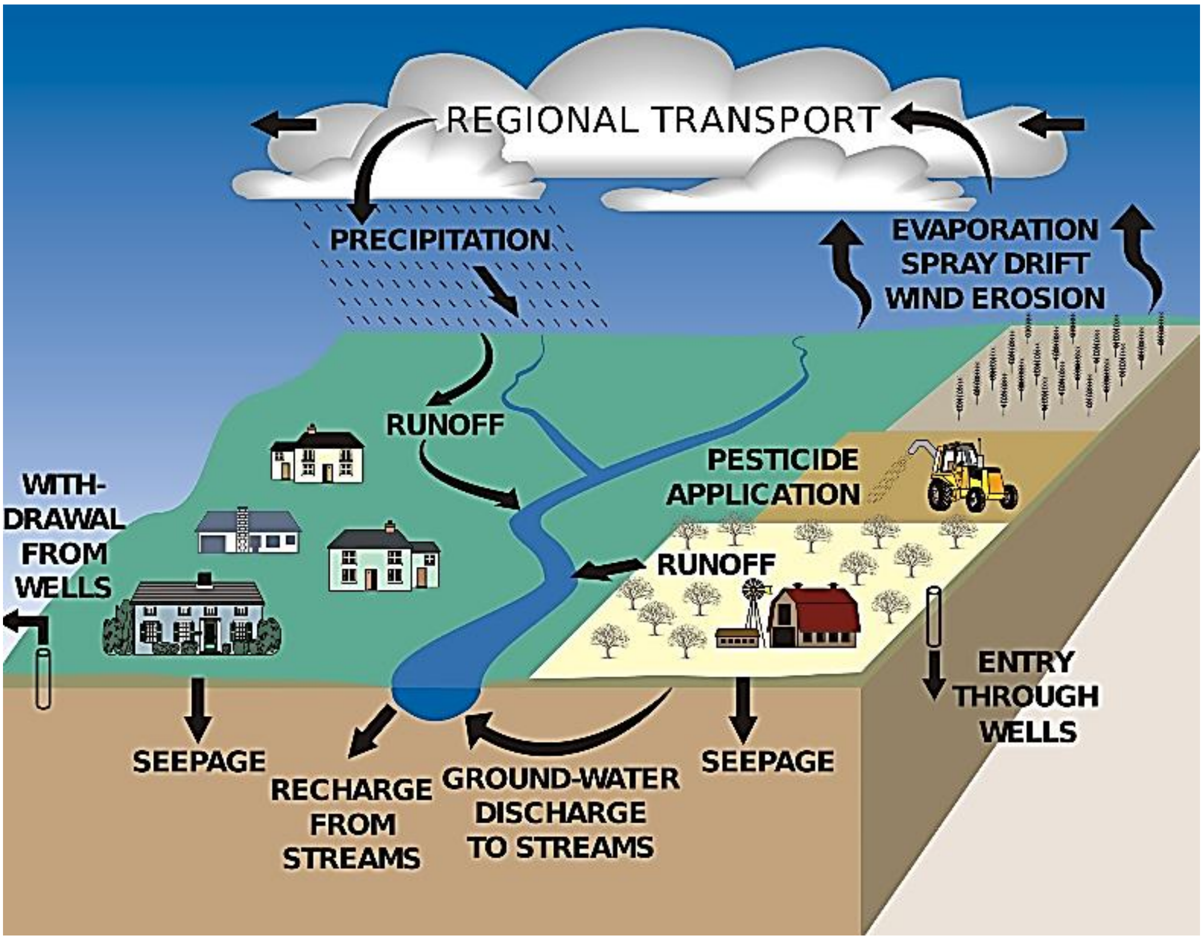
Irrigation of fertilized crops is one of the largest sources of agricultural pollution of water. On manure fertilized lands, the leaching rate of N is less than 5% of the applied amount, while in the case of P it is 3 - 20% of the applied amount. On the other hand, irrigation can mobilize and transport salts accumulated in the soil, through drainage water into water bodies, thus producing their salinization. Excessive irrigation can lead to increased groundwater levels in saline aquifers, causing them to infiltrate in watercourses.



Source: [Making it too salty- Salinization! - Follow Green Living]

Pesticides

Pesticide abuse has led to their occurrence in water bodies globally, causing severe environmental pollution, with serious consequences for the health of living organisms. Worldwide, 4.6 million tons of chemical pesticides are sprayed annually into the environment. About 500 types of pesticides, some of which are extremely poisonous to the environment, are widely used. The use of pesticides in various areas: recreational land, forests, roadsides, suburban and urban areas, makes their presence in water bodies more widespread. The ways in which pesticides reach the water bodies are: spray drift, surface runoff, leaching, by drainage from drainage waters.



Source: [Pesticide Pollution: 5 Steps to Reduce Your Impact (savethewater.org)]

Sushil Humagain, Eutrophication: Causes, Effects and Controlling measures, Eutrophication: Causes, Effects and Controlling measures - Online Science Notes;

Klimaszyk, Piotr; Rzymski, Piotr; Zelenakova, Martina, 2018, Water and Aquatic Fauna on Drugs: What are the Impacts of Pharmaceutical Pollution, Water Management and the Environment: Case Studies, pg. 255 – 278, Springer International Publishing; The effect of pesticides on aquatic organisms and mammals are dramatic, causing death, tumour injury, teratogenic effects, inhibits reproduction, accumulates in the body. Degradation of water quality with pesticide content has an impact on human health either through the consumption of fish in polluted waters or through the direct consumption of water.

Drugs

Drug pollution has become an almost inevitable phenomenon that is a growing concern. As the number of animals in large livestock complexes increases, so does the amount of drugs used to control disease. Thus, increasing amounts of drugs and which are largely not degraded in common water treatment processes, end up, along with manure in water sources. Here they may suffer from biodegradation, adsorption on sediments and in aquatic organisms. Thus, their bioaccumulation occurs in aquatic organisms (fish, shells, crustaceans), and through their consumption by humans, they reach the human body, selling serious toxicological effects.

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Dr. Alexandra Becherescu: Eco-Protective Technologies for Vegetable Crops

Organic products, in general, and organic vegetables, in particular, have become increasingly in demand on the market, in view of the fact that people are increasingly attentive to what they eat, knowing that this way they take care of their own health, wanting in addition to feel the taste food, in addition to thinking about the health of the planet.

With deep historical roots, organic farming has developed mainly as a practical occupation, in all the great human civilizations (Mesopotamian, Arabic, Greek, Roman, Chinese, etc.), building on a prosperous non-polluting agriculture, without chemical fertilisers and synthetic pesticides, relying on wisdom and skill in thought and work.

The production of sufficient, varied and cheap food, as basic food security needs, has been a relatively easy goal to achieve in developed countries, by promoting intensive land cultivation and animal husbandry systems. But this mirage of profit maximization was unfortunately associated with negative effects, where under financial pressures, production, including agricultural production, proved to be responsible for the destruction, directly or indirectly, of flora, fauna and agricultural land.

In order to ensure the organic production of vegetables, vegetable farms using conventional technology must have a conversion period of at least 2 years. This period is indicated by the Inspection and Certification Bodies, which may increase or decrease, depending on factors related to the previous exploitation and the degree of contamination with harmful substances of the land.

Some of the basic principles of organic vegetable production are:

- elimination of polluting technologies;

- realization of production structures and crop rotation in which the main role belongs to species and varieties with high resistance and adaptability;

- improving the natural fertility of the soil (by using appropriate crops and natural organic fertilisers);

- the economical use of conventional energy resources and their replacement as much as possible by the rational use of alternative energy sources (solar energy, biogas, etc.) and reusable by-products;

Eco-protective technologies for growing vegetables include the following aspects:

1. Crop rotation;
2. Soil works;
3. Fertilization;
4. Seeds and sowing or planting;
5. Control of weeds, diseases and pests;

1. Crop rotation

Crop rotation refers to the division of cultivated land into plots and the rational distribution of plants to be cultivated sequentially on these soils. While crop rotation refers mainly to the notion of space, rotation refers to the way vegetables grow on the same soil over time, so rotation refers to the temporal aspect.

Rational rotations combined with the rational application of organic fertilisers and associated with optimal soil work, ensure not only increased fertility but also contribute to the destruction or reduction of weeds, diseases or pests, helping the development of useful microorganisms in the soil.

2. The field preparation

The general objective of soil tillage is to create favourable conditions for the growth and development of crop plants, as well as to maintain, or even improve, its physical condition and fertility. Tillage system refers to the totality of works applied to the soil and their succession, on crops and soils, within a process of crop rotation.

The preparation of the field requires a series of works that are performed in different manners, depending on the cultivation system which is practiced, the characteristics of the land and the demands of cultivated plants.

3. Fertilization

One of the principles of eco-protective cultivation of vegetables is that plant nutrition should not be done with easily soluble fertilizing salts, but to facilitate their availability through living organisms in the soil (fungi, bacteria, insects and worms). To this end, organic vegetables must stimulate the activity of living organisms. The richer a soil is in living organisms, the more fertile it will be and also the plants will be the more resistant to parasite attack.

In organic vegetable growing, fertilization is carried out mainly by using natural organic fertilisers prepared according to a special technique and hard-to-dissolve mineral fertilisers with slow decomposition (phosphorus flour, silicates, natural potassium salts).

In addition to animal manure from animal husbandry, fertilization in eco-protective technologies is also based on the recycling of organic matter, secondary production consisting of plant debris resulting from gardens, vineyards, orchards, hedges, parks and green spaces.

4. The seed / Seedling

The seeds and planting material used in eco-protective technologies are produced in households, farms, associations and ecological agricultural societies. These units must comply with and apply both seed and planting material legislation, as well as ecological technologies for cultivating land, harvesting and storing crops, and preparing seeds and planting materials for sowing / planting.

Seeds and planting materials are an important source of soil infestation with harmful bacteria and fungi. In order to remove microbes from these propagating materials, it is recommended to treat them with solutions obtained from biological, liquid or solid preparations.

5. Disease and pest control

In vegetable growing, weeds, diseases and pests cause a decrease in production by about 30%, so weeds reduce production by 8.9%, diseases by 10.1% and pests by 8.7%. In order to minimize crop losses, the plants must be supported by certain crop-specific protection measures.

The main directions to be followed are:

- identification of pathogens, their biology and behaviour;
- identification of beneficial organisms;
- monitoring techniques;
- use of resistant cultivars;
- weed management.

Assoc. Prof. Dr. Renata Maria Sumalan: The Biological Activity of the Soil in ensuring a Sustainable Agriculture

This material to provide knowledge related to the role and importance of the biological activity of soil in the practice of sustainable agriculture. Thus, will answer the following questions:

1. What is the soil **microbiota** and what are the constituent elements.
2. How can soil microbiota influence and improve agriculture in a sustainable way
3. What are the technological measures that ensure a proper functioning of the soil microbiota?
4. How Applied Microbiology can help in the management of rhizosphere of the plant crops.

The soil is the upper part of the lithosphere that has formed over time under the influence of pedogenetic factors, climate, relief, macro, and specific microorganisms. Each type of soil has a characteristic biological activity that allows the circuit of the elements and provides synthesis of specific organic compounds that confer fertility.

1. What is the soil **microbiota** and what are the constituent elements.

From a compositional point of view, 4 constituent parts of the soil are distinguished (Figure 1.) mineral matter, water and air of soil, and the organic matter. The organic matter comprises two components: organic matter without lives (SOM) and the living organisms, respectively the soil biota which is responsible for the biological activity of the soil and implicitly determines synthesis of SOM.

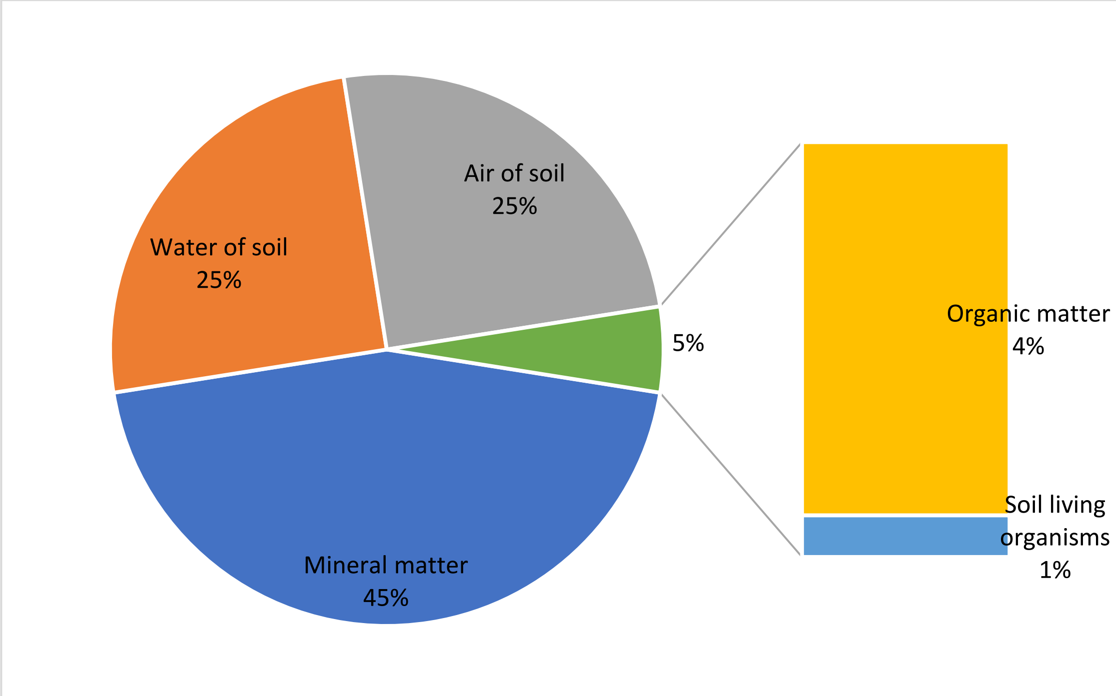

Figure 1. Components of the soil

The most significant contribution in the organic matter synthesis belongs to the microbiota, i.e., the total of small organisms (µm) that don't be observed with the naked eye. The soil microbiota components are bacteria (with cyanobacteria and actinomycetes), fungi, microscopic algae, protozoa, and tiny nematodes.

Microbial activity of the soil involves a series of processes based on biochemical transformations performed with the help of microbial enzymes at the top layer (first 50 cm) of the soil. Different types of soil are characterized by their own unique composition of microbes, and even within soil types of the composition differ dependent on factors such as pH, water content and technology adopted and crops type (Rousk & Bååth, 2011).

Bacteria are the dominant group of microorganisms found in the neutral soil where produce polysaccharides or glycoproteins thus, act as cementing agents and improve the soil structure. Other bacteria are present in a symbiotic relationship with the plants to help in processes like nitrogen fixation and mineral supply.

Actinomycetes produce different groups of antibiotics and decompose residues with recalcitrant property to biodegradation helping to increase the fertility of soil.

Fungi are dominant in well-aerated, cultivated, or acidic soils. Fungi also lives in the root zone and helps make nutrients available to plants. For example, *mycorrhizae* are a symbiotic relationship between fungi and roots that facilitate water and nutrient uptake for plants.

Viruses= biological entities phytophatogenic, zoopathogenic and phage, are found in soils and affect the activity of the microbiota - they represent the ultra-micropopulation of the soil (Rousk & Bååth, 2011).

2. How can the soil **microbiota** influence and improve agriculture in a sustainable way. Sustainable agriculture requires direct activities to preserve, protect and improve natural resources, herein the soil is the most important**.** A quality soil must have an SOM content between 2-6%, it has been formed over time by microbiota activity and this content must be preserved and improved (Blanco-Canqui & Lal, 2009).

For a farmer, it is important that soil microbiota functioning be viewed as a whole in accordance with abiotic, biotic, and anthropogenic factors. Thus, the microbiota performs several functions that are presented in Figure 2. Each component of the microbiota is responsible for decomposition processes and synthesis by which the activity of other microorganisms and plants is conditioned (*metabiosis*). As a result, the biological activity of the soil is characterized by a continuous dynamism that leads to the accumulation of organic matter (Termorshuizen, 2014). The size and richness of the microbiota directly determine the degree of soil health and implicitly of the entire ecosystem. The greater richness and abundance of the microbiota will determine faster circulation of elements, avoiding thus soil pollution (Termorshuizen, 2014).

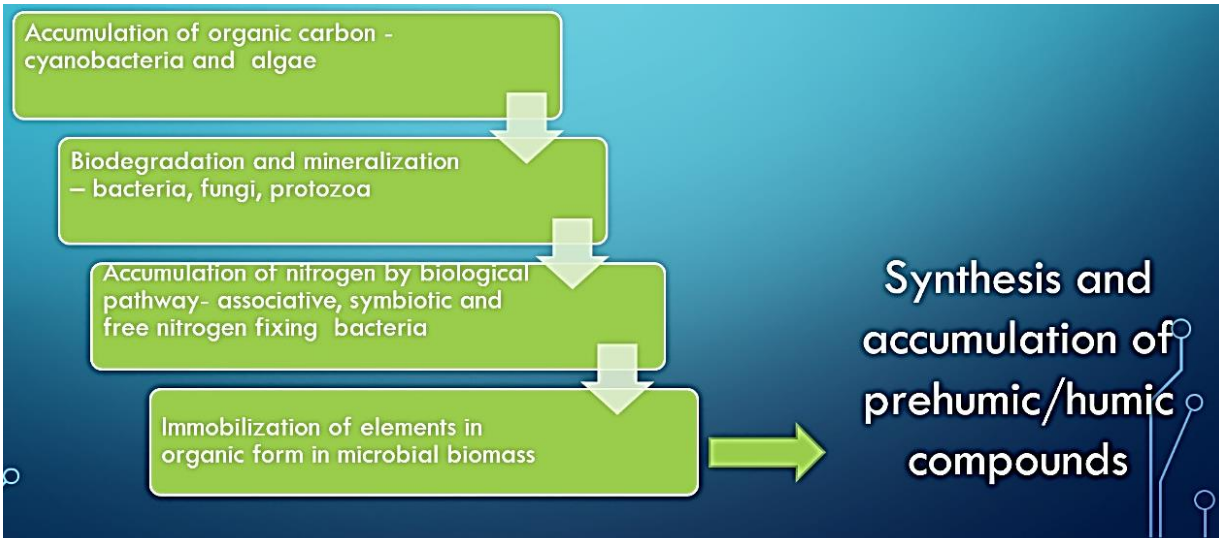

Figure 2. Soil biological activity and synthesis of humic compounds

3. What are the technological measures that ensure a proper functioning of the soil microbiota?

✓ The incorporation of plant residues at the soil surface is the main measure by which a constant biological activity is ensured.

The SOM amount in the soil can be preserved and enriched if the activity of the microbiota is ensured *by* addition the vegetal residues (Parikh & James, 2012). Here we must make an important remark. It refers to the total carbon content (C) in rapport to the total nitrogen (N) of these residues. The ideal ratio between C/N is 25. For 1 part of N corresponding 25 parts of C (Haney, 2012). In this case the soil microbial biomass will be increase.

✓ Avoid of crop maintenance systems with large numbers of mechanized works.

The lack of plants (even weeds) deprives soil microorganisms of access to organic compounds, even if the photosynthesizing microorganisms is the main solar energy catcher, because their intake is much lower compared to the plants. It will be chosen for cover crop maintenance or mulching.

- ✓ Avoid deep ploughing of the soil in a repeated way.

This results in intensification of microbial activity of degradation of SOM. The application of the minimum tillage system will lead to a decrease in decomposition activity while synthesis and conservation activity of the organic matter content will be intensified.

- ✓ The application of correct irrigation water norms contributes greatly to the preservation and protection of the organic matter of the soil.

If the organic matter of the soil is permanently in a continuous state of hydration, the soil microbiota has easier access to its decomposition and mineralization. At the same time, condensation processes and pre-humus synthesis are carried out with low intensity in soil kept permanently moist.

4. How Applied Microbiology can help in the rhizosphere management of the plant crops.

The **rhizosphere** is a dynamic environment where plant roots release a variety of compounds that support higher microbial populations and activities than in bulk soil, Figure 3. (De la Fuente Cantó et al., 2020).

Bacteria are one of the most abundant groups of microorganisms found in the rhizosphere region. Bacteria from the rhizosphere, called plant grow promoting rhizobacteria- PGPR, are richness and have higher proportions of Gram-negative and denitrifying bacteria than those in the bulk soil.

Beneficial fungi for plant are mycorrhizal fungi. They help plant in phosphorus acquisition and grow the plant tolerance to hydric stress only in symbiotic association with the roots of the plant (Rodriguez et al., 2009). The application of intensive technologies does not favour this association because of using of mineral fertilisers and the application of fungicidal treatments that destroy the mycorrhizal fungi.

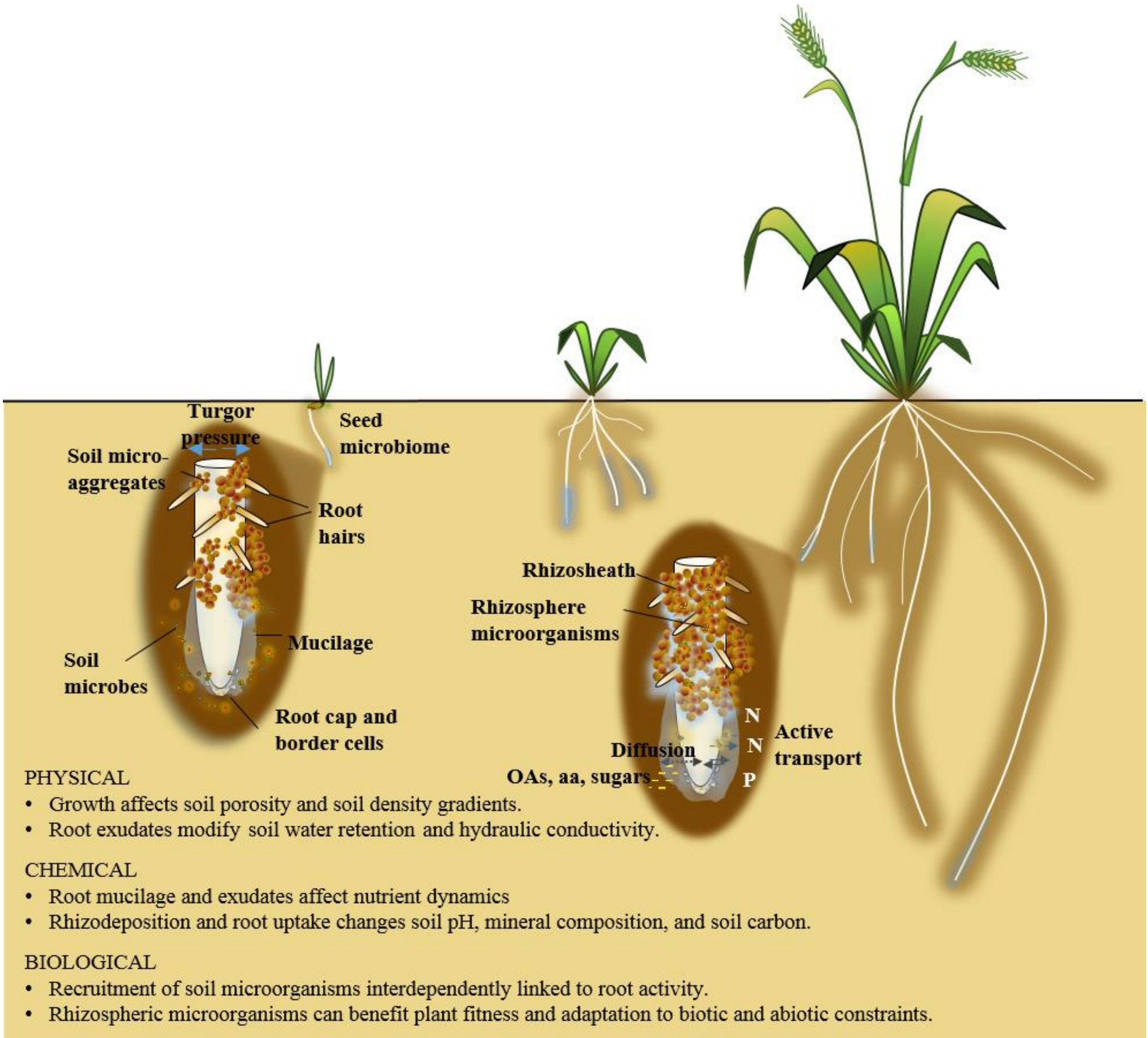

Figure 3. The rhizosphere and its impacts on plant fitness (De la Fuente Cantó et al., 2020).

In organic technologies microbial inoculants are very used. They are isolated, tested for traits in Applied Microbiology laboratory and benefit provided to plants in comparative fields. They are known as bio-fertilisers. The most used bio-fertilisers contain nitrogen-fixing bacteria (Hinsinger et al., 2009), (Mohammadi & Sohrabi, 2012).

It is well known that agriculture sustains and defines our modern lives, but it is often disruptive of natural ecosystems. This is especially true for soil systems, water resources, plant communities, and animal populations. Understanding, evaluating, and balancing detrimental and beneficial agricultural disturbances of soil and water resources are essential tasks to sustain and improve human well-being (Parikh & James (2012). It is necessary to accelerate research-based knowledge in ensuring sustainability in agriculture, the responsibility of the authorities but also of farmers to ensure a clean ecosystem.

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Prof. Dr. Miguel A. Altieri: "Agroecology: promoting natural bio-intensification processes in crop production"

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The science of agroecology, which is defined as the application of ecological concepts and principles to the design and management of agroecosystems, provides a framework to develop farming systems with minimal dependence on agrochemical and energy inputs (or even purchased organic inputs) emphasizing complex cropping systems in which ecological interactions and synergisms between biodiversity components provide the mechanisms for the systems to sponsor their own soil fertility, productivity and crop protection.

The design of such systems is based on the application of the following ecological principles :

1. Enhance recycling of biomass and optimizing nutrient availability and balancing nutrient flow.
2. Securing favorable soil conditions for plant growth, particularly by managing organic matter and enhancing soil biotic activity.
3. Minimizing losses due to flows of solar radiation, air and water by way of microclimate management, water harvesting and soil management through increased soil cover.
4. Species and genetic diversification of the agroecosystem in time and space.
5. Enhance beneficial biological interactions and synergisms among agrobiodiversity components thus resulting in the promotion of key ecological processes and services.

These principles can be applied by way of various techniques and strategies and at small and large farming scales. Each of these will have different effects on productivity, stability and resiliency within the farm system. The ultimate goal of agroecological design is to integrate components so that overall biological efficiency is improved, biodiversity is preserved, and the agroecosystem productivity , its self-sustaining capacity and resilience is enhanced. The goal is to design a quilt of agroecosystems within a landscape unit, each mimicking the structure and function of natural ecosystems.

Agroecology and the Design of Sustainable and Resilient Agroecosystems

Farming system design arises from the application of agroecological principles that lead to the transformation of the structure and function of agroecosystems by promoting management guided to ensure the following processes:

1. Increasing above and below ground biodiversity.
2. Increasing biomass production and soil organic matter content.
3. Efficient use of soil nutrients, water, solar energy, seeds, soil organisms, pollinators and natural enemies.
4. Optimal planning of plant-animal sequences and combinations.
5. Enhancement of functional complementarities and interactions between soil, crop and biotic components.

System redesign consists in practical steps to break the monocultural structure by restoring agricultural biodiversity at the field and landscape level. Biodiversity enhancement through crop rotations, cover cropping, polycultures, agroforestry and animal integration is the cornerstone strategy of system redesign, as increasing diversity within functional groups promotes key processes (pest regulation, nutrient cycling, etc.) fundamental for agroecosystem function . Higher plant diversity within the cropping system determines higher diversity of above and below ground associated biota which in turn leads to more effective pest control and pollination and to tighter nutrient cycling

Ultimately, redesign consists in the establishment of an ecological infrastructure involving plot to landscape-scale diversification, which encourages ecological interactions generating soil fertility, nutrient cycling and retention, water storage, pest/disease regulation, pollination, and other essential ecosystem services . The associated cost (labor, resources, money) to establish the ecological infrastructure of the farm (living fences, rotation, insect habitats, etc.) during the redesign phase tends to be high in the first 3-5 years. Once the rotation and other vegetational designs (cover crops, polycultures, field borders, etc.) start lending ecological services to the farm, key ecological processes (nutrient cycling, pest regulation, etc.) are set in motion, the need for external inputs is reduced and thus maintenance costs start decreasing as the functional biodiversity of the farm sponsors ecological functions.

Plant diversity and pest/disease regulation

Over the last 40 years, many studies have evaluated the effects of crop diversity on the abundance of insect pests. A metaanalysis analyzing results from 209 studies involving 287 pest species, revealed that compared with monocultures, the population of pest insects was lower in 52% of the studies, and higher in 15% of the studies. The abundance of predators and parasitoids of pests was higher in intercrops in 53% of the studies and lower in 9%. Many studies confirm that farms with species-rich vegetational schemes exhibited an increase in abundance of natural enemies, an increase in pest mortality, and a. reduction in crop damage when compared to monoculture farms. Unequivocally, most reviews suggest that crop diversification strategies lead to natural enemy enhancement, reduction of insect pest densities, and reduced crop damage, from a combination of ecological mechanisms.

Plant pathologists have also observed that mixed crop systems can decrease pathogen incidence by slowing down the rate of disease development and by modifying environmental conditions so that they are less favorable to the spread of certain pathogens [38]. For soil borne or splash borne diseases, Hiddink et al. [39] found that intercropping patterns and variety mixtures significantly reduced disease in comparison to monocultures. Host dilution was frequently proposed as the mechanism for reducing the incidence of pathogens. Other mechanisms, such as allelopathy and microbial antagonists, can also act to reduce disease severity in diversified farming systems [40]. Lower disease incidence contributes to less crop damage and higher yields in mixed crops as compared to corresponding monocultures.

Healthy soils-healthy plants

In the last 20 years a number of research studies have corroborated that the ability of a crop plant to resist or tolerate insect pests and diseases is tied to optimal physical, chemical and mainly biological properties of soils. Soils with high organic matter and active soil biological activity generally exhibit good soil fertility as well as complex food webs and beneficial organisms that prevent infection. Recent evidence suggests that the lower pest pressure observed in many organic systems, although associated with a greater use of practices that preserve beneficial insects, is also linked to enhanced soil biology and fertility. Several studies also document that farming practices which cause nutrition imbalances can lower pest resistance . Evidence is mounting that synthetic fertilisers can reduce plant resistance to insect pests, tend to enhance insect pest populations, and can increase the need for insecticide application. Furthermore, recent research shows how biotic inter- actions in soil can regulate the structure and func- tioning of above-ground communities suggesting that the below-ground component of an agroecosystem can be managed through a set of agroecological practices that can exert a substantial influence on pest dynamics.

Organic amendments such as poultry manure, meat and bone meal, and soymeal, significantly reduce populations of a wide spectrum of soil-borne plant pathogens. Pathogen control seems linked to the ammonia and (or) nitrous acid generated, the concentrations of which are controlled by pH, organic matter content, soil buffering capacity, and nitrification rate. Evidence also shows that compost-amended soils can suppress soil-borne phytopathogens and diseases. Soil microbiota which can be enhanced via compost application plays a key role in crop protection improving natural soil suppressiveness.

Conclusion

Agroecology provides guidelines to develop diversified agroecosystems that take advantage of the effects of the integration of plant and animal biodiversity. Plant diversification and soil organic supplementation are key for the biointensification of agroecosystems. Enhanced aboveground and belowground biota enhances complex interactions and synergisms between biological components, optimizing ecosystem functions and processes, such as biotic regulation of harmful organisms, nutrient recycling, and biomass production and accumulation, thus allowing agroecosystems to sponsor their own functioning.

Agroecologically designed farming systems emerge from the application of agroecological principles such as recycling of nutrients and energy, enhancing soil organic matter and soil biological activity, diversifying plant species and genetic resources over time and space at the field and landscape level, integrating crops and livestock, and optimizing interactions of farm components. The application of these principles moves farmers toward the productive redesign of their farms, emphasizing synergisms within the system and reducing their dependence from external inputs.

Table 1. Key strategies of bio-intensification

- Enhance diversity and abundance of beneficial biota (microrganisms, plants, insects, etc)
- Amplification of ecological interactions that lead to processes key to achieving optimal soil fertility, plant health and productivity
- Replace external inputs for ecological processes

Table 2. Ecological processes to optimize in agroecosystems
• Strengthen the immune system (proper functioning of natural pest control) • Decrease toxicity through elimination of agrochemicals • Optimize metabolic function (organic matter decomposition and nutrient cycling) • Balance regulatory systems (nutrient cycles, water balance, energy flow, population regulation, etc.) • Enhance conservation and regeneration of soil-water resources and biodiversity • Increase and sustain long-term productivity

Table 3. Mechanisms to improve agroecosystem immunity
• Increase of plant species and genetic diversity in time and space. • Enhancement of functional biodiversity (natural enemies, antagonists etc.) • Enhancement of soil organic matter and biological activity • Increase of soil cover and crop competitive ability • Elimination of toxic inputs and residues

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III. Ecological Conversion of Agriculture: Changes and Challenges in Plant Nutrition and Protection;

Prof. Dr. Ralf T. Voegele: Integrated and Biological Plant Protection; A Vision for the Future

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The search for new approaches to holistically sustainable agriculture requires the development of new cultivation systems that provide additional ecosystem services for food, fodder, material and energy use in addition to biomass production. The reduction of chemical-synthetic plant protection products (csPPPs) is a key tool to protect our natural resources such as groundwater and biodiversity. Along with an optimal use of mineral fertilisers, agroecological practices and precision farming technologies, a complete abandonment of csPPPs in a mineral organic cropping system (meCS) could not only improve the environmental performance of agroecosystems but also ensure their yield performance. In order to develop, investigate and evaluate such a meCS, all relevant research levels and aspects have to be identified and analysed. This approach is being implemented in the ongoing research project "Agriculture 4.0 Without Chemical-Synthetic Plant Protection" (NOcsPS). We want to develop and analyse a new cultivation system without csPPPs, but with an optimized use of mineral fertilisers and with innovative cultivation and utilization measures from the perspective of all relevant areas of agricultural sciences.

Currently, agricultural production is under enormous pressure, as it is blamed for the loss in biodiversity, contamination of the environment, contamination of ground water, etc. Within the NOcsPs project we want to develop novel methodologies and strategies in plant protection, which a) which provide a similar level of protection as csPPPs, b) offer farmers the same level of security as csPPPs, and c) are less harmful to the environment. The NOcsPS system combines the positive aspects of integrated and organic productions systems, and combines them with modern technological approaches and adapted cultural practices. We believe that with this combination we will be able to achieve yields comparable to integrated production without harming the environment.

The research project NOcsPS aims to develop a new cropping system that will make a substantial contribution to improve ecosystem services of agricultural landscapes, in particular by enhancing regulating ecosystem services while safeguarding provisioning services. As a major measure the use of csPPPs is completely abandoned. At the same time, all yield-relevant cultivation measures have to be optimized to safeguard yields. In the design of this new cropping system, new and existing technologies are combined with agro-ecological practices to promote natural regulatory processes and to optimize mineral fertilization and non-chemical crop protection. The overall aim of this type of cropping system is to improve the different ecosystem services based on the following basic hypotheses: (i) meCSs can improve the provision of regulating ecosystem services of agricultural landscapes compared to integrated cropping systems and (ii) meCSs can improve the supply of provisioning ecosystem services of agricultural landscapes compared to organic cropping systems.

An interdisciplinary consortium composed of scientists and stakeholders from the whole value chain is responsible for the design, analysis, and scientific monitoring of this new type of cropping system called “mineral-ecological” on different scale levels. The technical design of this new cropping system is based on the current state of research as manifested in expert knowledge and the modelling of fundamental natural, technical, and economic processes. In the NOcsPS project, different variants of a meCS are being tested in field trials at various locations in Germany. These field experiments will be carried out as exact trials but also on real farms. Multi-year system trials are needed to capture crop rotation and long-term effects of different cropping systems. Only a holistic approach will allow an adequate comparison of meCSs with conventional and organic cropping systems. This includes studies at plant, farm, regional, processor, and consumer levels with respect to success criteria and possible adaptations.

Biological control agents (BCAs) can be an effective alternative to csPPPs to control plant dis-eases. Selected BCAs with partially elucidated modes of action will be tested in specific plant/pathogen systems used in the NOcsPS project. An indirect mode of action of BCAs is the induction of plant defense reactions. In this context, it seems reasonable to document plant defense reactions after inoculation with BCAs and subsequent inoculation with a pathogen. This will put plants in a so called priming state. Priming describes a state in which the plant is prepared more quickly and more resiliently to deal with possible pathogen infection. Furthermore, the time of application (protective, curative) of different BCAs will be optimized in greenhouse trials depending on their modes of action. This will be supplemented by experiments to improve the performance of BCAs by means of innovative mixtures of different active ingredients (formulation). Once the effectiveness of BCAs has been validated in the greenhouse, their efficacy will be tested in the field. The detection and treatment of pathogen infections at an early stage is crucial for effective pathogen control. This requires innovative technologies for sensor-based pathogen monitoring, for applying BCAs as well as appropriate formulations and ways of application which aim at establishing our BCAs in the field. Based on field trials, the extent to which yield depression in meCSs can be reduced using BCAs for pathogen control will be examined.

For successful control of plant pathogens in meCSs using BCAs, an optimized application in terms of time and space is necessary. One potential technology for early detection of plant pathogens is the use of drone-based sensors that generate georeferenced image data. By combining hyper- or multispectral cameras with modern data analytic methods, and comparing pathogen detection via sensor technology and molecular and conventional methods, it is possible to generate procedures for an early detection of plant pathogens, and to establish them in the field. The capabilities of sensor-based pathogen detection and quantification under controlled conditions have already been demonstrated in several studies. Multiple detection methods are currently being developed to establish a monitoring system in order to detect plant pathogens, which are expected to occur more frequently once csPPPs have been abandoned. Molecular detection methods are being established for the pathogens *Fusarium graminearum* on wheat/rye/maize and *Sclerotinia sclerotiorum* on soybean. These molecular methods enable the detection of pathogens within the plant, but also on crop residues, or in the soil. They are, therefore, essential for a holistic assessment of pathogen pressure. An optical verification procedure of the data sets classified by data analytic methods will simultaneously be established for the same pathogens in order to determine infestation in the crop via optical sensors. For the purpose of hyper- or multispectral imaging based pathogen detection, a drone-based measurement system will be used in order to achieve a sufficient spatial resolution to detect plant pathogens and identify their location within the plant canopy for BCA application. Finally, a molecular detection method for the applied BCAs will be developed to gain insight into their establishment or distribution in the field. This is essential for an optimal termination of application. Numerous field trials will investigate the extent to which the use of novel BCAs in connection with precision farming technologies can counteract crop yield decreases in me CSs.

Through continuous further development and optimization of cropping systems, agriculture must continue to secure future global food supplies while, at the same time, preserving natural livelihoods. In addition to integrated and organic systems, advanced cropping systems are needed to improve ecosystem services of agricultural landscapes. Depending on local and global requirements, different cropping systems may be beneficial. The individual ecosystem services (provisioning, regulating, habitat, and cultural services) must be balanced in a local and a global context. If locally there are specific environmental requirements, then regulating services per unit area take precedence in the design of a cropping system. If, on the other hand, global environmental or nutritional goals have to be met, the focus will be on provisioning services and the output related maximization of ecological services. The development of a meCS is based on the goal of minimizing trade-offs between different ecosystem services and promoting synergies. This applies not only to the agricultural area under consideration, but also to interactions with areas and structures outside the agricultural landscape. They must be protected from pollutant inputs or land use change and, in return, support natural regulatory processes on agricultural land. Future analyses of this new cropping system will illustrate the extent to which it is possible to improve ecosystem services of agricultural landscapes by establishing a meCS with optimized mineral fertilization yet without the use of csPPPs.

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Suggested Further Reading

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Herman Thomsen: Water-saving tillage and seeding technology

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Among the most important factors concerning the influence of tillage and seeding on soil water conservation are: straw distribution, mulching, stubble cultivation, soil texture and structure, tire pressure, tillage depth, seeding technology and fertilization. Mulching is an important part of stubble cultivation, it promotes straw rotting, it ensures better emergence of volunteer grain and activates soil life. The finer the mulch material, the better it can be incorporated into the soil. The cultivator is not the right choice for shallow cultivation, whereas the compact disc harrow delivers a better results for this purpose.

Tillage depths of 3.5 to 4.5 cm are possible with the compact disc harrow, every cm means that approx. 150 t per ha more soil have to be moved, which can then also dry out.

Deep tire lanes produce compaction in the subsoil, so that the capillary rise of the water is prevented. Tire slip and tracks are expensive diesel guzzlers! To optimized the rolling resistance: Adjust air pressure to operating conditions and observe technical specifications!

Tandem axle, 20t load, 4 bar air pressure for 50 km/h (road travel)	**Tandem axle, 20t load, 1 bar air pressure for 10 km/h** (field use)

Regarding diesel fuel consumption, 5 cm track depth corresponds to a constant uphill ride with a gradient of 5%. Therefore, decreasing the air pressure in tires, can help to save tractor energy.

Intact soils with a correct plant distribution are able to produce high yields even with small amounts of water. The capillary rise for the water in the soil must be secured and the soil surface should be shaded by the crop plants as soon as possible. The strip-till method, where only a small stripe of soil is tilled for seeding, requires some points to be considered: very good straw distribution and chop quality of the combine harvester, dry soil conditions, plane field without deep lanes/tramlines, not many mice on the area to be cultivated, control of volunteer grain. For tillage systems, in contrast cultivators bring the best mixing result with the right tractor speed (10 - 12 km/h). There are different tools for the different machining depths (Fig. 3).

Left: Mulch Mix Share for depths of up to 15 cm, with very good mixing properties. Right: Narrow share for depths up to 30 cm to loosen the soil, without turning and mixing properties

Exact soil reconsolidation, with sowing depths that are appropriate to the size of the seed grain can help to ensure optimal field emergence. For that purpose, compact disc harrows combined with seed drill machines can ensure the final mixing, levelling and comminution of the soil. In order that the tillage tools work properly, travel speeds of 12 to 16 km per h should be used. Tire packers produce an even reconsolidation of the seedbed, depending on the soil, the correct diameter must be observed here: the heavier the soil, the smaller the tire diameter.

The seed harrow forms a plain surface on the cultivated area, but if there are poorly chopped crop residues, straw heaps can be dragged together.

Conclusions: Water-saving tillage and sowing is an extensive topic. Adequate implementation already begins in the combine harvester and straw chopper. Mulching is a favourable way to encourage active soil life. Stubble cultivation should be as flat as possible. Different tillage tools are required for the cultivator. Adjusting the seed drills places high demands on the operator. Field sanitation is more demanding with no-plough cultivation.

Prof. Dr. Borbala Biro: Bioeffective solutions, assessing and improving the soil health parameters and food-quality/safety aspects.

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The biological-ecological solutions are key-important aspects nowadays, so as to protect soil-plant health including direct relation with human health (Lehmann et al. 2020). This fact is has become a clear evidence. Only healthy soil- and healthy environment can able to provide healthy food and healthy people. There needs a paradigm shift in the way of thinking, to consider soil as a heritage a real value, with limited ability of renewing. The European Community therefore created the so-called “missions” in 5 different area, where stronger attention should be required:

Mission 1: Societal effect of climate change

Mission 2: Healthy oceans, seas and inland waters

Mission 3: Healthy cities and climate-neutral living

Mission 4: Human health and the cancer

Mission 5: Soil-health and Food

Considering all the 5 missions it is also evident, that those are having a direct and indirect interrelation with the soils.

- The soil is a renewable energy source.
- The largest reservoir of the waters and responsible for the geochemical cycle not only for the water, but also several mezo- and micronutrients.
- The 95% of our food is in relation with the soil.
- Regarding the green-house gases (CO_2, NO_2, NH_3…etc.) it is also the soil, where the reduction of their release is also possible.

- Some of the medicines are originating from the soil, through soil microorganisms, for instance the antibiotic-producing Actinobacteria and filamentous fungi
- Soil is providing a large biodiversity of several organisms in the Earth that is important for the soil ecological functioning.

Most of the soil-functions are strongly dependent on the soil living organisms, which are providing a network in the soil-plant-environment systems, called Soil-Food-Web (SFW). Among them it is the plants (with their root system) and some specific microorganisms with photosynthesis function (i.e. algae and Cyanobacteria), which are belonging to the 1st trophic level. Those organisms called as producers, known to be "producing" organic materials from inorganic sources. It is the 2nd trophic level in the SFW, which is having the ability of utilize the organic matters in soil through the enzymatic decomposition, demineralization activity. Those processes are considered as main activities for any soil functioning and ecosystem services and also main contributors for soil quality, soil fertility and soil-health. But are the meaning of the same in the soil?

- Soil-quality: Complexity of the whole physical-chemical- and biological characteristics of the soil, with a main effect of any soil-function, but generally a strong focus for the *soil-physics.*
- Soil-fertility: Mainly the presence and provision of soil-nutrients, and its availability for the crops in the soil-plant systems. The fertility can be improved artificially through the industrial inorganic fertilisers, and can be developed by the own self-capacity of the soil, or by using organic natural additives (manure and composts…etc.).

In this fertility aspects a strong focus is given to the *soil-chemistry.*

- Soil-health: the capacity of soils to providing healthy food and healthy environment. In this contest mainly the biological parameters are very important and considering of the food-quality and food-safety aspects.

At soil health parameter the strong focus is given to the *soil-biology*, among them for those organisms, which responsible for the suppressive ability of soil (against the *soil-borne plant pathogens*) If a soil is not healthy, we can say that it is receptive soil, i.e. not able to provide safe food sources for human life, due to the presence for instance some of the human pathogens (*Table 1*).

Table 1: Type, origin and survival of some soil-borne plant pathogens in the soil

Potential pathogens	Origin	Survival
Coliforms	Soil Sewage sludge/soil	about 30 days up to 30 weeks
Listeria	Sewage sludge/soil vegetables	About 8 weeks up to 2-3 weeks
Salmonella	Soil surface Sewage sludge/soil	15-500 days 2-72 weeks
Streptococcus	Sewage sludge/soil	About 7 months

In: Eu-Fp 6 funded Horizontal-HYG project

It is a question how we can realise the quality, the fertility and soil-health? Or which other characteristics can be assessed at all, so as to learn the real ecological value of the soil?

Buffer-ability of soils: Generally it is the soil responses to the various acids, any of the salts and several soil-pollutants. Considering this a short- and long-term effects can be evaluated and severity of those stress-effects are highly dependent on the affecting periods and the toxicity, chemical structure of the pollutants.

Regeneration ability (resilience) of soils: It is the time, which needed to return of soils into the balanced („normal, original") effect after any stress-effect or any disturbance. – The *1.* International Conference was in Budapest, in 1982: *International Conference on Soil Resilience and Sustainable land Use*.

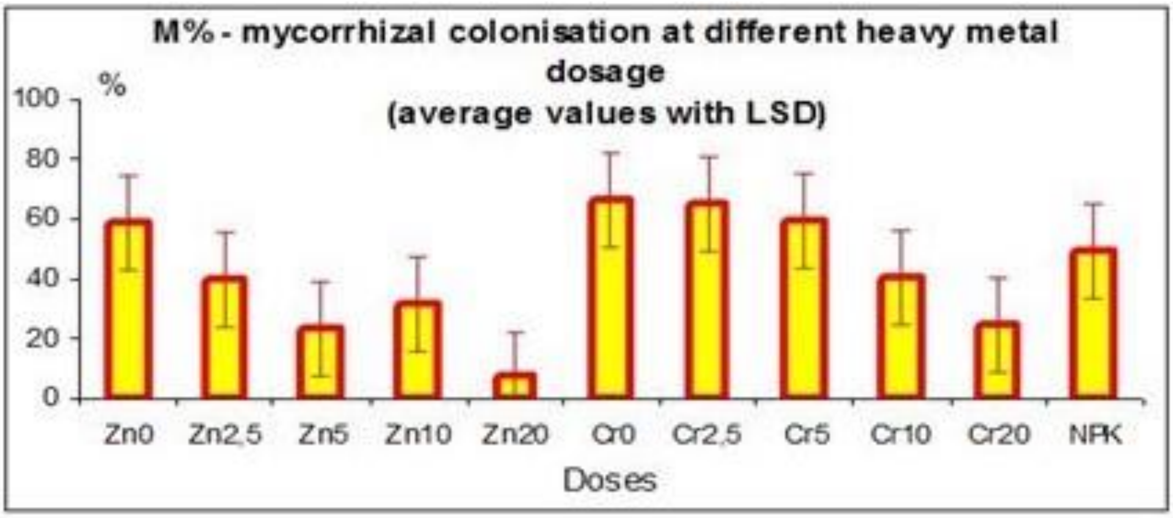
Soil must be able to recover from stresses (imposed by the sludge applications for instance, i.e. heavy metal-accumulation, other pollutants…etc.). Soil-management cannot be said to be sustainable if this is not the case. Up till nowadays we can show a limited knowledge, how to measure the soil resilience and what to apply to improve that characteristic.

Case study of using biosolids for symbiosis and soil-borne potential pathogens

In EU-FP 6 funded Horizontal-HYG project (https://horizontal.ecn.nl) the effect of sewage sludge biosolid-application was studied on several beneficial soil organisms. Project HORIZONTAL started in December 2002 with the aim to develop horizontal and harmonised European standards in the field of sludge, soil, and treated biowaste to facilitate the regulation of these major streams in the multiple decisions related to different uses and disposal governed by EU Directives.

It was the symbiosis, which can provide the largest effect on crops growth and development.

Using the symbionts as part of the bioeffective solutions the replacement of inorganic fertilisers can be potentially possible. The symbiosis might provide either the biologically fixed Nitrogen for plant and able to solubilize the hardly available phosphorous from the soil particles. It is suggested therefore to focus more efficiently on the functioning of symbiosis.



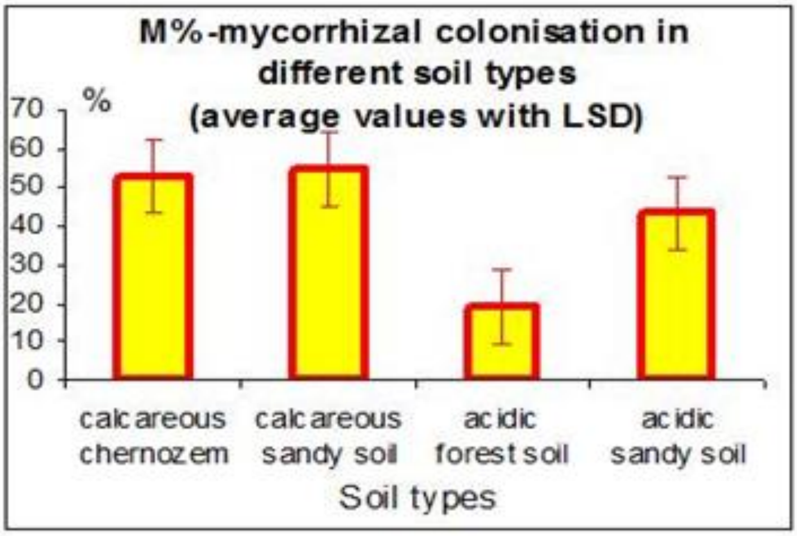


Figure 1 & 2: Colonization of beneficial symbiotic mycorrhiza fungi (AMF) at increasing doses of long-term sewage sludge addition in pot-experiment of using 4 different soil-types. Model-experiment, representing 16-year of sludge application. Further information in text.

Increasing amount of sewage sludge was applied, in pots, as 2.5, 5, 10 and 10 $g.10kg^{-1}$, representing 7.5, 15, 30 or 60 $t.ha^{-1}year^{-1}$ sludge added to the soil during a 4-year-period. In this case an accumulating doses of heavy metals might become toxic. In municipal sewage sludge the high Zn-content might have a risk, while in industrial (leather factory) sludge the increasing doses of Cr can become dangerous. In *Figure 1*, the symbiosis of arbuscular mycorrhiza fungi (AMF) was reduced in parallel with the increasing doses of both sewage sludge amendment. Considering the differences among soils, it was found, that mainly the acidic type of soils was very sensitive for heavy metals accumulation, not supporting the beneficial symbionts.

Examining of the presence and survival of potential plant pathogens in the soil, a simultaneous accumulation of Coliform bacteria a 3-order of magnitude (about 1000-times more) could be counted at the highest doses of sludge after a 4-year (representing 16-years) of application in the model-experiment. Regarding the soil-types it was the acidic soils, which supported highly the survival of food safety and food-quality types of bacteria.

We could conclude, that the abundance of beneficial symbionts (the AM fungi) is reduced, the potential pathogen Coliform bacteria on the other hand can be enhanced by the accumulating toxic metals on a long-term basis.

Beyond the soil-fertility, therefore more attention should be necessary for the soil-human-health and the food-quality and safety aspects in the agriculture.

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Assoc. Prof. Dr. Florian Crista: A Dynamic Fertlization for Sustainable Agriculture; Agriculture occupies a central place in the society , environment and economy of the European Union.

GENERAL DATA ON THE AGRICULTURE OF ROMANIA

At national level, agriculture is one of the important branches of the Romanian economy. The contribution of agriculture, forestry and fisheries to the formation of Gross Domestic Product is around 6% of GDP, and in the EU Member States it is around 1.7%.

Land Fund of Romania:

According to RGA 2018 data, out of the 23.8 million ha that the Romanian territory totals, the agricultural area used in agricultural holdings is about 13.3 million ha (55.9%), of which about 8.3 million ha is land arable. Depending on the mode of use, the arable land occupies approx. 62.5% of the agricultural area. Cereals and oil plants occupy about 80% of the arable land. The ratio between the arable area of the country and the number of inhabitants shows that each inhabitant of Romania has about 0.41 ha of arable land, higher than many countries in the European Union and almost double the EU 27 average, which is 0.212 ha / inhabitant . Romanian agriculture tends to follow the European model of agriculture which is based on a competitive, market-oriented sector, while also fulfilling other public functions, such as protecting the environment, providing more convenient residential settlements for the rural population, such as and the integration of agriculture with the environment and forestry.

The Common Agricultural Policy shifts its focus from direct subsidies to agriculture (Pillar-Pilon I of the PAC) to the integrated development of the rural economy and to the protection of the environment (Pillar-Pilon II of the PAC). Romania is one of the best endowed European countries in terms of agricultural land, water and human resources. Properly exploited, these benefits would allow for a more productive employment of rural labour and reduce income disparities between rural and urban areas.

Factors for plant nutrition and soil fertilization to ensure sustainable agriculture:

* Optimizing soil fertilization and its amendment
* Characterization of the agrochemical evolution of the soil under the influence of different fertilization and agro-technical methods;
* Study of fertilization technologies used in sustainable production systems;
* Research, formulation and testing of new complex solid and liquid fertilisers;
* Obtaining organic products with effects on plant nutrition.
* Establishment of unconventional ways and methods of fertilizing agricultural crops, to prevent the evaporation of nutrients in the environment;
* Complex testing in the laboratory, vegetation house and experimental lots in the field of some Romanian and foreign fertiliser products for obtaining the approval to be used on a large scale;
* Calculation of the balance of nutrients in agricultural farms;
* Characterization and complex evaluation of the agronomic efficiency of some secondary residual sources with fertilizing value, having low concentrations in nutrients;
* Fertilization of crops with low doses in conditions of assured economic efficiency;

* Computer-assisted diagnosis of plant nutritional disorders;
* Chemical testing of soil and phosphate rocks for the efficient use of phosphate rocks as sources of phosphorus.

It is wrong to consider that just the simple use of fertilisers in average quantities is equivalent to sustainable agriculture.

The application of fertilisers brings their optimal contribution only insofar as they are included in a system of well-ranked technological measures, and the doses that are established are correlated with the plant, soil, climatic factors, crop technology.

We must provide the plants with the necessary nutrients throughout the vegetation period through the fertilization system will have to distribute the fertilisers according to the requirements of each phase of growth and development, which requires differentiated application in relation to species, variety, hybrid, age, duration vegetation period, length of light period, soil conditions, etc.

Another factor that conditions the fertilization system is the size and quality of the crop, which is aimed at the crop and depending on it, both the quantity and the age at which the fertilisers are applied change.

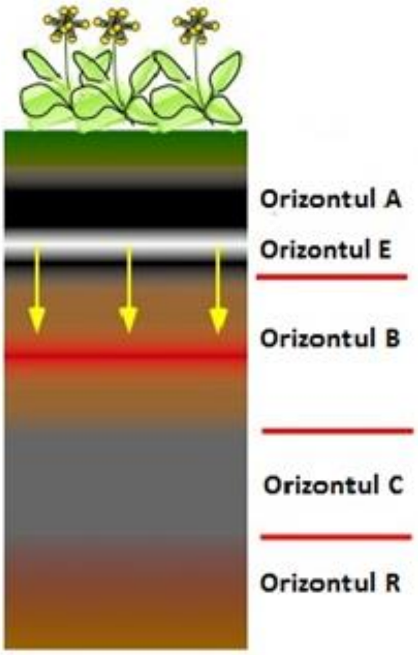
Farmers can benefit from financial support from European funds and the national budget if they comply with cross-compliance rules. Any farmer requesting financial support from European and national funds must comply with these rules throughout the year, on all agricultural plots on the farm, regardless of their size (including ineligible and those that are no longer used for production purposes). The cross-compliance norms include the Legal Management Requirements (SMR) and the Standards on Good Agricultural and Environmental Land Conditions (GAEC), grouped on the following areas:

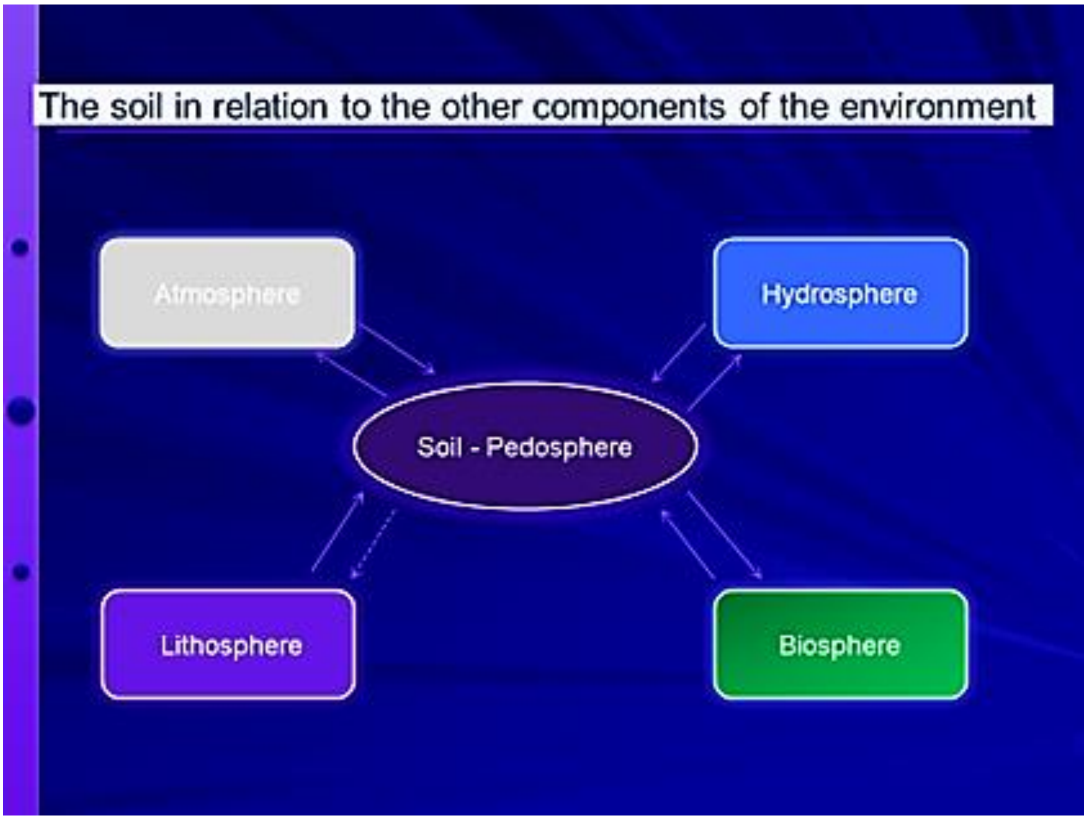
- **medium,**

- **climatic changes,**
- **good agricultural conditions of the lands,**
- **public health, animal health, plant health, animal welfare.**

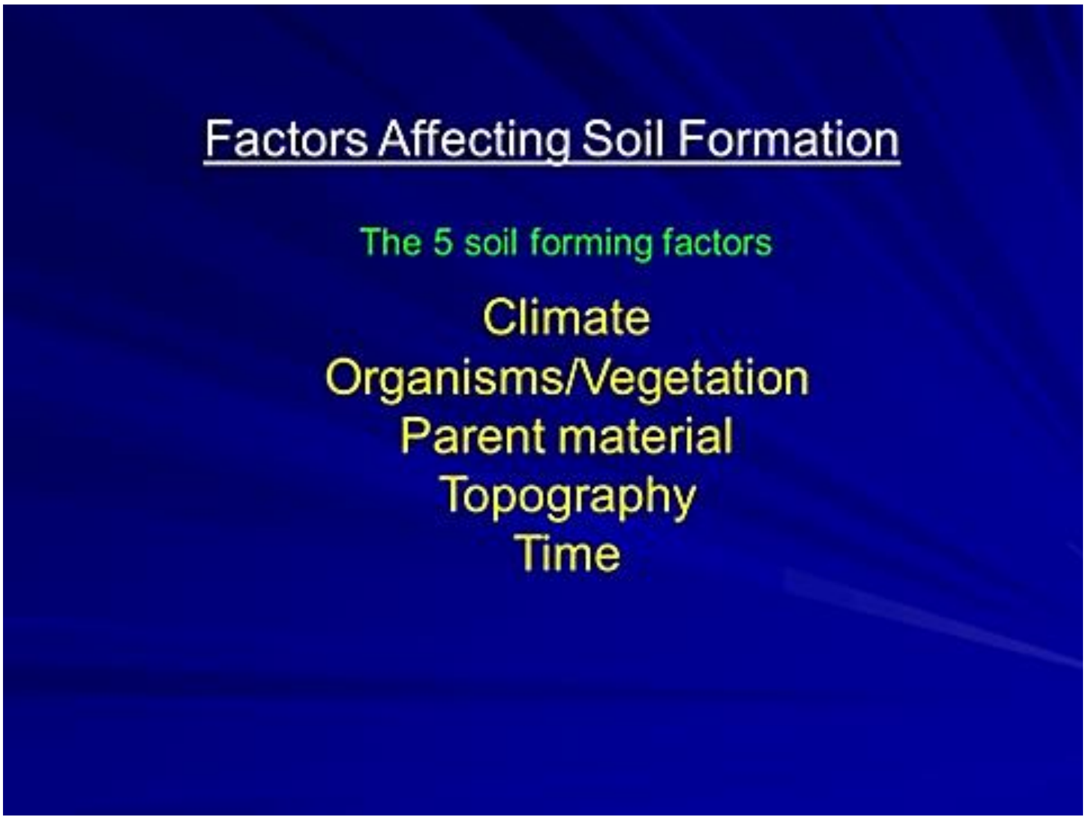
Dr. Lucian Dumitru Niță: The taxonomy and main soils in Romania

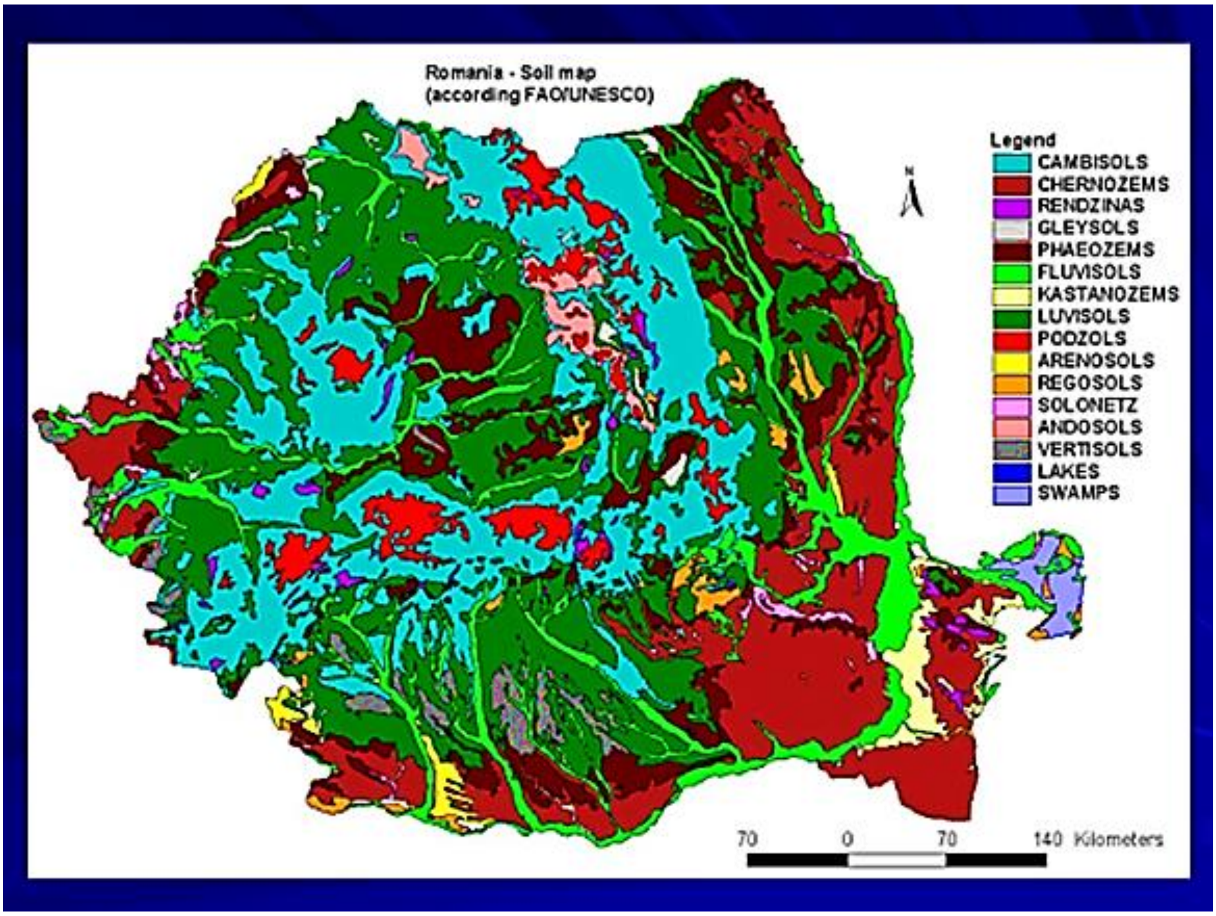
Pedology is the science that deals with the formation, evolution, properties, classification, distribution and rational use of soils. The term "pedology" comes from the words "pedon" with the meaning of soil and "logos" with the meaning of science.





The main functions of the soil





<u>Ecological functions</u>

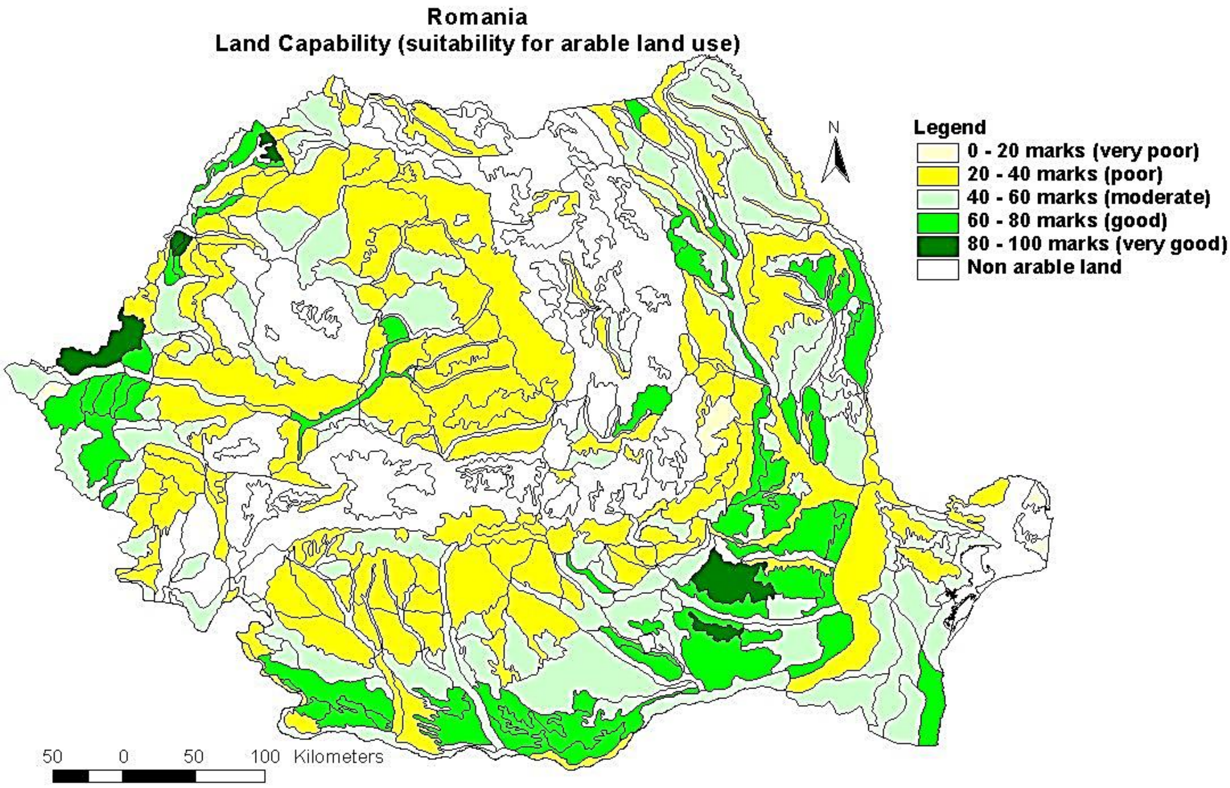
1. Contributions to plant biomass production - provides food, feed, renewable energy and raw materials
2. Filtration, buffering and transformation between the atmosphere, groundwater and the carpet, protecting the environment
3. Biological habitat and gene pool (soil fauna and flora are an important part of biodiversity).

<u>Technical, industrial and socio-economic functions</u>

4. Spatial basis for technical, socio-economic and industrial structures and their development: industry, housing, transport, sports, recreation, waste storage.

5. Source of geogenic energy, raw materials (gravel, sand).

6. Cultural and geogenic heritage, forming an essential part of the landscape and hiding archaeological and paleontological treasures.



Distribution of agricultural land by suitability classes

Suitability class	How to use							
	Agricultural total		Arable		Pastures and Hayfields		Vineyards and orchards	
	thousand hectares	(%)	thousand hectares	(%)	thousand hectares	(%)	thousand hectares	(%)
Total area of which in class:	*14852*	*100,0*	*9402*	*100,0*	*4931*	*100,0*	*519*	*100,0*
I – very good	410	2,8	355	3,8	54	1,1	1	0,2
II- goog	3656	24,6	3353	35,7	220	4,5	83	16,0
III - medium	3083	20,7	2364	25,1	597	12,1	122	23,5
IV - low	3623	24,4	1728	18,4	1767	35,8	128	24,7
V – very low	4080	27,5	1602	17,0	2293	46,5	185	35,6

Prof. Dr. Borbala Biro: Bioeffective soil-inoculation for tomato growth and the fruit quality, Szent Istvan University.

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The soil-inoculums are used worldwide in great quantities at Agri-, Horti-, and Viti-cultural practices. The inoculums are generally containing:

- living beneficial organisms;
- the products of organisms (extracts, hormones…etc.) and
- carriers, which are generally providing a longer survival ability of the organisms before- and during the application.

The carrier can serve first of all as a niche for the various organisms, providing both the place of living/functioning and also the appropriate nutrients, water and oxygen. In several cases the environmental conditions, such as the temperature can be also a key-important aspects, for instance among cold-or arid climates. It is known, for instance that corn can germinate only at soils with not less, than 10 ^oC. Such a temperature at early spring can be achieved by biochar-layering of soils, so as to improve the solar energy in soils, and assisting in microbial surviving and functioning activity as carrier for microbial inoculums.

Considering of the biotic and abiotic environmental stress-factors in the various soil-plant systems, those are considered to be crucial for any successful application of microbial inoculums. Beside it, the soil- management practices are efficient in successful plant breeding. The adaptation of crops and their interrelation with beneficial microorganisms are suggested to consider, as well. Biofertiliser type of microbes (N2-fixers and P-mobilizers) were the first that were applied for plant growth and nutrition. The plant- and microbial parameters and functioning of the system is shown in *Figure 1.*

A successful plant-growth and development can be possible of providing them by available nutrients from soils, and protect them from potential pathogens. Both of those aims is potentially possible by using beneficial microbial inoculums in any soil-plant systems. Regarding the soil-inoculation several types of industrial products are known and categorized for the registration, as followes:

1) Plant Strengthening Products (PSP), generally known as *biofertilisers* and almost all of the registered products belong to it

2) Plant Protecting Products (PPP), generally known as *biopesticides*, but registration needs more severe requirements, therefore not too many products are in this category

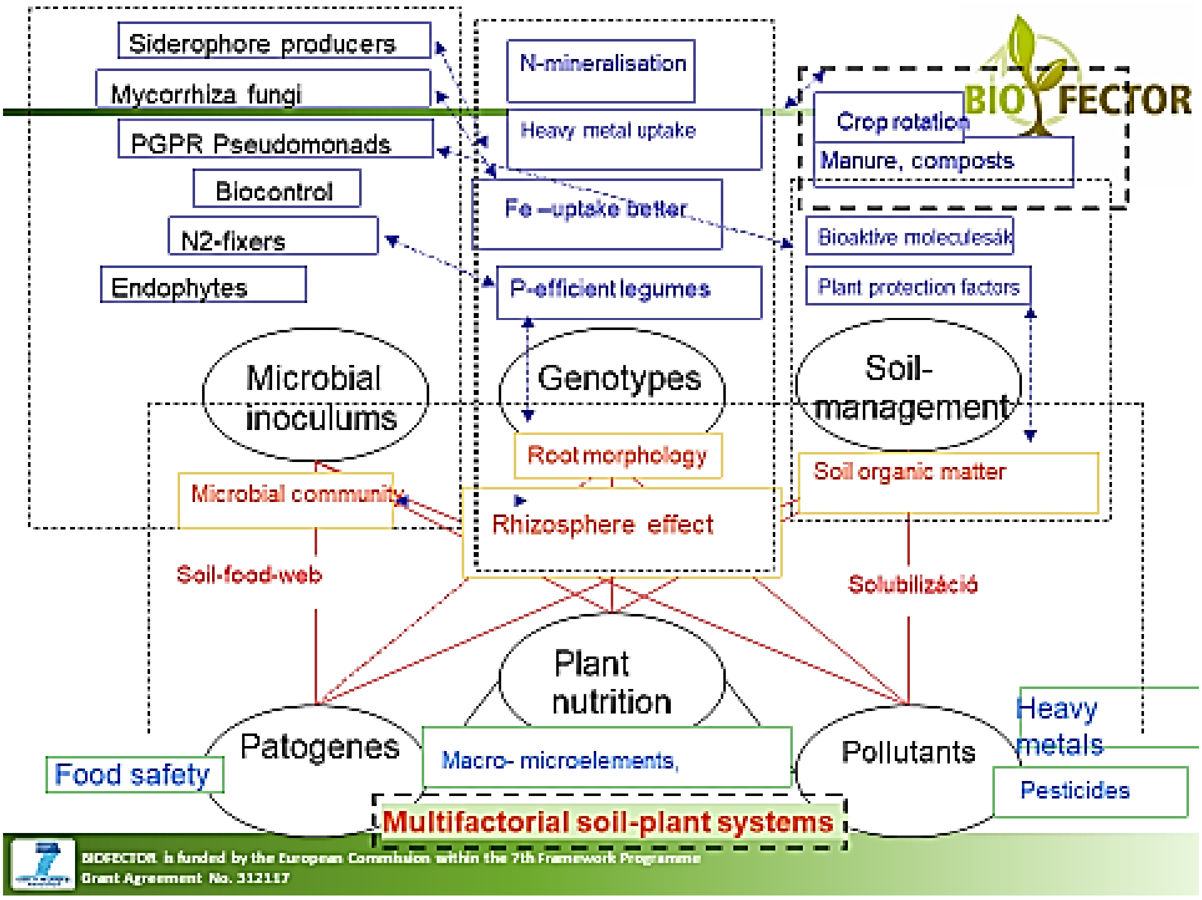

Figure 1. Biotic and abiotic soil-environmental factors, impact of plant-physiology and soil-management, affecting plant growth and development (source: Biro B., BIOFECTOR project).

Considering of the intensive agricultural practices, a greater focus is given for the so-called:

3) Soil Improving Products (SIP), which might be known as "*biosoils*" with the aim of developing improved secondary soil-structure with great aggregate stability, better aeration and enhanced water-holding capacity of soils. The biosolids are under intensive development in industry. The production is supported by the bacteria and fungi which are able to product exopolysaccharide (EPS) layers, called also as mucigel. In case of arbuscular mycorrhizal fungi (AMF) it is the glomalin (type of sugar-proteins) that might be produced. Both the mucigel and also the glomalins are rather sticky materials with great responsibility in soil-aggregate stability.

During the current application of such microbial inoculums, it was found, that the living bacteria and fungi might change of their behaviour and function, in harmony and interrelation with plant-physiological status and answering to environmental conditions. A biofertiliser for instance might result a better plant-nutrition and might protect the plants against the soil-born plant-pathogens in one step. The functioning of microbial inoculums are highly dependent on the biotic, abiotic environmental factors, shown in *Figure 1*.

In the EU-Fp7 funded BIOFECTOR project, therefore bioeffective soil inoculation was used, in which "bioeffectors", BE products were used as microbial inoculums. The aim of project was to replace or potentially reduce either of the commercially applied inorganic fertilisers and/or the pesticides. Bioeffectors therefore are not categorized to biofertiliser or biopesticide types, however both functioning is possible with the application.

Fruit quality of organic tomato with bioeffectors in field:

Regarding the EU-funded BIOFECTOR project, tomato (*Lycopersicum aesculentum*, var. Mobil) were grown at the University of Szent Istvan, Experimental Field in Soroksár, Hungary. Several type of bioeffectors, as single microorganisms and of their combinations was applied in slightly humous sandy soils, among organic conditions.

The following Biofector treatments were used:

BE1: *Trichoderma harzianum* strain T-22 (Trianum P);

BE2: *Pseudomonas sp*. (Proradix WP);

BE3: *Bacillus amyloliquefaciens* (Rhizo Vital 42 Fl.);

CFB, CFA: *Trichoderma* + Zn, Mg product respectively (Combifect),

MTD: *Trichoderma sp.* (Pannon Trade, Hungarian isolate)

AZO: *Azospirillum* sp. strain (Pannon Trade, Hungary)

Results was shown, that all of microbial inoculums could produce a tastier yield at year of 2017, in comparison with the non-inoculated control plots (*Figure 2, left*). The Brix value of the tomato fruits at the inoculated plots was found to be better, by 2-3 value and also the yield was significantly enhanced at all of the three bioeffector treatments. Yield of non-inoculated control was 25,9-;while at BE1 - 31,3-; at BE2 - 35,8-; at BE3 – 32,7. kg/plot was realized.

In 2015 on the other hand the yield was improved by tendentiously and could not be improved significantly. The annual effects can be considered during the application.

Considering the plant-protection potential of bioeffectors, in 2015, the tomato yield was divided to marketed and non-marketed ratio of the fruits. The combination of any *Trichoderma* strain (either Germanian or Hungarian origin) with other inorganic plant-nutritive elements (Zn, Mg in GTD product) and or with living bacteria, able to fix biologically the nitrogen (i.e. *Azospirillum* sp. strain involved into MTD product) was able to reduce the non-marketed ratio of the tomato fruits in comparison with the single inoculation of BE1 (*Trichoderma harzianum* T-22 strain) (*Figure 2, right*).

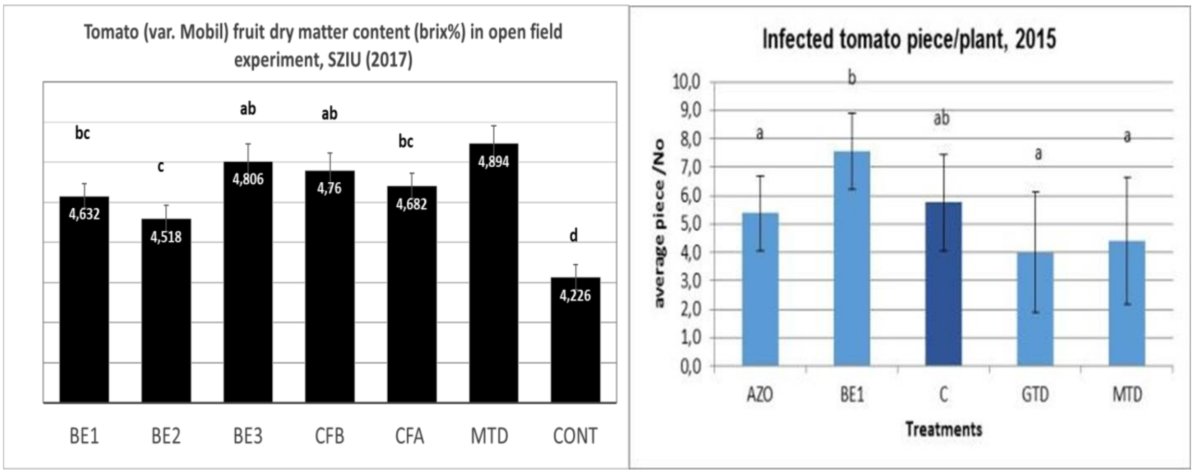

Figure 2. Fruit quality of tomato, inoculated by bioeffectors in organic system. Left: The brix value (taste) of fruits, Right: Non-marketed ratio of the yield/plant. (SZIU, Field-experiment, Soroksár, Hungary). Further information in text.

Microbial carriers and/or soil-improvers for successful inoculation

The bioeffective solutions require not only beneficial and efficient microorganisms, but it is also a requirement, that the soil might support of the survival of living introduced organisms in the soil-plant systems.

The biochar is an industrial product of the circular economy and of using organic agricultural wastes (i.e rice-husk, wood-chips…etc.), in general. The biochar is suggested not only for soil-structure and soil-quality improving, but it can be important also in supporting soil-microbial survival in soils. This can be potentially possible, because there are large surfaces that absorb nutritive element and providing a niche for the microorganisms (*Figure 3*).

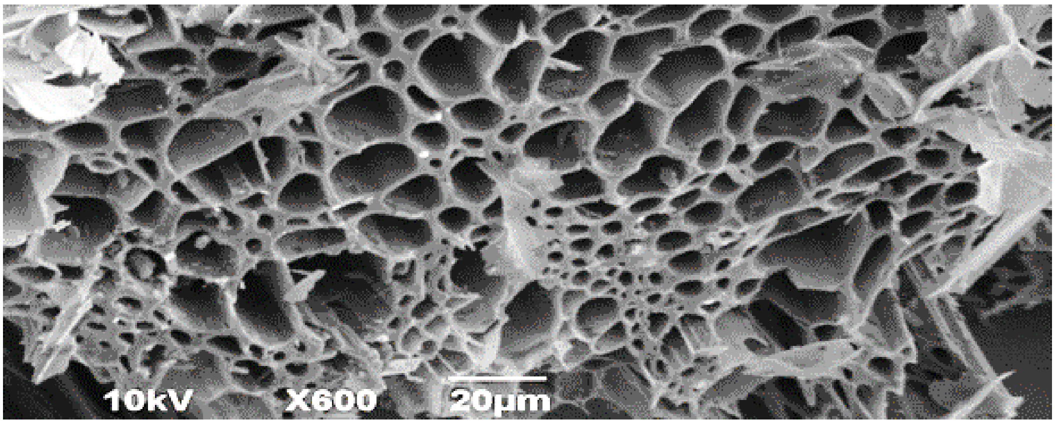

Figure 3. Biochar structure and surfaces at 600 magnification (source: Biro B., BIOFECTOR project).

The combination of biochar and the bioeffectors can be a potential solution for soil-inoculations. Increasing doses of biochar was used to study the tomato yield in pot experiment. Among the increasing doses, the application of 0.5-, 1.0- and 2.5% of biochar application could produce greater plant-biomass-production.

Among the field condition both the 4 t/ha and also 10 t/ha biochar amendment (i.e. the 0.5 and 2.5 % in pots, respectively) could be the best for the yield of tomato. If the biochar application was used parallel with bioeffector (BE) treatment, the yield was tendentiously greater, especially among the arid summer time condition. At that environmental condition the watering of biochar-amended soil is a prerequisite of the success, as it was mentioned by Kocsis et al. (2022) review article.

Effect of biochar application can be enhanced by the parallel application with beneficial microbial inoculums. Biochar is known to absorb the available nutrients from soil, therefore Nutrient mobilizing bacteria and fungi might improve the effect prominently at sever environmental conditions (*Figure 4*).

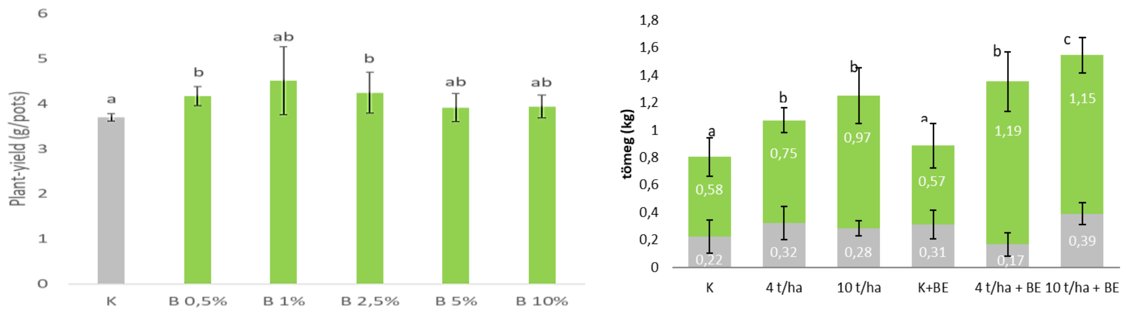

Figure 4. Effect of increasing doses of biochar on the biomass-production of tomato in pot-experiment (left) and among field conditions (right), inoculated or not by bioeffector (BE2) bacterium strain. (SZIU, Hungary). Further information in text.

Conclusion

Bioeffectors are used efficiently in organic agricultural practices. Inoculation of tomato is a suggested technology for improving not only the yield (biomass production and fruit quantity) but also to get a better and tasty fruit quality.

The inoculation of tomato can be duplicated, when the seedlings are planted into the soil. At that case the effectivity of microbial inoculation can be improved.

Application of bioeffectors on the other hand is being rather case-sensitive and also an annual effect can be found.

Type of microorganisms are crucial at the application. The P-mobilizing and the so-called plant growth promoting (PGPR) microorganisms might be beneficial for yield improvement, while the *Trichoderma* fungi could behave as biocontrol agent and therefore might be used more efficiently of replacing the pesticides among the horticultural practice.

The combination of bioeffectors with missing nutritive elements from the soil (i.e the Zn at high P-phosphor availability and the Mg for better photosynthesis) might improve the plant-growth and development.

Combined microbial inoculums, including not only the biocontrol fungi, but perhaps the N_2-fixing *Azospirillum*s are improving the plant-protection ability, so the ratio of non-marketable yield could be reduced. Healthier plant can be more suppressive against the so-called soil-borne plant pathogens that is also a great benefit of using bioeffectors and bioeffective solutions.

Further reading:

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Kocsis, T., Biró, B., Ulmer, Á., Szántó, M., Kotroczó, Z. (2018): Time-lapse effect of ancient plant coal biochar on some soil agrochemical parameters and soil characteristics. *Environ Sci Pollut Res* 25, 990–999.

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Assoc. Prof. Dr. Martin Kulhánek: Composts and the importance of soil organic matter for soil fertility, Czech University of Life Sciences in Prague

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Nowadays agriculture balances between the effort to produce the high yields to feed the increasing population and the keeping the sustainability of environment for the price of lower yields, but longer time horizon. Especially for the second way, it is necessary to have information about soil quality. One of the most important subject connected with soil quality is soil organic matter (SOM).

Two methods for determination of organic matter in soil are widespread across whole world: i) reduction of total organic carbon using potassium dichromate/sulphuric acid mixture with colorimetric determination and ii) determination of total soil organic carbon using combustion method and released CO_2 measurement (CN analyzers). However, both of mentioned methods are determining the soil organic matter quantity parameters, but not the quality. For instance, both methods are determining even the easily decomposable organic matter in soil (root residues; incorporated straw and others) and thus, the values of total organic carbon can be lower at fertile soil (chernozems) than at, e.g., sandy soils with high contents of easily decomposable residues.

SOM represents a wide scale of components: i) microbial biomass, ii) plant residues, iii) fungal and other proteins, iii) stable components; iv) passive components and many others. Each of them is playing crucial role in soil quality. This is the reason why the quality of SOM should be investigated as well. Methods for determination of SOM quality are existing since a long time. It represents the advantage in the possibility to compare the results with different publications as well as it makes the results from long-term experiments comparable among each other. One of the existing methods is determination of humic substances, humic and fulvic acids according to Kononova released in the year 1966. On the other hand, this method has a disadvantage mainly in the time and dangerous chemical consumption. Fractionation of one sample takes at least 2 days with a lot of risks to do a mistake. Because of that, this method is used mainly in scientific labs and so it is not widespread to provide data for farmers. One of the perspective methods to determine SOM quality is the measurement of the content of glomalin (stable protein produced by soil fungi). Glomalin has positive effect, mainly at the stability of soil aggregates. Especially the method for easily extractable glomalin is relatively easy and correlates good with passive SOM components determined with above mentioned fractionation (Balík et al. 2022). Other perspective method is using near infra-red spectrometry (NIRS), because each SOM organic matter component has a specific reflectance. This method is still in development, because the data of SOM fractionation are needed for NIRS calibration. To this purpose, the bright scale of analyzed soil is needed. However, NIRS spectrometry is easy to provide, the analysis itself is very cheap and so this method represents the good potential to the close future.

Application of composts is the proven strategy for soil organic matter improvement. Composting is a historically known process used in old civilizations (China, Egypt, Middle and South America) up to now. Nowadays, development of composting technology can be situated in the better-quality control and speeding up the whole process. The role of composts in agriculture and especially horticulture is often underestimated. The majority of compostable communal waste ends up in landfills.

Two major types of composts are used: i) with and ii) without reactor. Compost can be produced in small scale (few kilograms of materials) up to big scale (thousands of tons). The main factor to produce the quality compost is the good input material. Here should be controlled especially the pH value and C/N ratio. If the compost heap is composed form quality input materials, the process itself runs almost without needs of the quality control during composting.

One of the composting alternatives is vermicomposting – it means using the epigeic earthworms, mainly *Eisenia andrei*. One kg of earthworms can process 0.5 kg of waste daily. It can be used for processing especially plant residues (waste from vegetable processing, grape marc, apple pomaces and many others). This system is suitable even for offices and restaurants, where the produced vermicompost can be used locally to fertilize the gardens. Vermicomposts tea and extracts showed the positive role in plant protection, where foliar application resulted in competition with plant pathogens.

From the presented lecture it was possible to conclude that in the close future should be developed easy method for soil organic matter quality determination. The best potential shows using near infra-red spectrometry as a nondestructive cheap method without chemicals consumption. Composts and vermicomposts are commonly known as a SOM quality improvers. However, majority of compostable municipal waste is used in a non-renewable ways. The aim of the future sustainable strategies should be the redirecting of compostable municipal waste from the landfills to the composts and further in agricultural soils and especially to the horticultural production.

Reference: Balík, J.; Kulhánek, M.; Černý, J.; Sedlář, O.; Suran, P.; Asrade, D.A. The Influence of Organic and Mineral Fertilizers on the Quality of Soil Organic Matter and Glomalin Content. *Agronomy* **2022**, 12, 1375. https://doi.org/10.3390/agronomy12061375

Assoc. Prof. Dr. Florin Crista: Organic farming - achievements, challenges and perspectives!

Organic farming is a "modern" process of growing plants, feeding animals and producing food, especially fundamental to conventional agriculture.

The fundamental goals of this model of organic farming are:

- long-term maintenance of soil fertility,
- avoidance of all forms of pollution that may be caused by agricultural techniques
- the production in sufficient quantities of food of high nutritional quality,
- minimizing the use of fossil energy
- non-recoverable energy in agricultural practice,
- raising animals in living conditions in accordance with their physiological needs.

The role of the organic farming system is to produce cleaner food, more suitable for human metabolism, in full correlation with the conservation and development of the environment. One of the main purposes of organic farming is the production of fresh and authentic agri-food products that respect natural and environmental factors.

What are the specific practices of organic farming?

Organic farming differs fundamentally from conventional farming, through drastic restrictions on the use of synthetic fertilisers and pesticides, growth stimulants and regulators, hormones, antibiotics and intensive animal husbandry systems, and also through a strict ban on genetically modified organisms (GMOs) and their derivatives. Organic farming is also called "organic" or "organic", terms commonly used and accepted by the European Union.

PRINCIPLES

Organic farming is based on certain principles from which it must not deviate

a) The principle of health

This principle promotes the fact that the health of individuals and communities cannot be separated from the health of ecosystems - healthy soils produce healthy crops, which in turn provide health to animals and humans. Organic farming is intended, in particular, to produce high-quality, nutritious food that helps to prevent disease and protect human and animal health.

b) The ecological principle

The principle refers to obtaining an ecological production that is based on ecological and recycling processes. Organic farming, pastoral systems and the collection of flora and fauna must correspond to the ecological cycles and balances in nature.

c) The principle of fairness

This principle emphasizes that those involved in organic farming should manage human relations in a correct way, at all levels and between all participants in the production process - farmers, workers, processors, distributors, traders and consumers. Organic farming must produce enough food and other good quality products. This principle provides that animals must be provided with living conditions in accordance with their physiological requirements. Fairness involves production, distribution and trade systems that are open and fair and require real environmental and social costs.

d) The principle of administration

What is the mandatory period for conversion to crops?

Organic farming must be managed responsibly and with caution to protect the health and well-being of current and future generations and the environment. Caution and responsibility are the key

The transition from conventional to organic agriculture cannot be done overnight, but for a period long enough for the soil to become fertile and the balance of the ecosystem to be restored, according to the legislation. The duration of the conversion period in vegetable, animal and beekeeping production is:

- 2 years for annual field crops;
- 3 years for perennial crops and plantations;
- 2 years for meadows and fodder crops;
- 12 months for beef cattle.
- 6 months for small ruminants and pigs;
- 6 months for dairy animals;
- 10 weeks for poultry for meat production, purchased at the age of 3 days;
- 6 weeks for birds for egg production;
- 1 year for bees, if the family was bought from conventional apiaries.

This is the period that farmers have at their disposal to adapt the farm management to the rules of organic production.

Organic farming, between intentions and reality

Community rules on organic farming provide:

- a crop rotation so as to protect the soil and naturally interrupt the cycle of weeds and parasites,
- a use of natural enemies of plants and animals to avoid the harmful effects of chemicals;

- the choice of plant species and animal breeds perfectly adapted to local conditions, which are resistant to specific diseases;
- raising animals in the most natural conditions possible;
- protecting biodiversity by protecting plant species and indigenous animal breeds, which are threatened with extinction.

Organic farming is a dynamic sector in Romania that has seen an upward trend in recent years. The organization of product marketing is an important element of the organic farming chain.

As part of the campaign to promote organic farming in the European Union, at the initiative of the Directorate-General for Agriculture and Rural Development of the European Commission, the website www.ec.europa.eu/agriculture/organic/home_ro has been created with the main objective informing the general public about the organic farming system as well as a starting point in carrying out promotional campaigns in different Member States.

What subsidies are available for organic farming?

The subsidies granted to agricultural producers represent 1.731 billion lei and the payment will be made per hectare, directly by the Payments and Intervention Agency for Agriculture.

APIA also carries out European funds for the implementation of support measures financed from the European Agricultural Guarantee Fund

One of the essential conditions for the development of organic farming is the promotion of the concept of organic farming in order to make consumers aware of the benefits of consuming organic products, so that they offer a higher price for clean products whose quality is guaranteed by an inspection and certification system.

In order to promote organic products, the European Commission provides support of up to 50% to information and promotion programs proposed by professional and interprofessional organizations in the sector, which participate with at least 20% of the real cost of actions, co-financed by the state budget, in accordance with the provisions of Regulation (EC) no. Council Regulation (EC) No 3/2008 on information provision and promotion measures for agricultural products on the internal market and in third countries and with Regulation (EC) No. Commission Regulation (EC) No 501/2008 laying down detailed rules for the application of Regulation (EC) No 3/2008.

Perspectives on organic agriculture

Organic farming is on the rise, as a direct result of growing consumer interest in organic products.

To find solutions to the challenges posed by this rapid rise and to ensure an effective legal framework for the sector, the EU has adopted new rules.

Given the complexity and importance of the secondary legislation being drafted, the Commission has proposed postponing its entry into force by one year, from 1 January 2021 to 1 January 2022.

The postponement was initially requested by EU countries, the European Parliament, third parties and other interested parties. Here are some examples of changes that will be made under the new organic farming rules: strengthening the control system, in order to increase consumer confidence in the EU's organic farming system; new rules for producers, which will facilitate the transition of smaller farmers to organic production methods; new rules on imported organic products, to ensure that all organic products sold in the EU meet the same standard; several types of products that can be marketed as organic products.

The Romanian potential

According to data released by the Ministry of Agriculture and Rural Development, it is estimated that about 80% of Romania's organic production is exported to European markets.

80% of these intra-Community shipments include raw materials such as cereals, oilseeds, honey, berries, sunflower oil and only a small part of the percentage relates to processed products such as cheeses, wines or dairy products, bakery that are more sought after in the domestic market, along with eggs.

The main Community countries that represent important markets for unprocessed organic products (organic raw materials) are: Germany, Austria, Italy, the Netherlands, Switzerland and Denmark, which are also among the main suppliers of processed organic products.

It is estimated that in 2021 imports of organic products from Romania amounted to 175 million euros.

Prof. Dr. Dan Manea: The benefits of crop rotation in farming

Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" Timișoara.

1**. Better nitrogen management.** Nitrogen is one of the crucial nutrients for plant development. They need a “fixed” type of nitrogen from the soil either in the form of ammonia, nitrate or nitrite. One way nitrogen is drawn into soils is through the activity of symbiotic bacteria (*Rhizobium spp.*) living on the roots of legumes, such as soybean, peas, lentils or other previously mentioned examples. When a farmer plants leguminous crops, legumes together with these nitrogen-fixing bacteria enrich soils with the “fixed” type of nitrogen.

2. Reduced land and water pollution. Some studies estimate that around 80 percent of the nitrogen used as agricultural fertilisers end up released freely in the environment, contaminating water resources. The practice of crop rotation reduces the need for the application of fertiliser**s** and minimizes the risk of land and water pollution.

3. **Improved soil structure.** When rotating crops on the same land, soil structure improves because we alternate between deep and shallow rooted plants.

4. Water conservation. In combination with improved soil structure, crop rotation enhances water holding capacity of soils. Soils with good structure allow fast and thorough absorption of water. Some of this water is readily taken by crops, while the additional water is retained deeper in pores to be drawn by plants during a drier season.

5. Prevention of soil erosion. Amongst the reasons why crop rotation reduces erosion are: reduced soil disturbance, better cover crops, diverse root systems, different space demands, healthy soils.

6. **Pest, weed and disease control.** Crop rotation is one of the methods of *Integrated Pest Management (IPM)* – an ecologically-friendly method of crop production that aims to reduce the use of chemical pesticides and herbicides in agriculture.

7. Climate change mitigation. **B**y implementing crop rotation, the use of nitrogen fertiliser can be reduced by up to 100 kilograms per hectare each year. This in turn considerably *lowers emissions of nitrous oxide* and helps prevent further changes in greenhouse gas concentrations stemming from our activities. By improving the soil structure, leaving soils undisturbed and practicing cover cropping, *crop* rotation farming boosts *the ability of soil to store more* *carbon,* and therefore, helps to offset carbon emissions associated with agricultural production.

8. Production of green manure cover crops. Green manure are fast-growing crops sown to cover bare soil, add organic matter and enrich soils with minerals. When dug into the ground while still green, they return most nutrients to the soil and improve soil structure. Crop rotation farming benefits from this method by achieving stabilized long-term productivity of farmlands.

9. Higher crop yields. The list of positive effects of crop rotation would not be complete without mentioning increased yields. All the previous benefits combined together create a perfect environment to grow healthy and abundant crops. Such positive results happen most likely due to the weed and pest suppression, maintenance of healthy soils and smarter use of nutrients in crop rotation.

10. **Creates a healthier environment for life**. Crop rotation could help tackle the widespread chemical contamination of the environment we live in. The practice is, therefore, beneficial to our health and could be one of the ways to maintain our food security while minimizing negative effects of agriculture on ecosystems. This only highlights the importance of crop rotation in creating a sustainable future.

Prof. Dr. Dan Manea: Agrotechnical methods of weed control in agricultural crops

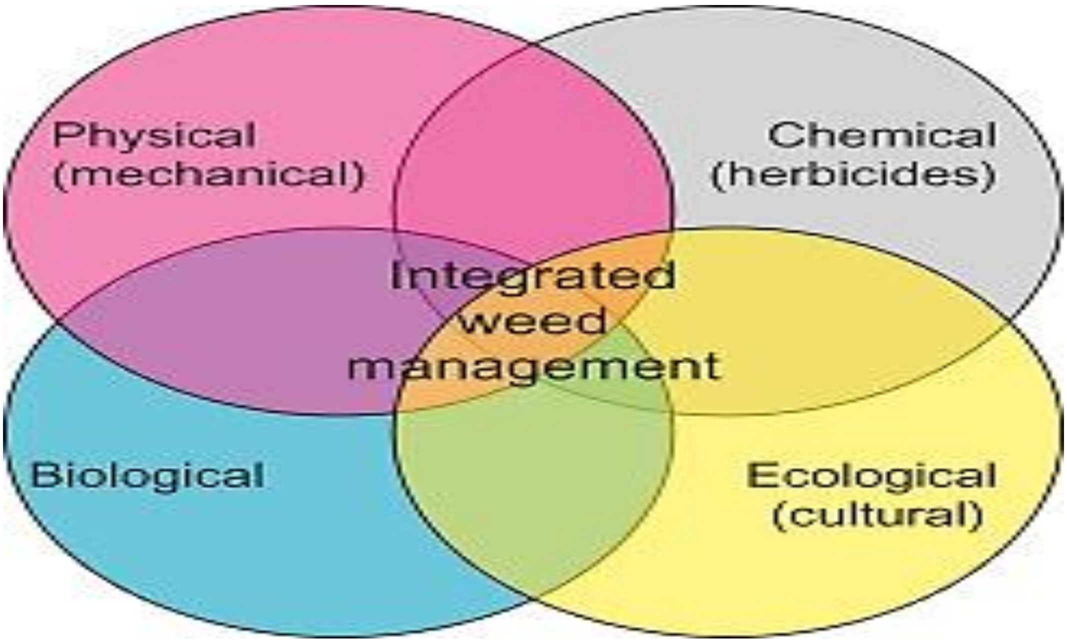
Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" Timișoara.

Weeds are recognized worldwide as an important type of undesirable economic pest. A plant growing out of place, that is a plant growing where it is not wanted, is common, accepted explanation of what a weed is.

The definition given by EWRS appears to describe weeds more sufficiently, which states weed as a any plant that is objectionable or interferes with the activities or welfare of a man.

Weeds are a concern of everyone and not just agriculturists. Weeds are a nuisance in crop production, forestry, aquatic ecosystem, public amenity areas, industrial establishments, grasslands etc.

Integrated Weed Management (IWM) is a process of selecting and using a combination of management techniques that, together, will control a particular weed species or infestation efficiently and effectively. IWM is recommended because, over the long run, it should lead to greater success in meeting our management objectives. Using more than one control method creates additive effects that weaken the noxious weed and prevents the weed from establishing resistance to one control method continually being used.



There is never a fix all solution that will always control a specific weed. The control methods used in IWM largely depend on the species at hand and the site in which it is found.

Assist Prof. Dr. Alin Flavius Carabet: Biological Agents for Crop Protection

Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" Timișoara.

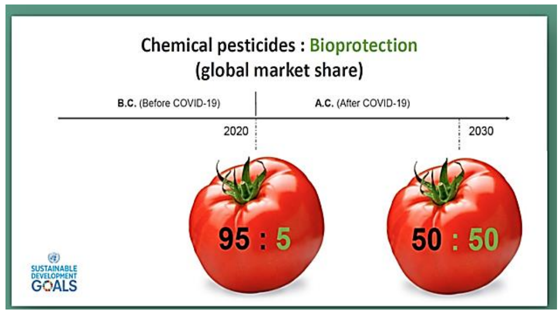
The different nature of Biological Products like biopesticides and biostimulants has changed the concept of crop planting.

Biopesticides are used mainly for solving biotic stresses, such as diseases and pests, in crops, while biostimulants are mainly used for alleviating crop losses caused by abiotic stresses, such as drought, extreme temperature, high soil salinity and heavy metal toxicity.

Biopesticides are reduced risk pesticides that are naturally derived or synthetic equivalents of natural materials such as animals, plants, bacteria, fungi and certain minerals, generally posing little risk to humans or the environment.

A plant biostimulant is a substance(s), microorganism(s), or mixtures thereof, that, when applied to seeds, plants, the rhizosphere, soil or other growth media, act to support a plant' s natural nutrition processes independently of the biostimulant' s nutrient content. The plant biostimulant thereby improves nutrient availability, uptake or use efficiency and tolerance to abiotic stress, and consequent growth, development, quality or yield.

There is a need that the bioproducts to be introduced more and more IPM solution and the goal for 2030 is to reach a 50% of global market.



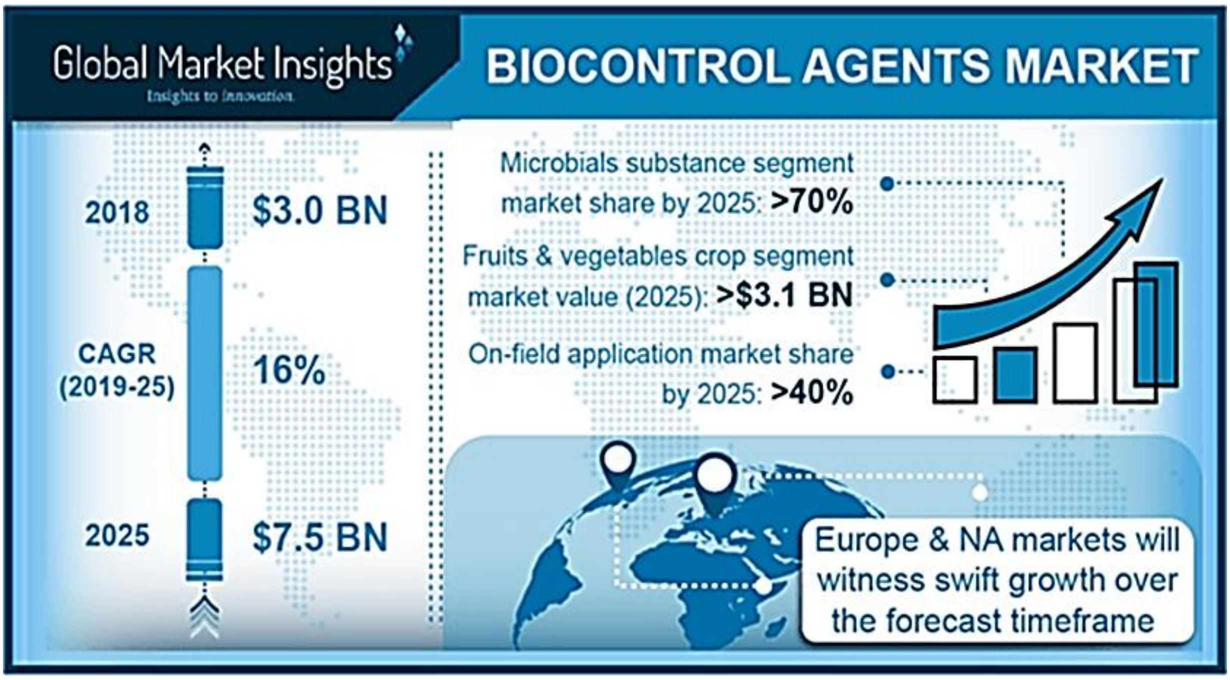
Global, national, and local food systems thrive as nature positive prosperity motors of human wellbeing and planetary health. Biobased technologies and nature-based solutions become a fundamental bridge to achieve these goals. Sustainable and regenerative agriculture become the main means to counteract climate change and to restore planet Earth´s ecosystems functions and biocapability. For this to happen "globally-local", harmonized, and proportionate regulatory frameworks (for biobased solutions) are an urged moral imperative (BIOAG WORLD Congress)

BIOFUNGICIDES

BACTERIAL-BASED PRODUCTS
MINERAL-BASED PRODUCTS
FUNGAL-BASED PRODUCTS

BIOINSECTICIDES

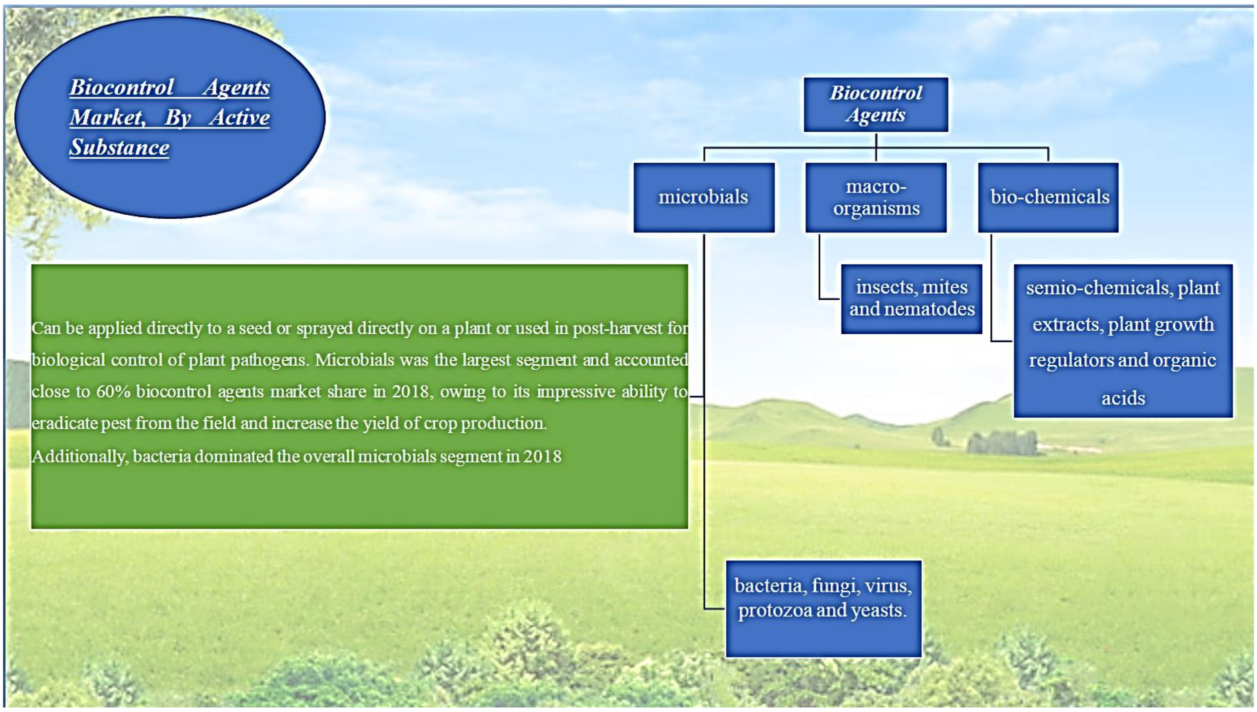
FUNGAL-BASED PRODUCTS
BACULOVIRUSES (BVS)
AZADIRACHTIN-BASED PRODUCTS
MINERAL OIL-BASED PRODUCTS
SEX PHEROMONES
BIOTIC AGENTS/NATURAL ENEMIES



According to Biocontrol Agents Market (Global Market Insights) the growth of the biocontrol industry mainly attributed to replacement of synthetic chemicals in the farming and rapidly increasing organic farming in Europe.

These agents are environment friendly, have no hazardous effects on humans compared to other synthetic agrochemicals and are effective throughout the season, thus making them ideal for the pest control.

These attributes shall be responsible for the market growth in coming years.



Biocontrol agents have always been used by farmers for crop protection and nourishment. They had substantial impact on society growth and environment. The industry consists worldwide spread of manufacturers who produces several types of biocontrol agents. Increasing demand of organic food products along with government legislations against use of chemical fertilisers will boost biocontrol agents market growth by 2025.

Prof. Dr. Ovidiu Ranta: Safe application of plant protection products, UASCN

In the context of conserving resources and the environment, farmers are encouraged and supported in the fight against the reduction of chemical residues and the aim is to reduce the environmental impact of pesticide treatments due to the negative effects of cascading on agroecosystems. At the same time, they are under pressure to increase the cost of chemicals, while at the same time ensuring healthy harvests and maximizing production. These challenges may be addressed by increasing the "accuracy" of the spray, which could provide maximum effective coverage while applying lower chemical doses. From an economic and environmental point of view, this can be considered the most viable approach. For this purpose, air injection nozzles capable of reducing drift can be used (Zande et al. 2008; Nuyttens, D.; 2006) and thus implicitly pollution, while maintaining a similar coverage to conventional nozzles, hydraulics (Derksen, R., 2000).

Common definitions of spray drop deposition are deposition rate, chemical formulation, droplet size distribution, droplet spread density, and droplet stain area.

The spray quality in the field is normally measured with collectors represented by water-sensitive paper. The collectors are placed in certain determined target areas and inspected after treatment (Sundaram, K.M.S. et al., 1987, Thériault, R., et al. 2001).

The quality of the coverage of the target area depends on: the degree of coverage and the number of drops, as well as the size of the drops. For increased efficiency, it is considered that a higher number of drops per unit area will also mean an increased likelihood of reaching the critical limit for pest control. According to the recommendations given by Syngenta Crop Protection AG, for satisfactory results the thresholds are: minimum 50-70 drops / cm^2 for fungicide, minimum 20-30 drops / cm^2 for insecticides or pre-emergent herbicides and minimum 30-40 drops / cm^2 for post-emergent contact herbicides (Water-Sensitive Paper, 2021, Zhu, H., et al. 2011, Wang, G., et al. 2019).

According to the definition given in ISO 22866 "the drift is the amount of plant protection product that is transported from the immediate vicinity of the treated area to another area, under the action of air currents, during the application process". The consequence of the drift is that part of the volume of solution applied is carried by drafts and can lead to contamination of watercourses, sensitive areas (e.g. natural parks, children's playgrounds, wetlands, etc.), urban environment or unintentional deposition of solution on neighbouring crops. This last fact can lead to the appearance of residues of active substance, which are not allowed or the production of direct damages (phytotoxicity) on the neighbouring crops.

When spraying phytosanitary treatments, the aim is to reduce pesticide consumption, treatment costs and environmental impact by:

- punctual application of pesticides, only on the target object - respectively on the vegetal mass of the treated crop or on weeds;
- application of variable doses of herbicides depending on the degree of weed infestation and the spectrum of weeds;

- minimizing treatment overlaps at the ends of the plot or bypassing obstacles in the field;
- localized application (punctual) is practiced for treatments in large crops (cereals, potatoes, beets, etc.) and for vineyards and fruit trees;

There are two types of localized application processes:

- “online” procedures - based on the instantaneous recognition of the target (target) together with the application of the combat treatment;
- “step to step” staged procedures in which the target is located before the phytosanitary treatment is performed.

Prof. Dr. Olimpia Alina Iordănescu: Possibilities for obtaining "clean fruits" in the context of sustainable agriculture

Faculty of Horticulture and Forestry, Fruit growing Department

The normal development of metabolic processes in the human body requires a constant consumption of energy substances, vitamins, mineral substances etc. Due to their rich content in vitamins and minerals, as well as carbohydrate intake, proteins and lipids, fruits are amongst the foods of important physiological value

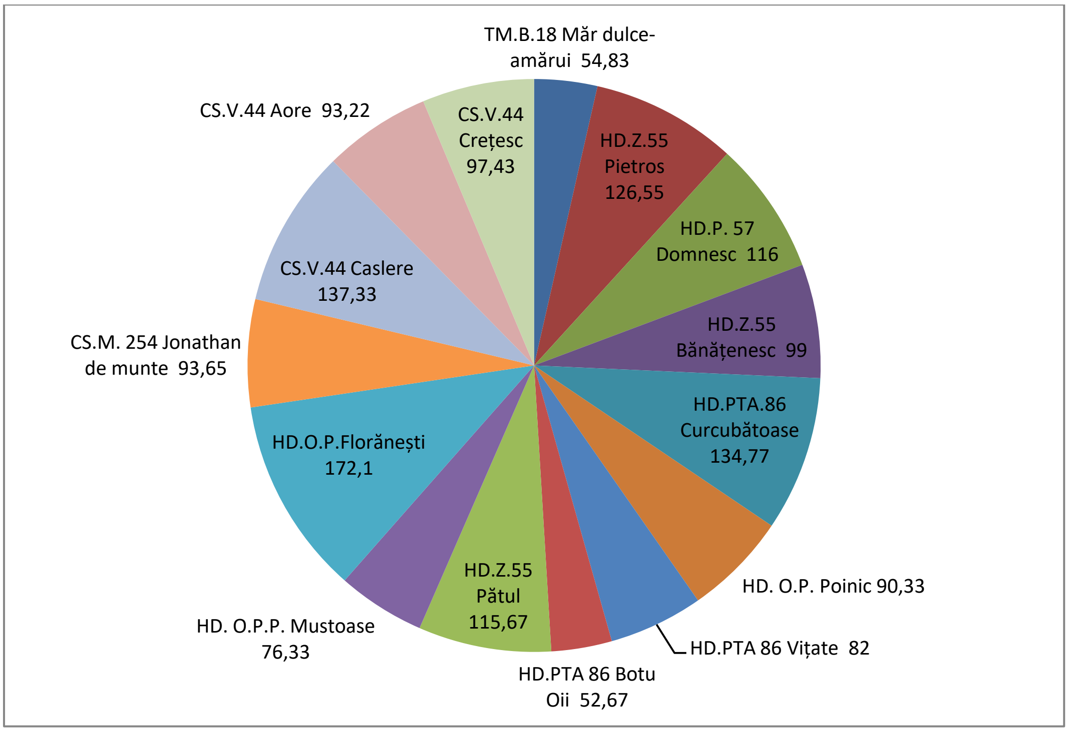
Trends in the development of fruit growing are: cultivation of varieties resistant to diseases and pests, thus reducing the number of treatments, resistant to unfavourable climatic factors (drought, frost), thus reducing the damage caused by them; cultivation of varieties grafted on rootstocks of very low vigour or dwarf ones, which keep the trees at a low height favourable to the execution of their care operations; cultivation of as few varieties as possible of a given species, productive varieties and high demand on the market; cultivating a diversity of species / varieties that can be found in different areas of cultivation, very favourable pedoclimatic conditions for growth and fruiting.

The purpose of the research concerning biodiversity conservation consist in identification, studying, sampling and characterization of biological material represented by old varieties and local apple populations in Banat

Research objectives are: Identification of the biological material representative for the proposed areas; Sampling of biological material; Description and characterization of the initial biological material; Selection and multiplication

Regarding the vigour of the tree reported by the height of the trunk and its diameter, the studied apple varieties are divided into three groups: vigorous: Curcubătoase, Bănățenesc, Florănești, Poinic; with medium-high vigor: Caslere, Cretesc, Jonathan de munte, Mustoase, Domnesc and with low vigor: Botu Oii, Aore, Dulce amărui.

The value of the apple-size index of the varieties studied falls within the following groups: small: ´Botu Oii´ ´Dulce-amărui´ ,´Vițate´, ´Poinic´ ,´Florănești´, middle: ´Bănățenesc´, ´Domnesc´, ´Pietros´, ´Caslere´, ´Crețesc´, ´Curcubătoase´ and big: ´Pătul´, ´Aore´, ´Jonathan de munte´, ´Florănești´.



The weight of the fruit of apple varieties

Concerning the weight of the fruit, the varieties which have exceeded the value of the experience: ´Florănești´ variety – very significant positive and ´Caslere´ variety – distinct significant positive, followed by: ´Curcubătoase´, ´Pietros´, ´Domnesc´ and ´Pătul´ varieties, which were not statistically assured.

Pests and diseases resistance

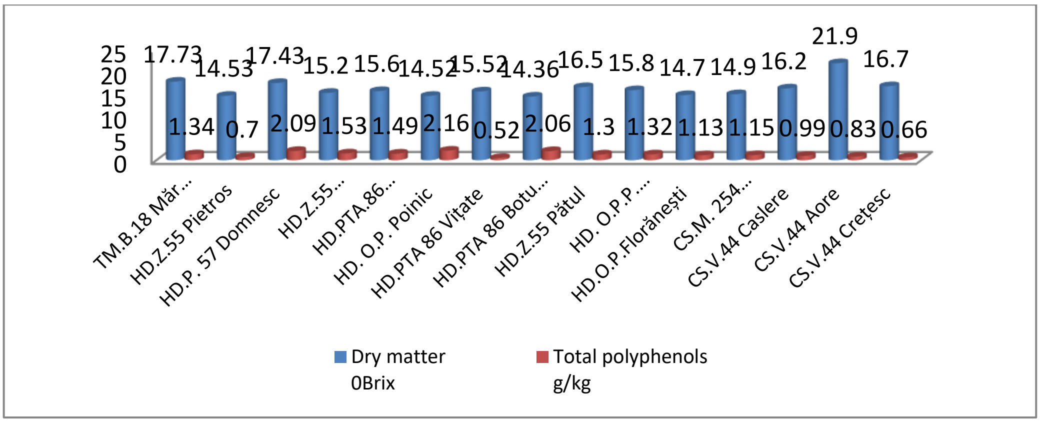
Variety	The main diseases			The main pests
	Scab *Venturia inequalis*	Monilia *Monilinia laxa*	Mildew *Podosphaera leucotricha*	Apple worm *Cydia pomonella*
TM.B.18 Măr dulce-amărui	middle resistant	resistant	middle resistant	sensible
HD.Z.55 Pietros	resistant	middle resistant	middle resistant	middle resistant
HD.P. 57 Domnesc	resistant	middle resistant	middle resistant	middle resistant
HD.Z.55 Bănățenesc	resistant	resistant	resistant	middle resistant
HD.PTA.86 Curcubătoase	sensible	middle resistant	middle resistant	sensible

HD. O.P. Poinic	resistant	middle resistant	middle resistant	middle resistant
HD.PTA 86 Vițate	middle resistant	sensible	sensible	sensible
HD.PTA 86 Botu Oii	resistant	resistant	resistant	resistant
HD.Z.55 Pătul	resistant	resistant	resistant	resistant
HD. O.P.P. Mustoase	sensible	sensible	Sensibil	sensible
HD.O.P.Florănești	middle resistant	middle resistant	middle resistant	middle sensible
CS.M. 254 Jonathan de munte	resistant	resistant	resistant	resistant
CS.V.44 Caslere	middle resistant	middle resistant	middle resistant	middle resistant
CS.V.44 Aore	middle resistant	resistant	resistant	resistant
CS.V.44 Crețesc	resistant	resistant	middle resistant	resistant

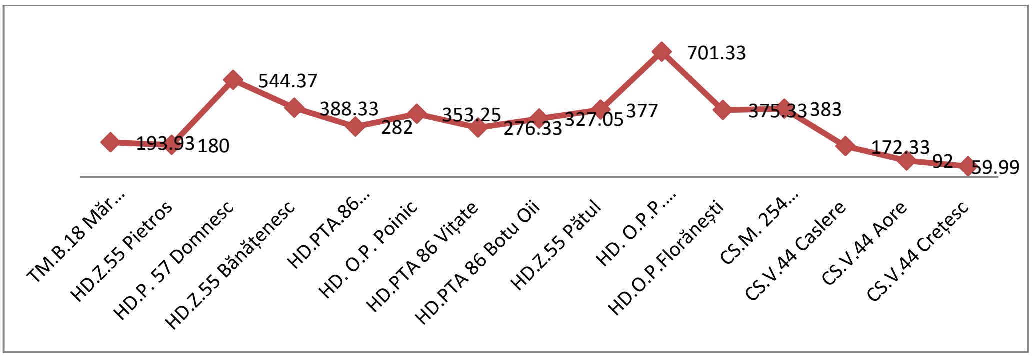
Regarding the resistance to diseases and pests, three of the studied varieties have proven good resistance both to the scab attack, mildew and monilia, and to the worm attack, respectively: ´Pătul´, ´Botu Oii´, ´Jonathan de munte´, the last of which surpasses all expectations, knowing that the ´Jonathan" variety is susceptible both to scab and to mildew.

High values of sugar content were obtained for ´Măr dulce amărui´, ´Domnesc´ and ´Aore´, all three being very significantly positive, followed by the variety ´Creţesc´ - significantly positive.

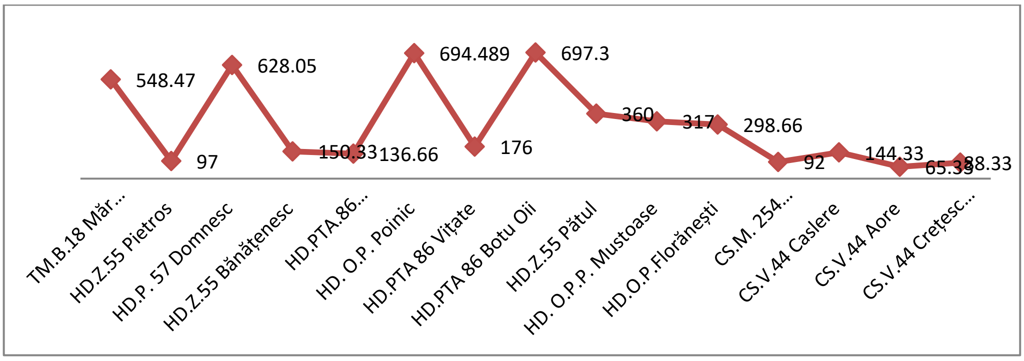
A high polyphenol content was recorded for the varieties Domnesc, Bănățenesc, ´Curcubătoase´, ´Poinic´ and ´Botu Oii´ all being very significantly positive.



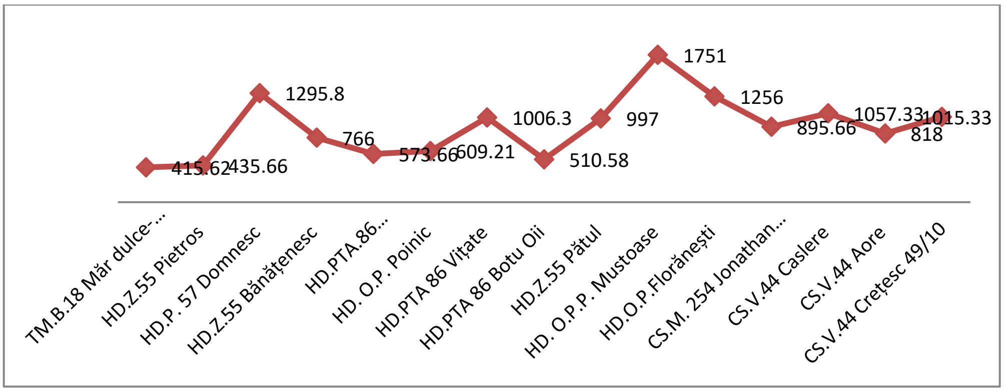
The chemical composition (dry matter and polyphenols) of fruits of ancient apple varieties



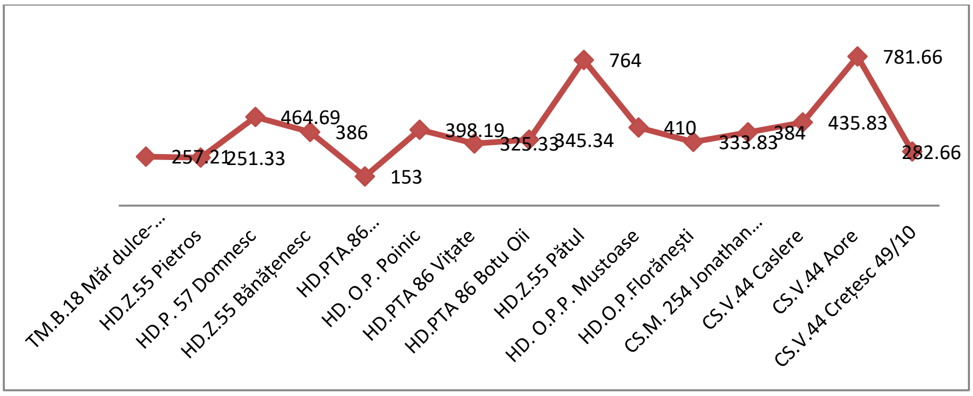
The calcium content (ppm) in fruits of ancient apple varieties studied



The magnesium content (ppm) in fruits of ancient apple varieties studied



The potassium content (ppm) in fruits of ancient apple varieties studied



The phosphorus content (ppm) in fruits of ancient apple varieties studied

The highest calcium content was recorded in the varieties: ´Mustoase´ (701.33 ppm), ´Domnesc´ (544.37 ppm), ´Bănățenesc´ (388.33 ppm); the highest Mg content was recorded in the ´Botu Oii´ (697.3 ppm) and ´Poinic´ (694,489 ppm); the highest value of the K content was recorded in the ´Mustoase´ (1751 ppm), followed by ´Domnesc´ (1295.8 ppm) and ´Florănești´ (1256 ppm).

Microelements content in fruits of ancient apple varieties studied

Variety	Cu	Cd	Ni	Pb	Zn	Fe	Mn
TM.B.18 Măr dulce-amărui	2.130	0.19	0	0.69	0.761	2.00	0.0
HD.Z.55 Pietros 49/11	0.862	0	0	0	0.824	3.762	0.335
HD.P. 57 Domnesc	1.907	1.02	0	0.17	1.007	3.827	0.75
HD.Z.55 Bănățenesc 49/5	1.146	0	0.492	0	1.734	4.274	0.604
HD.PTA.86 Curcubătoase 49/6	1.168	0	0.357	0	1.563	3.090	0.440
HD. O.P. Poinic	2.152	0.17	0	0.28	3.29	3.790	0.54
HD.PTA 86 Vițate 49/8	1.166	0	0	0	1.208	6.729	0.685
HD.PTA 86 Botu Oii	1.202	0.05	0	0.27	2.629	2.659	0.345
HD.Z.55 Pătul 49/1	1.065	0	0.114	0	2.996	5.497	2.546
HD. O.P.P. Mustoase 49/9	1.695	0	0	0	1.072	4.988	0.454
HD.O.P.Florănești 49/7	0.943	0	0	0	1.053	4.038	0.430
CS.M. 254 Jonathan de munte 49/2	1.065	0	0	0	0.720	3.295	0.362
CS.V.44 Caslere 49/3	1.105	0	0	0	2.347	5.415	1.863

CS.V.44 Aore 49/4	1.166	0	0	0	0.873	4.916	0.527
CS.V.44 Crețesc 49/10	1.288	0	0	0	1.385	4.343	0.327

Maximum limits for arsenic and heavy metals in fresh vegetables and fruits for trade and human consumption **(mg/kg fresh product)**

(OMAAP nr.293/640/1 din 2001/2002)

Vegetable and fruits	As	Cd	Pb	Zn	Cu	Sn	Hg
Fresh vegetables other than leafy vegetables	0.5	0.1	0.5	15.0	5.0	-	0.05
Leafy vegetables	-	0.2	0.5	-	-	-	0.03
Fresh fruits	0.5	0.05	0.5	5.0	5.0	-	0.05

Fresh fruits	Macroelements content Maximum allowed limit (ppm)			
	Fe	Mn	Zn	Cu
	10.0	5.0	5.0	5.0

Pătul *Aore*

Vițate *Caslere* *Botu Oii*

Domnesc *Mustoase* *Curcubătoase*

IV. Soil Cultivation: Connecting Biodiversity and Climate Change Mitigation and Adaptation

Dr. Markus Weinmann, Prof. Dr. Günter Neumann: Bio-Effectors in Crop Production: Chances and Challenges

University of Hohenheim, Stuttgart, Germany

Bio-effectors, such as microorganisms and active natural compounds, are of increasing interest as promising alternatives to precarious agrochemicals. Improved availability and use efficiency of mineral nutrients, tolerance to abiotic stresses, yield and quality traits, as well as biological control of pathogens are well documented for controlled laboratory and greenhouse systems. Under variable field conditions, however, the expression of desired effects is often hampered and the complexity of interactions between plants, microorganisms and their environment, governing the actions of bio-effectors, is poorly understood (Fig. 1).

BioFector was a recent EU funded project (2012-2017) that, by developing integrated strategies for the use bio-effectors in crop production, aimed to improve the efficiency of alternative plant nutrition strategies. These included organic and low-input farming, use of fertilisers based on waste recycling products, and fertiliser placement technologies, thus decreasing the dependency of agriculture on conventional mineral fertilisers. Therefore, 38 innovative bio-effector products were tested in more than 150 experiments with wheat, maize and tomato under diverse geographic and climatic conditions by an international consortium of 22 project partners coordinated by the University of Hohenheim (Weinmann et al. 2022).

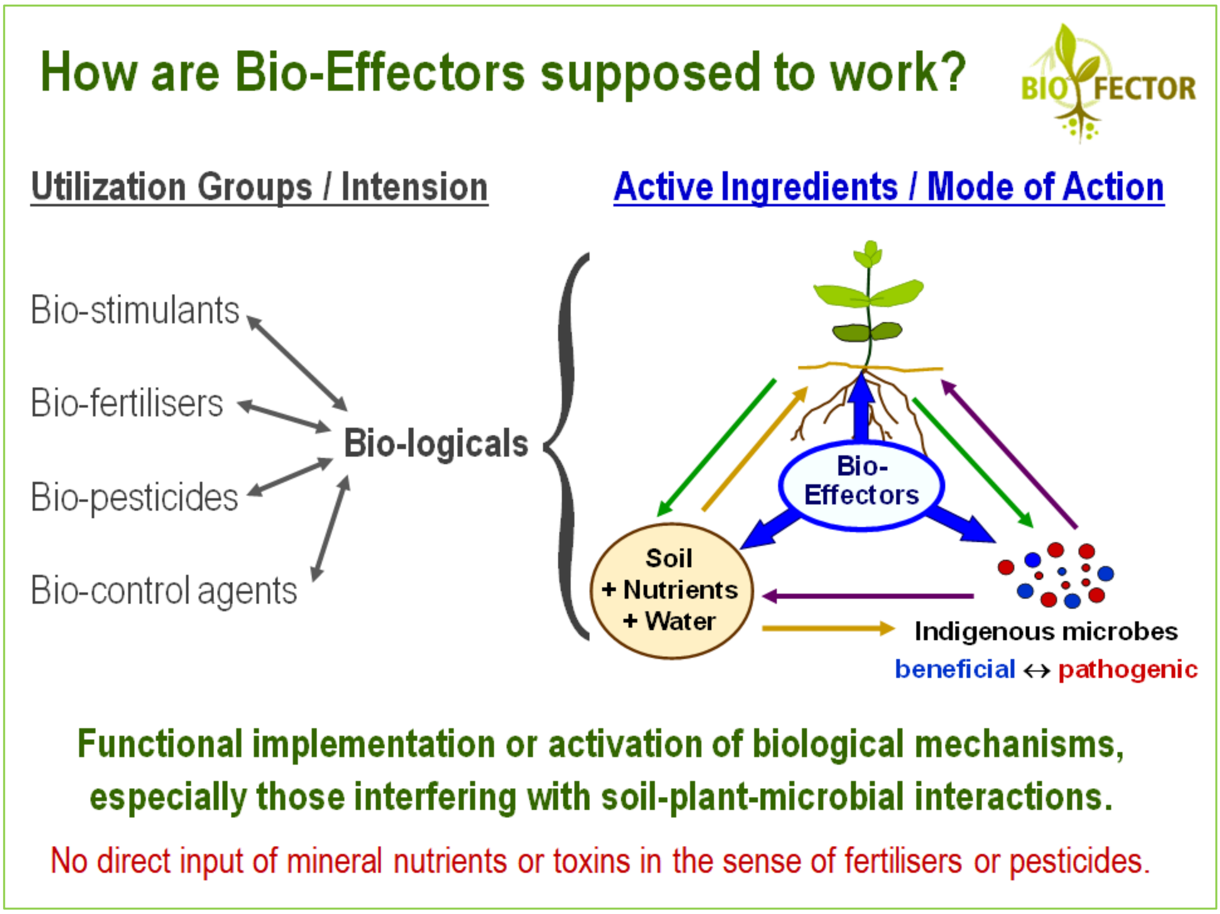


Fig. 1: Bio-effectors as active ingredients of various groups of biological products (bio-preparations) and their integrated action in multifaceted soil-plant-microbial relationships (Weinmann, 2019).

Results showed that benefits from the application of bio-effectors, such as plant growth-promoting rhizobacteria and fungi, are largely influenced by site-, crop- and management-specific conditions. Especially in tomato cultivation, reproducible yield increases of up to 100 % were produced by microbial bio-effectors in combination with organic fertilisers. In agricultural productions systems, the right set of conditions required to achieve significant improvement by bio-effector treatments was found to be much more restrictive. Combinations with fertiliser placement strategies, such as the Controlled Uptake Long Term Ammonium Nutrition (CULTAN), could induce the formation of dense rooting zones providing favourable conditions for colonization by microbial inoculants to support the expression of root growth-promoting traits and efficient acquisition of mineral nutrients such as nitrogen and phosphorus (Nkebiwe et al. 2016). Promising results were also obtained with active natural compounds, such as algae extracts, micronutrients and silicates to improve the resistance of early sown maize to cold stress and the yield of wheat with decreased fertiliser supply. A main conclusion and perspective for future use of bio-effectors is that the exploitation of synergistic interactions of microbial agents together with supportive natural compounds and adapted fertilization strategies could favourably contribution to the development of sustainable agro-ecosystems, especially when applied in concert with well integrated farming practices.

Funding supplied by the BIOFECTOR project (Resource Preservation by Application of BIOefFECTORs in European Crop Production). Grant Agreement Number 312117 under the Seventh Framework Program (FP7), European Commission, Brussels, Belgium.

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Funding supplied by the BIOFECTOR project (Resource Preservation by Application of BIOefFECTORs in European Crop Production). Grant Agreement Number 312117 under the Seventh Framework Program (FP7), European Commission, Brussels, Belgium.

Prof. Dr. Florin Imbrea: Specific Crop Technologies with the Role of Reducing the Impact of Climate Change

The challenges facing farmers today due to climate change are complex, complete, and solving them requires breaking traditional boundaries from the perspective of their technological variant.

Adapting cultivation technologies in order to both mitigate and mitigate the effects of climate change must become an urgent priority, requiring certain measures to stop them, otherwise the negative effects of climate change will increase sharply in future.

Climate change over the last two decades has caused changes in the rainfall regime, becoming more and more chaotic, soil moisture no longer meets the biological requirements of plants in various stages of growth which has a major impact on the production system. Due to water scarcity and long periods of drought on many areas, there are lower yields, less safe per hectare, with side effects in the global chain of the agri-food production system.

Given the current context, research at the university in this direction has focused on providing technological solutions to support farmers.

Such a technological solution refers to the technology of cultivating corn by mulching with plastic wrap. Corn is a very important crop both for our country and worldwide, and at the same time very affected by climate change, especially the lack of rainfall and very high temperatures during the flowering period.

The advantages of such a cultivation system are the following:

- allows an earlier sowing (in the middle of March) and, thus, reduces the risk of lack of humidity during sunrise, especially in dry springs;
- all operations related to fertilization and herbicide are performed before sowing;
- the doses of nitrogen and herbicide fertilisers used are reduced by 30%;

- the risk of crust formation and the risk of reseeding are eliminated;
  - due to the surface covered with foil, of 8,600 - 8,700 sqm, the evaporation surface is reduced to 1,300 - 1,400 sqm, and in irrigation conditions it is reduced by 2/3 and the value of the watering norm;
- does not require mechanical or manual pruning during the vegetation period;
- the growth rate of the plants is intense, the flowering earlier, and the humidity at the time of harvest lower, which determines the reduction of the expenses with the drying of the production on the one hand, and on the other hand the possibility of a correct corn-wheat rotation. in the optimal period;
- obtaining constant productions every year.

The additional financial costs involved in this maize cultivation system are given by the cost of photodegradable plastic film, which is around 100-150 euro / ha, but which is recovered by the smaller amounts of fertiliers and herbicides used in the elimination of the expenses with the mechanical parts, from the cost of the lower expenses, with the drying of the production and, last but not least, from the production increase achieved.

Another proposed technology refers to the sunflower, also a very important crop both in our country and in the world, and provides for the cultivation with a permanent vegetable carpet made either with the help of a torch or with the help of white lupine.

Among the positive effects of this sunflower cultivation system are the constant production which, in dry years, is above the level of production in the classical system, positive effects related to soil structure, increasing soil supply capacity, reducing water losses by evaporation; We should also mention other benefits of reducing soil and groundwater pollution by reducing the leaching of fertilisers (especially nitrates and nitrites) that were not consumed by pre-emergent crops: these "residual" fertilisers are used by the intermediate crop which transforms into organic matter.

Another advantage is that solar energy is captured by intermediate crops during the summer-autumn to winter, so the organic matter has led to the enrichment of the soil in parallel with a lower mineralization of humus due to a lower oxygen content in the soil covered by the cover. vegetable; in the medium and long term, it contributes to maintaining or increasing the humus content of the soil.

In conclusion, the farmer remains the decision-maker in the production process and also, every decision matters, as well as everything matters.

Prof. Dr. Hermann Ketterl, Tobias Heinrich: Field robotics for Soil Sampling and Analyses

Ostbayerische Technische Hochschule Regensburg

A common method for soil tests on farms is to mix several soil samples from a field together to make a NPK analysis. The ability to get position precise information about the soil, without complex chemical applications is part of the project Electronical Laboratories for Intelligent Soil Examination (ELISE). Several mechanical and optical tests on soil samples are covered. This method is preformed spot precise, to get not just the average but the distribution of soil properties on a field to have the ability to treat different areas based on its needs. One part of the analysis is based on automatic sample preparation and image recognition performed with a microscope. The samples are observed by a camera, which is attached to a transmitted light microscope. The automatic analysis, done with computer vision algorithms, aims to quantify bacterial and fungal biomass in the actual sample view. Moreover, the algorithm can classify organisms according to their colour and shape.

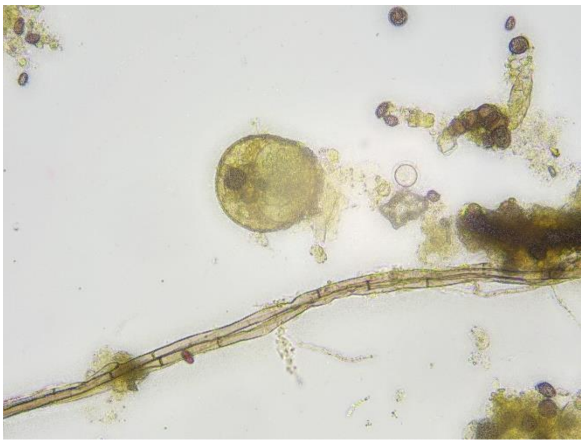

Figure 1: Microscope picture of different stacked focal levels.

To get a processable picture, several images from different focal levels must be taken through the sample thickness using focus stacking.

This produced picture (Figure 1) is used to classify, locate and quantify – in first step filamentous organisms e.g. fungal with a method called sematic segmentation. The result represents an image sized mask, which indicates the class of the fungi with class equivalent values at the pixel positions – covered by the organism. This information is used to calculate their mass per soil mass.

To quantify the bacterial biomass two approaches are implemented. For low density of bacterial existence, the individual bacteria are counted for a part of the field of view by an image detection algorithm to be extrapolate afterwards to the soil mass. For high density of bacterial occurrence, specified regions of interest with only bacteria present are chosen. An image classification which has been pretrained by pictures of bacterial density patterns – previously determent by making the sample countable due to preforming sample dilutions, is done. The second option for high density bacterial count is, to automatic preform dilutions until the image detection is confidently countable.

Values, like crumb stability or soil compaction, are taking additionally into account. Parallel performed chemical analyses are used to find correlations between the analysing methods. This is especially important to give specialized advises for farmers in a change from conventional to organic farming methods. These tests are performed in-situ since laboratory applications are mostly not comparable to outdoor use.

V. Digitalization of Agriculture: Rationality and Risks

Assoc. Prof. Dr. Ovidiu Ranta: Optimization of agricultural production processes through Smart Farming; UASVM Cluj-Napoca

Digitization and the evolution of technology have had a very strong impact on agriculture, reaching a very high level, so a central goal of agricultural engineering and technology is the development and supply of machines and machine systems, which allow security of supply, minimal use of resources and overall profitability and support for optimal management.

A central effort is to reduce greenhouse gas emissions, especially in the following four areas:

- increase the efficiency of the machine;
- improving the management of technical processes;
- management systems for machines optimization;
- use of renewable energy.

Agriculture - key to the development, production and application of renewable energy (consumes and produces large amounts of energy simultaneously).

Farms are already energy producers or indirectly contribute to the production of renewable energy because they provide land and biomass.

Agricultural production and energy consumption offer huge potential for creating a short circular energy saving in rural areas.

Automation in agriculture covers the future topics "Precision Agriculture" and / or "Smart Agriculture". The vision is to provide and feed each plant and each animal as individually and optimally as possible. Resource utilization is minimized and yields are economically optimized. Automation is also a forerunner and a cornerstone for extended range of machines and machine systems. The vision of an agricultural automation system that combines the ideas of precision agriculture with autonomy ultimately leads to an integrated control of the process that can be described as "smart" or "digital agriculture".

There is no precise definition for "Precision Agriculture". Only a few precise agricultural concepts have been imposed on the market.

Tractors and harvesters are equipped with GNSS-based steering systems (GNSS: Global Navigation Satellite Systems). Sectional control systems are gaining more and more acceptance on larger farms.

After mechanization of agriculture, automation has found its way into many industries for decades. Efficient and productive crop production is no longer just bigger, wider and faster. Increasingly, natural premises set limits for technical growth, on the one hand, and possibilities for optimizing the use of resources through technical support, on the other.

In addition to entrepreneurial goals, agriculture is increasingly called upon to take steps to combine production and environmental protection in order to maintain the long-term use of natural resources for food production. It is undeniable that farmers are already implementing this successfully in many areas. There are limitations to conventional methods, and new standards and technologies require or allow for potential optimization that the farmer has to deal with. Today, a number of technologies offer the farmer the opportunity to operate efficiently using control units, sensors and modern application technology, not only through influence, but also through individual inventory management from a spatial point of view.

The measurement principle of all optical sensors on the market is very similar. All sensors measure the light reflected by the plant's support as it passes through it. We usually have two possibilities to take the information in agriculture:

Passive systems depend on sunlight and can only be used during the day, so active systems can operate independently of outdoor light conditions and can therefore be used day and night.

Active systems, the quality of the measurement depends largely on the distance between the light source and the crop, because the artificial light sources are very weak compared to the sun, and the amount of light suddenly decreases with the distance between the light sources.

With the information taken with the help of the sensors, data maps can be created with the help of which modern technologies such as Section Control can be implemented.

Dr. Evelyn Reinmuth: Digitalization and Ethics in the Agricultural Context, University of Hohenheim

Digital technology can provide a solution for various challenges of our society, which is to produce enough food for an increasing world population, reduce environmental impact of farming, increase food safety, and increase traceability and transparency in production (van der Burg et al. 2019). One of the main goals of the use of such technology is to reduce the ecological footprint of farming (Vaudour et al. 2015).

Digital technology is data-driven, which can be a challenge and opportunity at the same time in the context of ethics for example. Decisions are no longer only based on location specifics but can also be compared to other contexts and data sources worldwide (van der Burg et al. 2019) to better assess possible consequences. Here, ethics come into play: what is the right, good, and acceptable action (van der Burg et al. 2019).

In this lecture it was the goal that students gain an understanding of the most relevant key features of decision-making in digital tools (in the agricultural context). They should be able to assess any digital tool using the understanding of key features of digital tools and be able to understand the relevance of ethics in the context of decision-making in a digital environment or application of digital tools (in the agricultural context).

Ethics

The Data Ethics Commission of Germany believes that the following ethical and legal principles and precepts should be viewed as benchmarks for action: "Ensuring the human-centered and value-oriented design of technology, fostering digital skills and critical reflection in the digital world, enhancing protection for individual freedom, self-determination and integrity, fostering responsible data utilization that is compatible with the public good, introducing risk-adapted regulation and effective oversight of algorithmic systems, safeguarding and promoting democracy and social cohesion, aligning digital strategies with sustainability goals" (Data Ethics Commission of Germany, 2020, p. 13). An ethical decision produces trust and shows that a decision-maker has respect, acts responsible and fair. Ethical decision-making requires a decision-maker to consider different options and eliminate unethical alternatives before deciding. To understand ethics in the context of digitalization it helps to separate ethics from technology and first gain an understanding of how decision-making works in general from a technical point of view.

Decision-making in digital technology

The understanding of the technical decision-making process helps us to reflect on the areas of ethics in digitalization. Ethics in digitalization in agriculture relate to data ownership and access, distribution of power, and impacts on human life and society (van der Burg et al. 2019).

The decision-making process in any digital tool or digital environment follows a certain structure which can be reduced to three elements: a) if-then, b) sequence of actions, and c) loop (do so until). These three elements are the key elements of every computer model which is the heart of any technology. The quality of a technology is determined by how the programmer understands and designs the representative model of the real world and human action. Every technical decision-making process is a programmed path that considers certain aspects of a decision, which are all accounted for to achieve a certain outcome = decision (Aurbacher et al. 2013). The models of a decision process try to imitate what we as humans normally do. In technical terms, each decision is broken down into every single step of a decision-making process our brains normally process intuitively. Every aspect to be considered is part of the decision tree in the technical model that represent the decision mechanism. The modeller of a digital tool determines how the decision-making process is set-up (Reinmuth und Dabbert 2017).

“Simple” decision-making processes of digital tools

Example: A sensor measures soil moisture to determine whether a field is to be irrigated or not.

Logic: If soil water content, measured by a sensor in X cm depth <= [VALUE], then the sensor reports to the irrigation system that the soil moisture content is too low. The irrigation system recognizes the value and is being set to: If soil moisture value is lower than [VALUE] – then the irrigation system is automatically turned on for a fixed amount of time with a fixed amount of pressure.

Ethics of application: In arid regions, the ethics refer for example to the setting of how much water is being used for irrigation to not harm the farming operations of the neighbours or deplete the water reservoir. Ethics also extends to legal liabilities, if too much water extraction results in a penalty fee for the farmer.

Ethics of programming: The programming code of the sensor needs to be designed in a way that it can detect even very small variations in soil moisture content. The irrigation system needs to be able to account for different settings to control the amount of water to be applied. If such a flexibility is not being given, the company which produces the technology should inform the customer about the limitation of their system. It also shows that farmers still have a certain responsibility when using technology to take care of the appropriate use in each context.

Complex technology

More complex technology can support with more complex decisions because it can account for more details. An example for complex digital tools is an Artificial Intelligence (AI). The basic logic (if-then…) still applies here. AI is, however, based on a more complex form of the "if-then" logic. Several "if-then" rules are applied sequentially in a decision path and "if-then" rules are being given weights in the decision-making process. Tasks AI systems can fulfil are for example: detection, classification, segmentation, prediction, and recommendations (Johnson, O. 2021). To set up the knowledge of the AI, a training dataset is required. The data chosen to train the AI determines what kind of idea the AI has of the real-world context it is applied to. The training dataset should be based on statistics to have a good representation of the real-world. Technically, the goal is to provide examples of high diversity to the machine which are yet specifically enough to achieve the desired outcome.

Ethical Challenge: It is most difficult to train a machine to consider various ethical aspects in its decision-making. Why? Ethical "if-then" rules are highly difficult to achieve because ethics often relate to certain contexts or involve high uncertainties in the decision-making process. Example: If a trained AI can detect a cat – any cat in a picture, technically, it will detect with a high probability that there is a cat in the picture. BUT: nothing more and nothing less! This trained AI will not know what to do with a dog picture other than knowing it is NOT A CAT. It does not know that this is an animal, how to manage its health status or how to ensure animal welfare based on this model and these training data. All the other aspects mentioned above would require a completely different and much more complex model and training data set-up.

Ethics: A dataset contains a certain image of the real world. Depending on which data you choose for your training dataset, the AI will for example discriminate females when being given only male examples in the training dataset. Your dataset determines what is “right” or “wrong” for the AI, what is a desired outcome and what is an undesired outcome. Therefore, ethics in technology is heavily driven by design and data quality.

Conclusion:

A commitment to ethics in technology is determined by how those who write the programming code/design understand the ethical implications of a technology. It is also determined by the users of such technology.

“Technologies aren´t inherently good or evil, technologies are tools - they are power. What you do with power determines whether it is something we applaud or something that we deplore. But it is not the tool that determines the endpoint - it is the user.” Professor Alta Charo, Bioethicists, University of Wisconsin-Madison (Movie: Human Nature)

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Dr. Dr. h.c. Heinrich Gräpel: The impact of agricultural experimentation on a responsible plant protection, University of Applied Sciences, Osnabrueck

Summary

The registration of plant protection products is strictly regulated as well as the methodology of the required trials.

All trials concerning the impact of plant protection products on human health and on environment have to be conducted under 'Good Laboratory Practice' (GLP).

All trials dealing with the efficacy and selectivity of plant protection products have to be carried out under 'Good Experimental Practice' (GEP).

Much trial work has to be done beside the registration process in order to optimize the local application of pesticides.

These trials are performed by product suppliers, official and private plant protection services and last but not least by farmers themselves. They include small scale trials as well as field application with farmers' equipment.

Responsible plant protection practice is impossible without extensive agricultural experimentation.

1. **What is the meaning of 'responsible plant protection' in this context?**

Responsible plant protection is always an 'integrated plant protection' meaning that all methods keeping the crop healthy shall be applied (e. g. resistant varieties, mechanical weeding and the use of chemicals if appropriate).
Always check properly if an application is really necessary (respect economic thresholds if available).
Use only plant protection products registered for the intended purpose.
Generally spoken: apply ‚good plant protection practice'.

This concept is defined in the 'Regulation (EC) No 1107/2009 of the European Parliament and of the Council, of 21 October 2009, Article 3, 18:
….'good plant protection practice' means a practice whereby the treatments with plant protection products applied to given plants or plant products, in conformity with the conditions of their authorised uses, are selected, dosed and

timed to ensure acceptable efficacy with the minimum quantity necessary, taking due account of local conditions and of the possibilities for cultural and biological control'.

2. Registration procedure of plant protection products in the European Union

The registration procedure of plant protection products in the European Union is based on the 'Regulation (EC) No 1107/2009 of the European Parliament and of the Council,
of 21 October 2009 regulates, amongst others, the registration process of plant protection products.

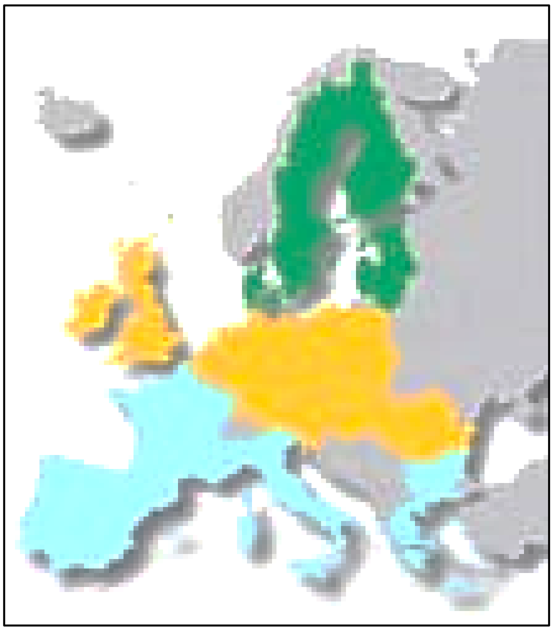
1st step: Registration of active ingredients.

Active ingredients are registered by the EU Commission after consultation of the EU member states and different EU institutions like the European Food Safety Authority.

2nd step: Registration of plant protection products.

Products with registered active ingredients are registered by the member states.

Therefor a three-zone model is used:



Zone A=North

Zone B = Middle

Zone C = South

Registration schema:

The applicant applies for registration in one zone (rapporteur member state).

This country examines the data and registers the product.

Now the applicant can apply for registration of the product in the other states in the respective zone.

These states can register the product without further examination (mutual recognition) or ask for additional tests.

3. Legal requirements for tests in the registration process.

As part of the registration process different types of trials have to be performed, depending on the purpose of testing.

They are described in the 'Directive 2004/10/EC of the European Parliament and of the Council, of 11 February 2004'.

Good Laboratory Practice (GLP)

The application of these principles should help to avoid the creation of technical barriers to trade, and further improve the protection of human health and the environment.

These principles of good laboratory practice should be applied to the non-clinical safety testing of test items contained in pharmaceutical products, pesticide products, cosmetic products, veterinary drugs as well as food additives, feed additives, and industrial chemicals.
These test items are frequently synthetic chemicals, but may be of natural or biological origin and, in some circumstances, may be living organisms. The purpose of testing these test items is to obtain data on their properties and/or their safety with respect to human health and/or the environment.

Good Experimental Practice (GEP)

EPPO (European and Mediterranean Plant Protection Organization)

Standard PP 1/181

Conduct and reporting of efficacy evaluation trials, including good experimental practice

"This standard is designed to be used in conjunction with the specific EPPO Standards from the series PP 1 on efficacy evaluation of plant protection products.

It provides guidance on how to organize trials, and how to plan, conduct and assess them, then record and interpret them, so as to obtain comparable and reliable results.

It is also based on the principle that trials should be performed according to Good Experimental Practice (GEP)"

To perform GLP and/or GEP trials as described in the directive, an official certification of the test facility is prescribed.

4. Examples for different kind of registration trials

Efficacy trials are performed to find the optimal dose-rate of a test product and to check the efficacy spectrum:

The trials have to be carried out under different climatic and environmental conditions in at least three vegetation periods.

The minimum number of efficacy test is required depending on the test item. This type of trial is also used to compare the efficacy of the test product with one or more already registered products as standards.

Selectivity trials are used to test the selectivity of a product to the cop with the intended and with the double dose-rate in comparison with an already registered standard and to check the effect on yield.

Selectivity trials have to be performed on fields without the intended target (weed-free or without diseases) to avoid side effects on the yield.

A special type of selectivity trials are variety trials. As some products, e. g. herbicides, show negative effects on different varieties of the intended crop a set of varieties are tested in at least three vegetation periods under different climatic and soil conditions.

5. Trials beside the registration process

Often new products or the appearance of new pests or diseases cause application problems.

So application trials, sometimes even with farmers equipment are necessary. Please find some examples below.

Registration trial against *Diabrotica virgifera* (LeConte); in Lenauheim (Romania), 2010, with farmers equipment. Plot size 400 m².

Application trial in potato, in Lovrin (Romania), 2018; Test of in-furrow application of a biological product.

VI. Global Integration of Agriculture: Social and Geographic Networking

Dr. Klára Bradáčová: No chemical-synthetic plant protection under field conditions

University Hohenheim, Banat Green Deal Project: Agriculture in Responsibility for our common World 25th January 2022

Bio-effectors (BEs) are a diverse group of beneficial soil microorganisms and active natural compounds, which by modes of action, such as phytohormonal activities, mobilization of sparingly available mineral nutrients or interactions with the soil microflora can have direct and/or indirect effects on plant performance. Especially under conditions where plants are exposed to environmental stresses, shoot and root growth as well as the nutritional status of the plant can be promoted. The application of BEs could thus contribute to an optimized management of soil fertility, as it allows for a more efficient utilization of mineral nutrients contained in soils or conventional fertilisers (Biofector, 2012).

Different biostimulants, algae extracts and micronutrients are currently used in innovative cropping systems to improve crop yields under both biotic and abiotic stresses.

The use of different biostimulants and micronutrients is based on the findings from our previous studies (Bradáčová et al., 2016, Bradáčová et al., 2019a, Bradáčová et al., 2019b, Bradáčová et al., 2020).

For instance, as observed in the literature, the benefit of plant growth-promoting microorganisms (PGPMs) as plant inoculants is influenced by a wide range of environmental factors. Therefore, microbial consortia products (MCPs) based on multiple PGPM strains with complementary functions, have been proposed as superior, particularly under challenging environmental conditions and for restoration of beneficial microbial communities in disturbed soil environments. Interestingly, the MCP inoculant stimulated root and shoot growth and improved the acquisition of macronutrients only on a freshly collected field soil with high organic matter content and high background microbial activity, exclusively in combination with stabilized ammonium fertilization. This was associated with transiently increased expression of AuxIAA5 in the root tissue, a gene responsive to exogenous auxin supply, suggesting root growth promotion by microbial auxin production as a major mode of action of the MCP inoculant. High microbial activity was indicated by intense expression of soil enzyme activities involved in C, N and P cycling in the rhizosphere (cellulase, leucine peptidase, alkaline and acid phosphatases) without detectable effects induced by MCP inoculation. Contrastingly, the MCP inoculation did neither affect maize biomass production, nor nutrient acquisition on soils with very little C-org and low microbial activity, although a moderate stimulation of rhizosphere enzymes involved in N and P cycling was recorded. There was also no indication for direct MCP-induced solubilisation of Ca-phosphates on a highly buffered calcareous sub-soil supplied with rock-phosphate. The results demonstrate that the MCP strategy, combining large numbers of PGPM strains with complementary properties, not necessarily translates into plant benefits under challenging environmental conditions. Soil properties, such as organic matter content, pH buffering and particle size distribution but also the fertilization regime may crucially influence the plant-microbial interactions (Bradáčová et al., 2019a).

Thus, a better characterization of the conditions determining successful biostimulants application, algae extracts application and the application of Zn, Mn and Si is mandatory also in the following following field experiments.

Another example is more focusing on the adoption of micronutrients and algae extracts as efficient biostimulants proving its plant-growth promoting effects under stress conditions.

Therefore, in the current NOcsPS project, our task is to develop and establish innovative, efficient fertilization strategies, with maintaining the optimal yields under no use of chemical-synthetic plant protection agents.

To reach this purpose and test different fertilization strategies, field experiments over two years are carried out in the field research station Heidfeldhof, University of Hohenheim. The main cultures for the field experiments are: winter wheat, maize and soybean.

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Assoc. Prof. Dr. Mihai Herbei: Monitoring the Crops by using Remote Sensing Images

Multispectral satellite images were used to assess vegetation and crops since the 1970s. Each multispectral band contains specific information and their combination results in new and more complex information, and it provides a higher safety in characterizing vegetation and especially crops, and also other objects of interest.

Remote sensing is used to analyse different aspects like crop area assessment, land cover and land use, mapping crop season and crop, aspects of growth dynamics of the crops, determination of vegetation indicators, current monitoring in agriculture.

Research has used technology based on satellite images for assessing vegetation stages of sunflower crop. The satellite images used in the present study represent the period April-September (sunflower vegetation period) from the sites: http://earthexplorer.usgs.gov/ and www.landsat .gsfc.nasa.gov. Image analysis was performed with ArcGIS 10 software by analysing satellite images and extracting the information contained in spectral bands (R, G, B, NIR), respectively their combinations used in the calculation of indicators NDMI, NDBR and NDVI. Following the vegetation stages of sunflower crop was achieved according to BBCH code through periodic observations on plant growth and development, in order to correlate the data with information obtained from the analysis of satellite images. Experimental data were analysed in terms of statistical safety according to the appropriate mathematical-statistical methods (p, R2 , test F). In order to assess interdependencies between certain spectral bands and the indexes used to evaluate vegetation stages of sunflower crop, were used regression analysis and the result was the polynomial functions of second degree, with safety related parameters

Fig. 1 Study area

Table 1. Index values NDMI, NDBR and NDVI in relation with vegetation stages of sunflower crop

Time of year for determining	Stage of vegetation	NDMI	NDBR	NDVI
22_Apr	Growth stage 1: Leaf development 2-4 Leafs (12-14 BBCH)	0.17190±0.018*	0.28672±0.049*	0.05078±0.043*
24_May	Growth stage 3: Stem elongation (32-33 BBCH)	0.11795±0.013	0.20595±0.016	0.22890±0.019
09_Juni	Growth stage 6: Flowering; Full flowering (65 BBCH)	0.15322±0.045	0.30720±0.057	0.40743±0.043
19_July	Growth stage 7: Development of fruit (71-73 BBCH)	0.11432±0.028	0.41089±0.042	0.25001±0.046
12_Aug	Growth stage 8: Ripening (80-81 BBCH)	0.09615±0.016	0.23169±0.019	0.24849±0.018
28_Aug	Growth stage 9: Plant dry (92-97 BBCH)	0.00895±0.085	0.11917±0.077	0.20813±0.098
13_Sept	After harvest: land with plant debris and disking field	0.18254±0.002	0.29009±0.009	0.03519±0.013

* ±Standard Deviation

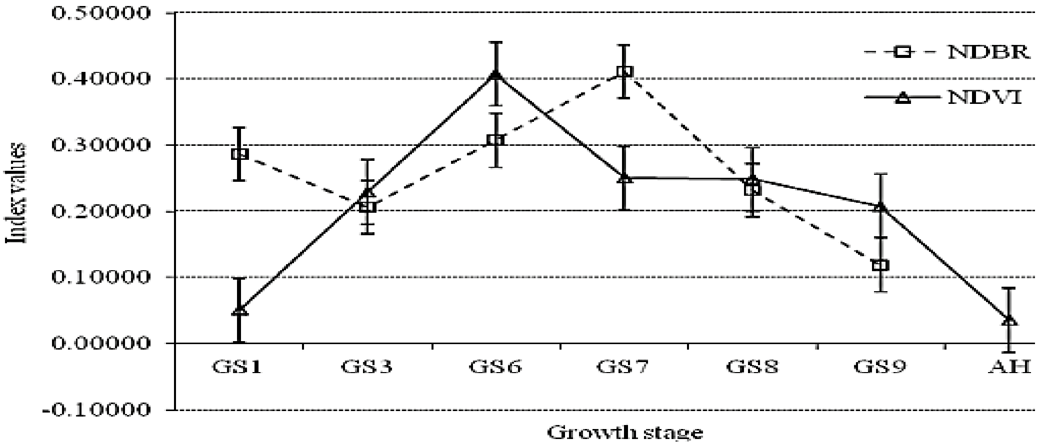


Figure 2. Distribution of specific indexes NDBR and NDVI for sunflower crop in the vegetation period: GS1 – 12-14 BBCH; GS3 – 32-33 BBCH; GS6 – 65 BBCH; GS7 – 71-73 BBCH; GS8 – 80-81 BBCH; GS9 - 92-97 BBCH; AH - After harvest

Table 2. Description functions of the relation between NDVI index and NIR band for characterizing the vegetation stages of sunflower crop

Vegetation stage	Equation	Equation number	p	R^2	F
12-14 BBCH	$NDVI = 1.003E-10x^2 - 7.188E-06x + 0.1702$	(4)	< 0.01	0.642	42.193
32-33 BBCH	$NDVI = 1.809E-09x^2 - 3.399E-05x + 0.2549$	(5)	< 0.01	0.898	209.77
65 BBCH	$NDVI = -1.644E-09x^2 - 9.588E-05x - 1.107$	(6)	< 0.01	0.966	670.34
71-73 BBCH	$NDVI = -2.361E-10x^2 + 1.849x - 0.00886$	(7)	< 0.01	0.854	137.77
80-81 BBCH	$NDVI = -2.141E-09x^2 + 9.303E-05x - 0.8894$	(8)	< 0.01	0.605	36.058
92-97 BBCH	$NDVI = -2.453E-09x^2 + 9.695E-05x - 0.569$	(9)	< 0.01	0.993	3148.2
AH - After harvest	$NDVI = 5.145E-10x^2 - 3.651E-05x + 0.6818$	(10)	< 0.01	0.435	18.083

-

- ***BIOMASS PREDICTION MODEL IN MAIZE BASED ON SATELLITE IMAGES***

Based on spectral information from the satellite images and specific indices obtained, it was possible to analyse and to generally characterize the vegetation cover and agricultural crops, dynamic analysis of the vegetation stages, evaluating the efficiency of mineral nutrition for crops, the potential for combustion and other matters of interest. This study examined the relationship between NDVI and NDBR indices and biomass production for feed from maize crops, hybrid Micado, located at 45°47' N and 21°12' E, Timisoara, Romania. Satellite images were taken during the growing season in five BBCH stages, together with determinations on chlorophyll content and quantity of biomass. In order to characterize the framework and the values of spontaneous vegetation biomass and debris from the maize crop, satellite images were taken also in two moments outside of the growing season (before crop establishment and after harvest

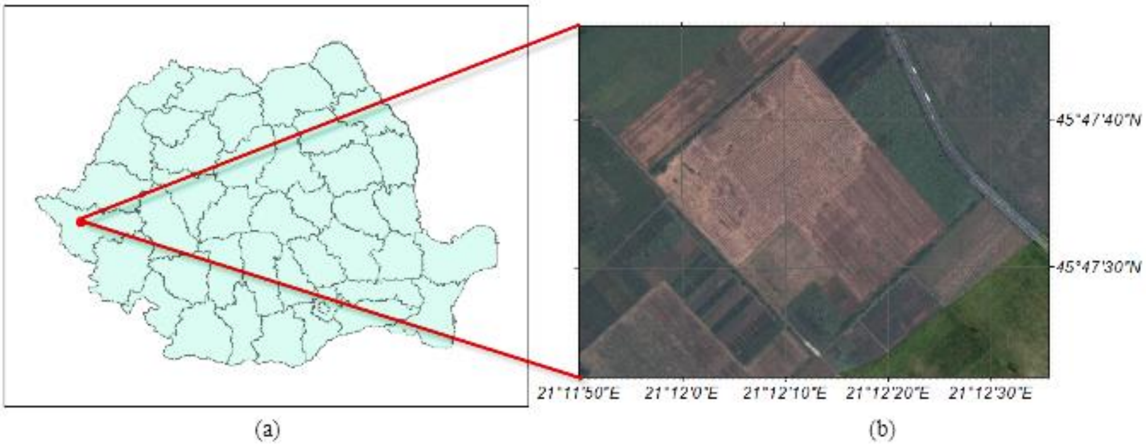


Fig. 3 Study area

TABLE 1. Growing stages and parameters characterizing the corn crop

Period	Moment and growing stages	Chl (SPAD units)	NDVI	NDBR	Biomass (t ha^{-1})
March	Before seeding	2.10±0.11	0.152416±0.026	0.011216±0.037	0.15±0.001
April	12-13 BBCH; Stage 1 Leaf development	24.1±0.25	0.035641±0.002	0.035095±0.034	2.39±0.005
May	17-18 BBCH; Stage 1 Leaf development	49.40±0.38	0.245394±0.008	0.241790±0.009	15.62±0.004
June	53 BBCH; Stage 3 Stem elongation	55.30±0.29	0.320839±0.002	0.323941±0.008	28.93±0.016
July	71 – 73 BBCH; Stage 7 Development of fruit	58.15±0.43	0.294240±0.001	0.463913±0.001	50.78±0.034
August	83-85 BBCH; Stage 8 Ripening	58.63±0.47	0.307872±0.015	0.491038±0.018	51.92±0.028
	After harvest	16.02±0.21	0.258827±0.026	0.170754±0.039	2.70±0.007

Based on identified correlations between spectral data from satellite images and data that reflect the level of development of the maize crop (Chl) and biomass production (Bm), the interdependency relations were analysed between vegetation parameters (Chl), biomass production (Bm), and NDVI and NDBR indices. Such models are of interest to analyse the dynamics of the crop, for estimating the biomass production and optimal timing for harvest. By regression analysis, it was possible to predict the biomass production of the maize crop based on NDVI and NDBR indices, as well as the content of chlorophyll. NDBR index, although currently used for characterizing the potential for combustion, it had a high correlation with the amount of biomass determined by the soil measurements.

$$y = 454.18x^3 - 226.52x^2 + 118.89x - 4.296 \quad (4)$$

where: y – biomass yield; x – NDBR

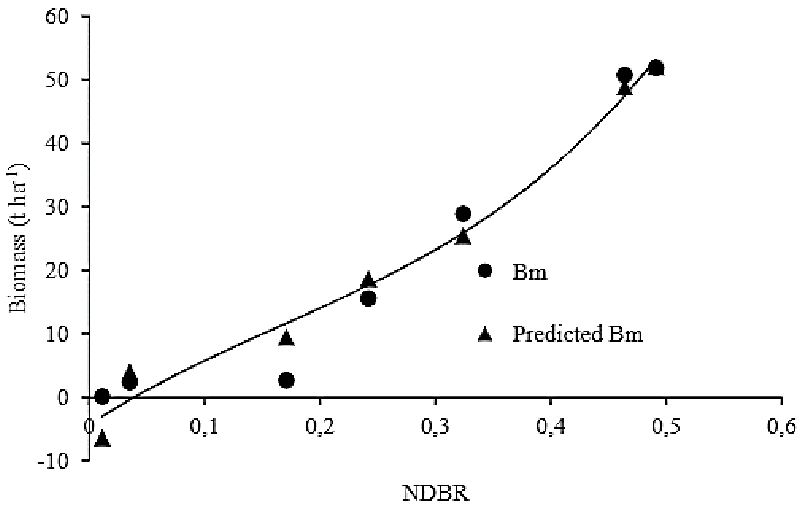


Fig. 4 The distribution of actual Biomass and predicted values based on NDBR index

Assoc. Prof. Dr. Adrian Șmuleac: Precision Agriculture: Global Positioning System (GPS). GIS for AGRICULTURE

A GIS is a technical and organizational set of people, equipment (hardware), programs (software), algorithms and procedures (methods) that ensure the processing, management, manipulation, analysis, modelling and visualization of spatial data in order to solve complex planning problems and land management.

GIS mapping produces visualizations of geospatial information. The 4 main ideas of Geographic Information Systems (GIS) are: Create geographic data, Manage it in a database, Analyse and find patterns, Visualize it on a map.

Geographic Information System is an organized collection of Software, Hardware, Network, Data, People, Methods / Procedures

Two types of data can be integrated into a GIS system: Vector and Raster data.

Vector data can represent point, line, and area features more accurately.

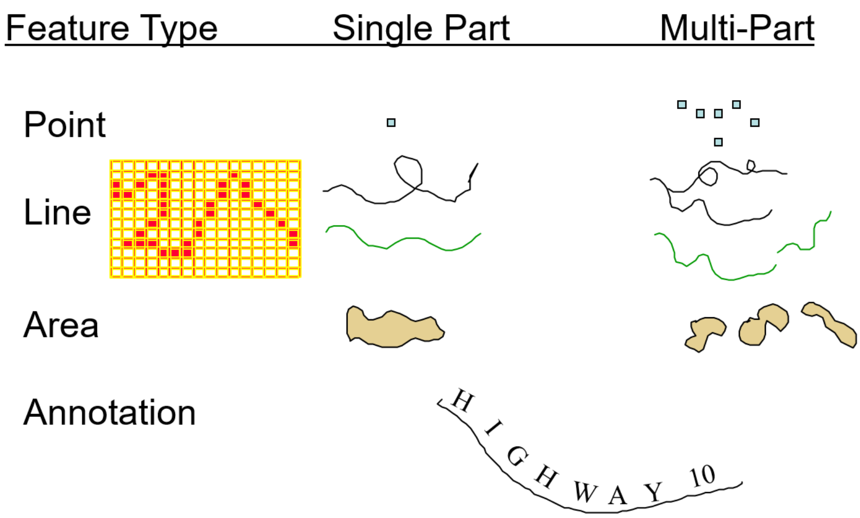


Fig. 1 Vector data

A Field Data Model Uses a Raster or Grid Data Structure.

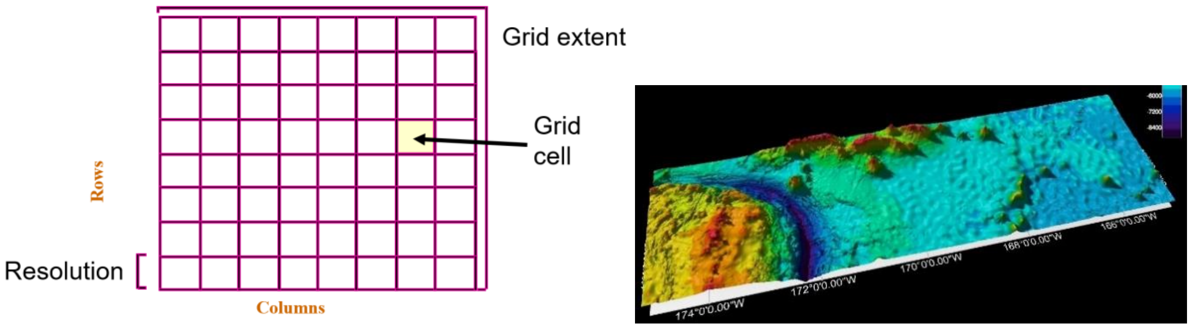


Fig. 2 Raster data

GIS systems are characterized by the ability to analyse data from various points of view. Spatial analysis helps us understand: Where are certain objects, What are the relationships between objects, What decisions to make at a given time. To perform a spatial analysis we must identify the CATEGORY of analysis. Each category represents a set of questions related to spatial analysis. Understanding the questions that fall into each category helps us to better understand the problem and explain it to others.

Table 1. Spatial analysis categories

Category	DESCRIPTION
WHERE?	If we don't know where we are, "we are lost." The first question in a spatial analysis is WHERE?
MEASURING SIZE, SHAPE, DISTRIBUTION	There are situations when we want to describe an object from a geometric point of view (area, length, height or volume), or we want to highlight a certain distribution of a phenomenon
DETERMINATION OF RELATIONS BETWEEN OBJECTS	There are situations when we want to describe and quantify certain relationships that exist between 2 or more objects (which object is closer or which is inside)
SEARCHING FOR THE BEST ROUTES AND LOCATIONS	There are situations when we want to determine the best route to travel between 2 locations or which is the right location to build a new store.
DETECTION AND MEASUREMENT OF PATTERNS	There are situations when we want to determine certain patterns or patterns from existing data (HOT SPOT, COLD SPOT) or how these patterns change over time.
PERFORMANCE OF PREDICTIONS	There are situations when we want to predict a phenomenon in the future or how a phenomenon will spread depending on certain factors.

The workflow in a spatial analysis begins with asking questions and ends with a decision. Spatial analysis is not a tool or a model that we can execute. It is a workflow that provides a way to approach problem solving. It is also important to understand that some stages of the workflow may need to be reviewed. For example, as you go through an analysis, you may think of a new question that would require reviewing or repeating certain steps. In this case, we will work through the steps based on the new question until the necessary answer is obtained to continue the initial flow of analysis.

Table 2. Workflow in GIS spatial analysis

Workflow	DESCRIPTION
Question?	Determining space questions
DATA EXPLORATION AND PREPARATION	Choice of data based on questions. Examination qualitative and redundancy Prepare data as needed (crop, update, or edit attributes)
ANALYSIS AND MODELING	Break down the problem into smaller, shapable components. Quantification and evaluation of spatial questions.
INTERPRETATION OF RESULTS	Examination of results based on spatial questions. Identify possible problems based on the results.
REPEAT AND / OR MODIFY	Make adjustments based on results. Additional questions.
PRESENTATION OF FINAL RESULTS	Presentation of the results of the decision makers.
DECISION-MAKING PROCESS	Use the results of space analysis to make decisions and measures.

A thematic map is a visual representation of the characteristics of a geographical location. The characteristics illustrated on the map may consist of either qualitative properties (e.g. descriptive information about certain types of soil that are in a particular region) or quantitative properties of a geographical area (eg population or demographic information). The attributes used are stored by categories (name, type) or by quantitative values (groups of symbols: percentage, range).

- ***Quality thematic maps***

Qualitative thematic maps present a spatial distribution of a single phenomenon or geographical element (e.g.: pedological map, map of a county, geological map, etc.).

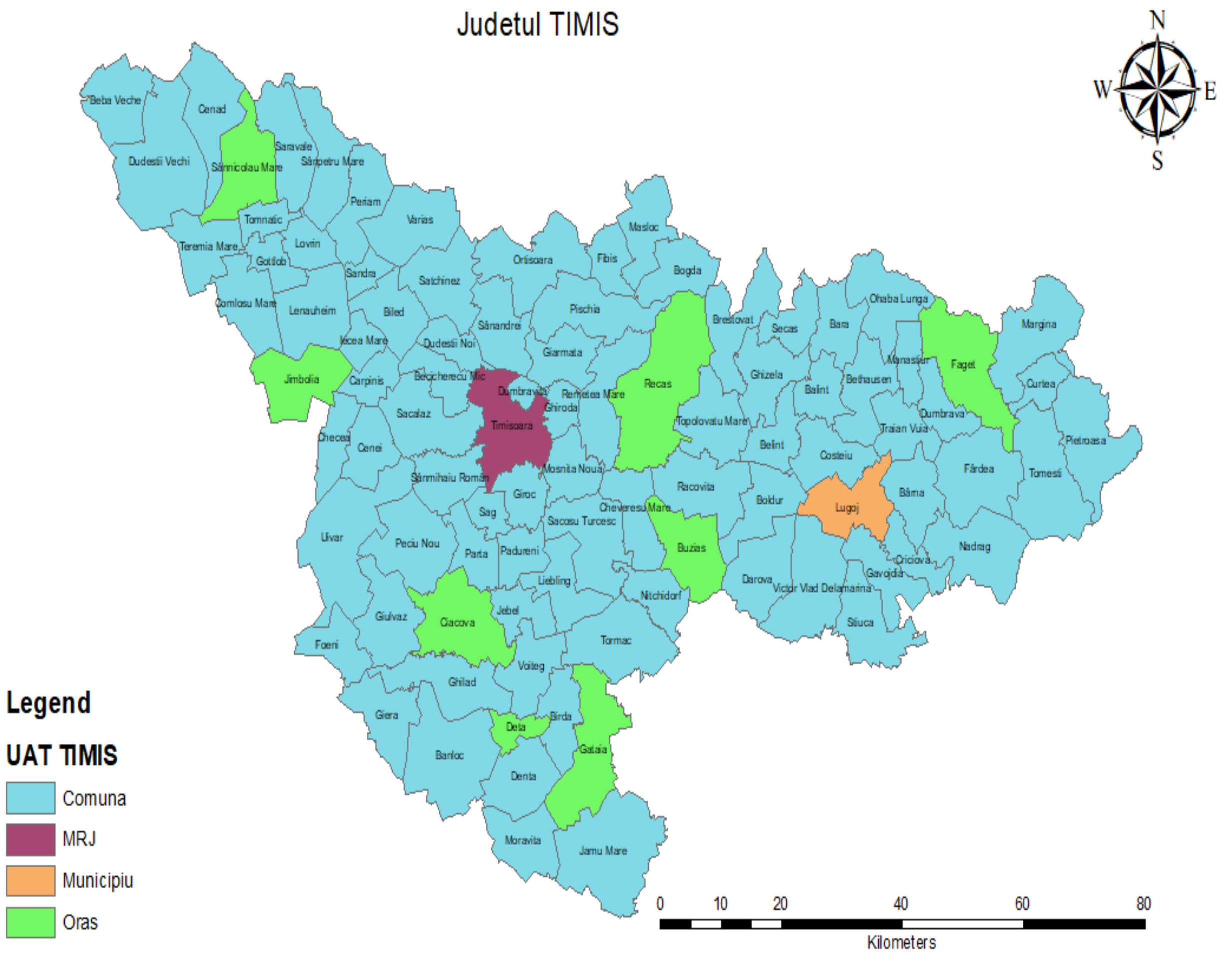


Fig. 2 Qualitative Thematic map

- ***Quantitative thematic maps***

Quantitative maps are drawn up to highlight the spatial distribution of tabular - numerical data. These maps represent the variation of a single variable (e.g. population, age, income, etc.). Quantitative maps are made by several methods: The area method (CHOROPLETH MAP) is used to represent the elements that have a continuous spread; Choropleth maps are the most commonly used method in thematic mapping of a geographic area; Point method (DOT MAP) - is used to represent elements that do not have a continuous spread; This method can restore a certain geographical distribution or the size of a phenomenon. This method is often combined with the proportional symbols method.

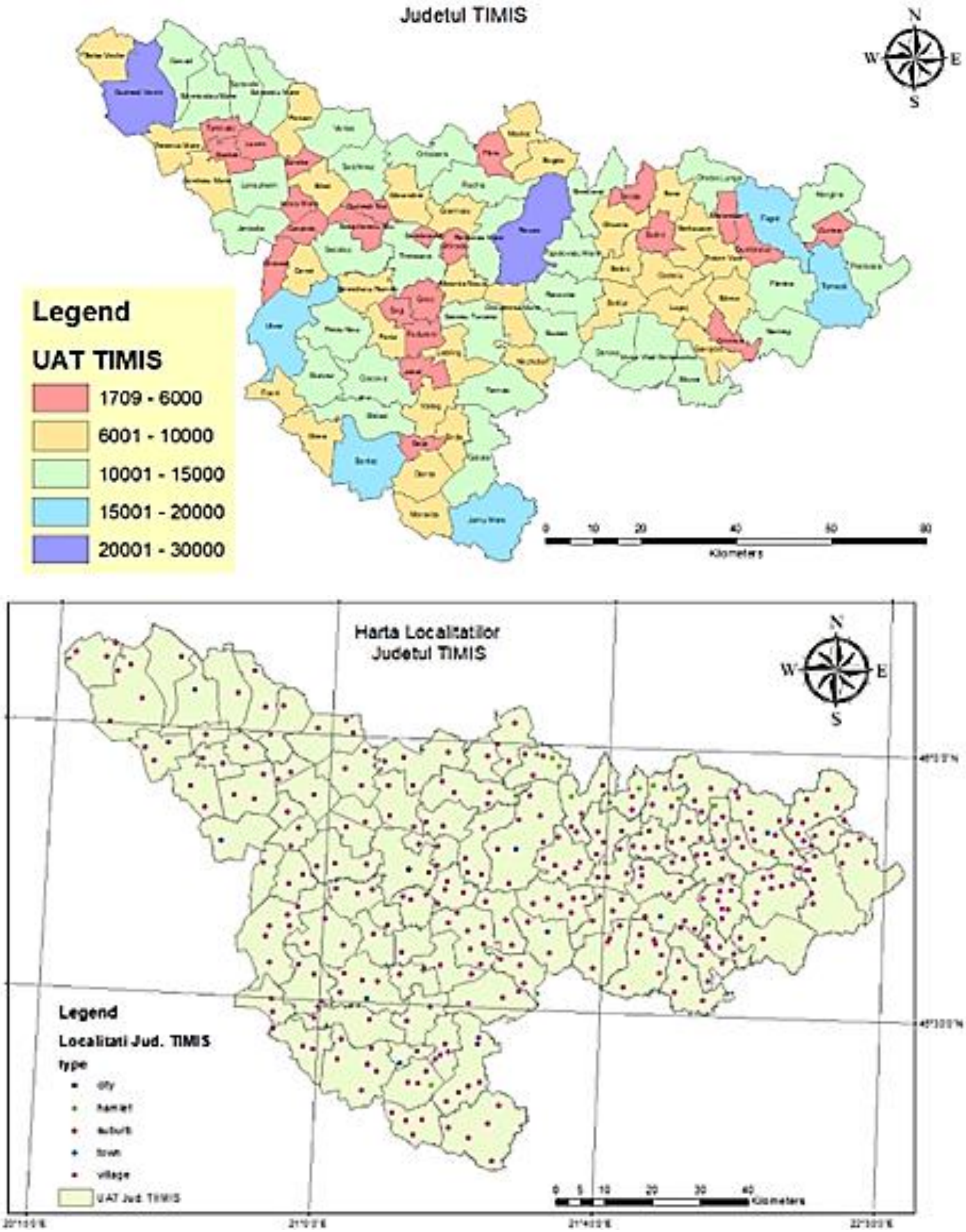


Fig. 3 Quantitative Thematic map

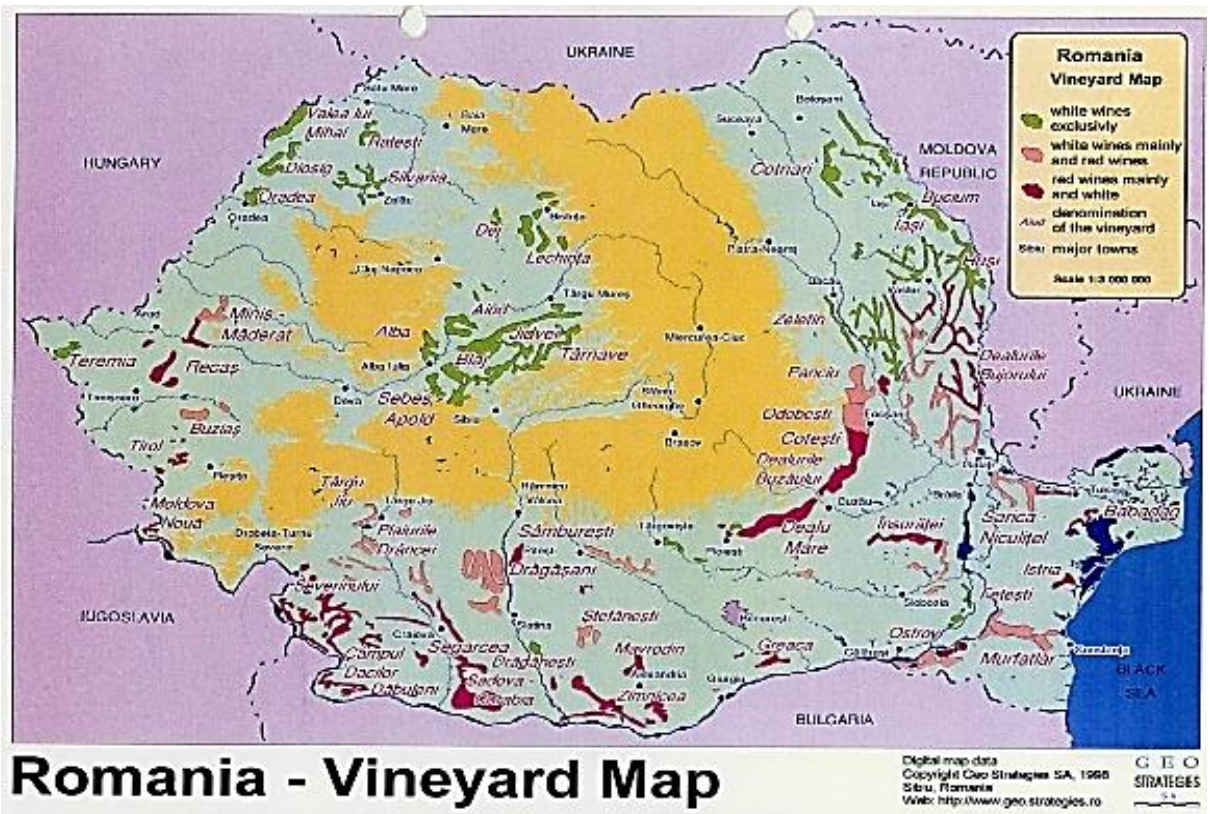
Dr. Aneta Anca Dragunescu: ROMANIA`S MAIN VITICULTURAL AREAS

Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" Timișoara.

The viticulturally Romania is divided into regions, and within each viticulturally region, the ecological factors exert different influences, giving rise to the areas called vineyards and viticulturally centres.

- The **wine region** is a habitat that has some peculiarities regarding the ecological conditions, the cultivated varieties, the applied technologies, the level of the yield obtained and the qualitative characteristics of the resulting viticultural products. Within each wine region, there is a different influence of ecological factors, giving rise to those areas called **vineyards** and **wine centres** being characterized as follows:
- The *vineyard* represents the natural and traditional viticultural unit, with relatively similar conditions regarding the ecological factors, the production directions, the cultivated varieties and the applied viticultural technologies, which together lead to obtaining quantitative and qualitative productions with similar characteristics.
- The *viticultural centre* - comprises a smaller viticultural area, included in a vineyard or outside it (independent viticultural centre), concentrated around a locality of economic and social importance.

In Romania, the specific ecoclimatic and ecopedological conditions determine great differences of the ripening periods of the grapes from one region to another. Thus, the same variety will reach maturity 4-5 weeks earlier in the South of the country, compared to the centre or North of the country.



Romanian –VINEYARD MAP-

Based on these differences in ecologic conditions, cultivated varieties, applied technologies or the productive level of grapes, the particularities from one wine region to another differ greatly.

The wine regions of Romania and their varieties:

- *Wine regions from the hills of Muntenia and Olteniea*
- *Wine regions from the hills of Banat*
- *Wine regions from the Transilvanian plateau*
- *Wine regions from the Crişana and Maramureş hills*
- *Wine regions from the Moldova hills*
- *Wine regions of Dobrogea*
- *Wine regions of the Danube* *Fig.1.*
- *Sandy wine regions favourable to the southern part of the country.*

Zoning was established as early as the 60`s to take advantage of the quality this region gives both in species and varieties.

Due to ecoclimatic and ecopedologic characteristics, our country is divided in 8 distinct wine producing regions, 37 vineyards and 171 wine centres.

A wine region is a habitat which contains certain ecological characteristics, where varieties flourish, and technology is used to take full advantage of the products being made.

In each wine region, certain ecological factors influence the final result, creating wineries and wine centres.

Regarding the total area of grape wines, it has oscillated from a peak of 300.400 ha in 1972, dropping to the current area of 180.000 ha in 2019.

The wine regions from the hills of Muntenia and Oltenia

This is the second highest area of the country, the average elevation of the wineries being 242 m. The climate is temperate continental, with East European continental influences. The heliothermal resources are high, contrasting the low hydrological ones. The major products of superior quality are the red, white and aromatic wines, while table wines represent a very small percentage (in Dragasani). A significant area is used to grow table grapes. In the major wine producing areas of Breaza and Pietroasa, exceptional conditions for wine producing exist, which include the local varieties that produce aromatic white and rose wines: Tămâioasă românească, Grasă de Cotnari, Busuioacă de Bohotin.

The assortment contains multiple varieties of superior white wines: Fetească albă, Fetească regală, Riesling italian, Sauvignon, Pinot gris and Muscat Ottonel, also varieties of superior red wines: Cabernet Sauvignon, Merlot, Pinot noir, Fetească neagră and Burgund mare. The Dragasani winery produces white and red table wines from the Crâmpoşie and Novac varieties. Dealurile Buzaului, Dealu Mare and Dragasani produce the varieties of: Victoria, Cardinal, Augusta, Chasselas doré, Afuz Ali, Muscat de Hamburg şi Muscat d'Adda. The Sortogroup Coarna, along with the new grape varieties, are obtained in the other research stations.

The wine region of the Banat Hills

Located in Southwest Romania, it meets, to a certain extent, the conditions of a single vineyard. Grape plantations have an insular character and are constituted in several wine-growing centres: Moldova Nouă, Tirol, Silagiu, Recaş and Teremia. The predominant soils in this region are terra rossa (calcareous soils), brown soils (on the slopes), brown-argilo-clay and regosols. Is specialized in the production of white and rosé table wines and, to a lesser extent, of high quality white and red wines. Representative varieties: Creaţă de Banat, Majarcă albă, Steinschiller, Riesling italian, Sauvignon, but also red wine varieties: Cadarcă, Burgund mare, Merlot and Pinot noir.

The wine region of the Transylvanian Plateau

It includes vineyards ranging from Apold (SB) to Bistrita-Nasaud and Dej. It is characterized by moderate heliothermal resources, rich water resources, and the average duration of the vegetation period is 173 days. All other temperatures and precipitation average values indicate the presence of a cool climate.

Ecoclimatic conditions make it possible to obtain high quality wine products due to long and sunny autumns. Superior quality white wines, aromatic wines and sparkling wines are produced.

It includes 5 vineyards (Tarnave, Alba Iulia, Sebes-Apold, Aiud, Lechint,) with 17 wine centres and 2 independent ones.

Varieties grown: Chardonnay, Feteasca alba, Feteasca regala, Riesling varietal, Sauvignon, Traminer roz, Pinot gris, Neuburger, Iordana, Pinot noir, Cabernet sauvignon, Feteasca neagra, Muscat Ottonel.

The wine regions of the Crişanei and Maramureşului Hills stretch from the Miniş wine center in the South, to the Halmeu centre (SM) in the North. It is characterized by a climate with high heliothermic values compared to Transylvania, but with the highest water resources compared to the other 7 regions. The plantations occupy grape varieties for top quality white wines, raw material for sparkling wine and a few for red wines. The region has 4 vineyards composed of 11 wine centres and 2 independent centres. Varieties grown: Feteasca regala, Furmint, Mustoasa de Maderat, Riesling varietal, Sauvignon, Traminer roz, Pinot gris, Cabernet Sauvignon, Cadarca, Feteasca neagra, Merlot, Pinot noir, Burgund mare, Muscat Ottonel, Tamâioasa româneasca.

In 1880 the Minis Viticulture is formed, followed by the Research and development station for viticulture and vinification, in 1957.

The wine region of the Moldova's Hills includes the plantations from Hlipiceni (BT) to Timboieşti (VN) and Smârdan (GL). Due to the large surface area, between the ecoclimate in the northern part of this wine region and the ecoclimate in the South, there are appreciable differences that are often reflected in the quantity and quality of the wine-making production obtained, as well as in the selection of varieties. The region has 12 vineyards with 44 wine centers and 8 independent ones. The most notable are: Odobeşti, Coteşti, Panciu, Cotnari, Nicoreşti and Huşi. This vast wine region is focused on the production of white and red table wines, superior white wines, sweet varieties (Cotnari) and of raw materials for sparkling wines (Panciu and Ivesti). The production of red wines is insular in nature and comprises the vineyards of Dealul Bujorului, Nicoreşti, Iveşti, Uricani and Iana. This region is known for a vast amount of varieties, including: Grasă de Cotnari, Fetească albă, Frâncuşă and Busuioacă de Bohotin (Cotnari); Zghihară de Huşi, Băbească neagră (Nicoreşti); Fetească neagră (Uricani). They succesfully grow: Aligoté, Fetească regală, Italian

Riesling, Sauvignon, Pinot gris, Galbenă de Odobeşti and Şarba, as for red wines: Cabernet Sauvignon, Merlot, Băbească neagră and Oporto.

The wine region of the Dobrogea

It includes the vineyards from Mangalia to Tulcea and Macin. It comprises 3 vineyards: Murfatlar, Istria-Babadag, Sarica-Niculiţel, 9 wine centres and 5 independent centers. The special quality of the wines obtained here is also due to the ecological factors. It is said that here are the richest heliothermic resources (with the highest annual averages), with beneficial effects on the maturing and making of the grapes, and the presence of the Black Sea makes the effective duration of sunshine to be the highest in the country. The wine region of Dobrogea consists of both wine making, but also wide scale cultivation of grapes for consumption. Grapes for consumption: Cardinal, Regina viilor, Chasselas doré, Muscat de Hamburg, Muscat d'Adda, Afuz Ali. Small areas are dedicated for grapes which will be turned into raisins. Wine region dedicated to the production of superior quality red and white wines: Aligoté, Italian Riesling, Fetească albă, Fetească regală, Sauvignon, Pinot gris, Chardonnay, Muscat Ottonel, Cabernet Sauvignon, Pinot noir, Merlot and Burgund mare.

The wine region of the Danube Terraces is located mostly on the Danube Terraces in the Southeast of the Romanian Plain. Vineyards: Ostrov and Greaca.

Climate is temperate continental, steppe and silvostepical, with insufficient precipitation and extreme thermal temperatures, temperatures that endanger the normal development of vegetation phenophases. The wine region has the largest heliothermal resources in the conditions of modest water resources, but improved by the beneficial presence of the Danube. It is specialised in growing table grapes. Varieties grown: Muscat Perla de Csaba, Cardinal, Victoria, Chasselas doré, Muscat de Hamburg, Muscat d'Adda, Italia, Afuz Ali, Tamina, Xenia and Greaca.

It has a modest production of white table wines. White wine varieties: Feteasca regală, Italian Riesling, Sauvignon, Selected Crâmpoşie, Donaris, and red wine varieties: Cabernet sauvignon, Merlot and Burgund mare.

The wine region of the sands and other favourable lands in the South of the country

- The vineyards and centres between Vraţa (MH) and Râmnicelu (BR).
- The ecopedological, ecoclimatic and orographic conditions of this region are less favourable to the vine due to summer and winter temperatures.
- There are: 3 vineyards with 8 wine centres and 11 independent ones.
- Cultivated varieties: Feteasca regala, Riesling varietal, Aligote, Cabernet Sauvignon, Feteasca neagra, Pandur.

Fig.2. Romanian viticulture in pictures

Assoc. Prof. Dr. Ciprian George Fora: Benefits of the shelterbelts in landscape and crop protection

Starting with almost a century ago the first effects of the increasing of the temperatures and limiting of precipitations quantities on spontaneous plants composition became obvious. The first alarm signals were sounded at that time as a result of scientific research and observations. Nowadays the phenomenon is much more pronounced and is estimated that the impact on Earth life will be major in next decades. In such conditions installing of the protective shelterbelts in agricultural lands can be a part of the solution to limit the impact of climate change on the environment conditions and to ensure better crops protection.

Scientific definition of the protective shelterbelts in Romania: Climate protection shelterbelts (figure 1), are strips of forest made up of trees or trees and shrubs, which are arranged on cultivated land or near certain objectives (roads, railways, farms), in order to protect them from the wind (Ciortuz & Păcurar, 2004).

Legal definition: Protective shelterbelts are formations with forest vegetation, located at a certain distance from each other or from an objective, in order to protect it against harmful factors and/or for the climatic, economic and aesthetic-sanitary improvement of the lands (Low no. 289/2002, art. 1; Low no. 46/2008, Appendix 1, point 28).

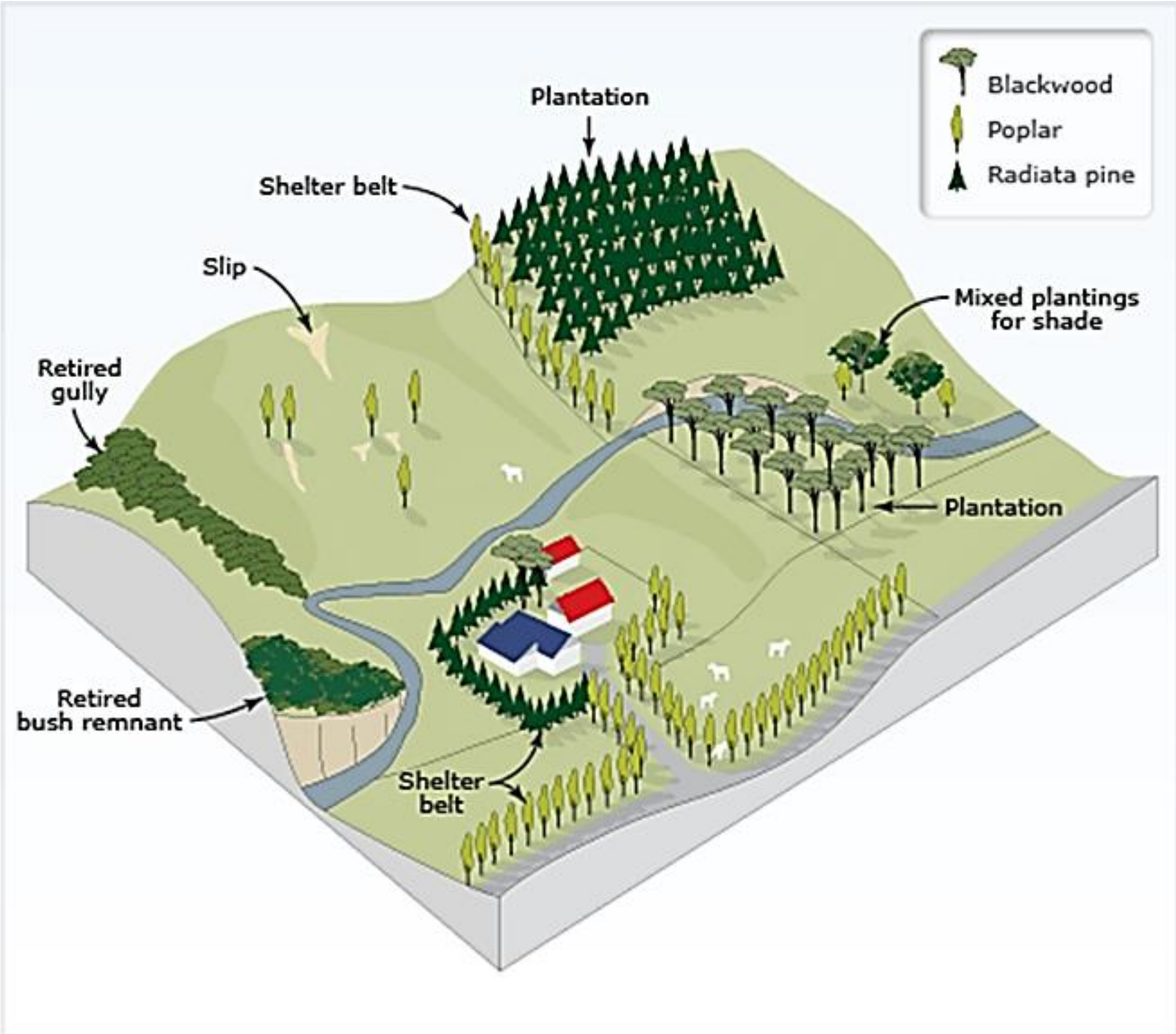


Fig. 1. Shelter belts and territory organization
(Source: https://teara.govt.nz/)

Supplementary legal definitions: Shelterbelts are formations with forest vegetation covering a minimum of 0.1 ha, located at a certain distance from each other or from a target, in order to protect it from the effects of harmful factors and/or for climate, economic and aesthetic-sanitary land. Forest corridors also fall into the category of protective belts (OMARD no. 198/19.08.2021, Appendix); The forest corridors are made up of plantations of forest trees and shrubs, which connect forests or networks of shelterbelts, located at distances of up to 10 km from each other (Low no. 289/2002, art. 5, paragraph 2).

Territory organization – scientific definitions: The organization of the territory represents a complex of economic-organizational, technical-topographical and legal measures adopted in order to use rationally the entire land fund of the country as a means of production (Timariu, 2004); The organization of the territory within the agricultural holdings (figure 1), includes the set of measures that are expected within the agricultural units according to the natural and socio-economic conditions for the organization of the territory of each category of use, sizing and efficient location of investments in the territory, of the use with maximum efficiency of the hydro-ameliorative arrangements and of the mechanized means (Bold et al., 2003).

Topical concept of shelterbelts known IV phases in Romania (Vasilescu, 2004; Catrina 2007): Phase I (1860-1937). The stage of orientation and exposure of forest crop problems in semi-arid areas. Approx. 1000 ha shelterbelts; Phase II (1937-1961). The stage of making shelterbelts on a scientific basis. Approx. 18.000 ha shelterbelts (14.000 km length); Phase III (1961-1989). The stage of stopping the research and deforestation of the existing shelterbelts. Approx. 3.000 ha shelterbelts; Phase IV (after 1989). The stage of reanalysing the issue. Design the necessity of 300.000 ha of shelterbelts.

Classification of shelterbelts by objective to be protected:

- shelterbelts to protect agricultural land from harmful climatic factors and to improve climatic conditions in the protected area;
- anti-erosion shelterbelts to protect soils against erosion;
- shelterbelts for the protection of roads and transport, especially against snow;
- shelterbelts for the protection of dams and banks against water currents and floods;
- shelterbelts for the protection of localities and various economic and social objectives.

Classification of shelterbelts by the location in relation to the direction of injury:

- main shelterbelts placed perpendicular to the direction of action of the predominant harmful factor or to the resultant of the dominant harmful factors;
- secondary shelterbelts, located perpendicular to the main ones and completing the network of belts in a given territory.

Classification of shelterbelts by consistency or density:

- impenetrable or compact shelterbelts (communication routes);
- semi-penetrating shelterbelts (intended for field protection);
- penetrable shelterbelts, through which the wind penetrates easily.

Species selected for the establishment of shelterbelts for Romanian climatic and soil conditions:

- Trees species: *Quercus robur*, *Quercus pubescens*, *Quercus pedunculiflora*, *Quercus cerris*, *Juglans regia*, *Ulmus pumila*, *Tilia tomentosa*, *Tilia cordata*, *Tilia platyphyllos*, *Robinia pseudoacacia*, *Gleditsia triacanthos*, *Acer platanoides*, *Acer pseudoplatanus*, *Acer tataricum*, *Acer campestre*, *Pinus nigra*, *Prunus mahaleb*, *Eleagnus angustifolia*, *Malus sylvestris*, *Rhus typhina*, *Maclura pomifera*.
- Shrubs species: *Tamarix ramosissima*, *Crataegus monogyna*, *Cornus sanguinea*, *Cotynus coggygria*, *Syringa vulgaris*, *Sambucus nigra*.

Where shelterbelts are needed? Establishment criteria: Regions with insufficient or unevenly distributed rainfall; Regions with a dry climate (pedological and atmospheric drought); Regions subject to periodic drought affecting vegetation and crops.

Situation of shelterbelts at national level. Emergency areas for the installation of shelterbelts (figure 2) are: Emergency I (steppe areas); Emergency II (forest-steppe areas); Emergency III (extended forest-steppe areas).

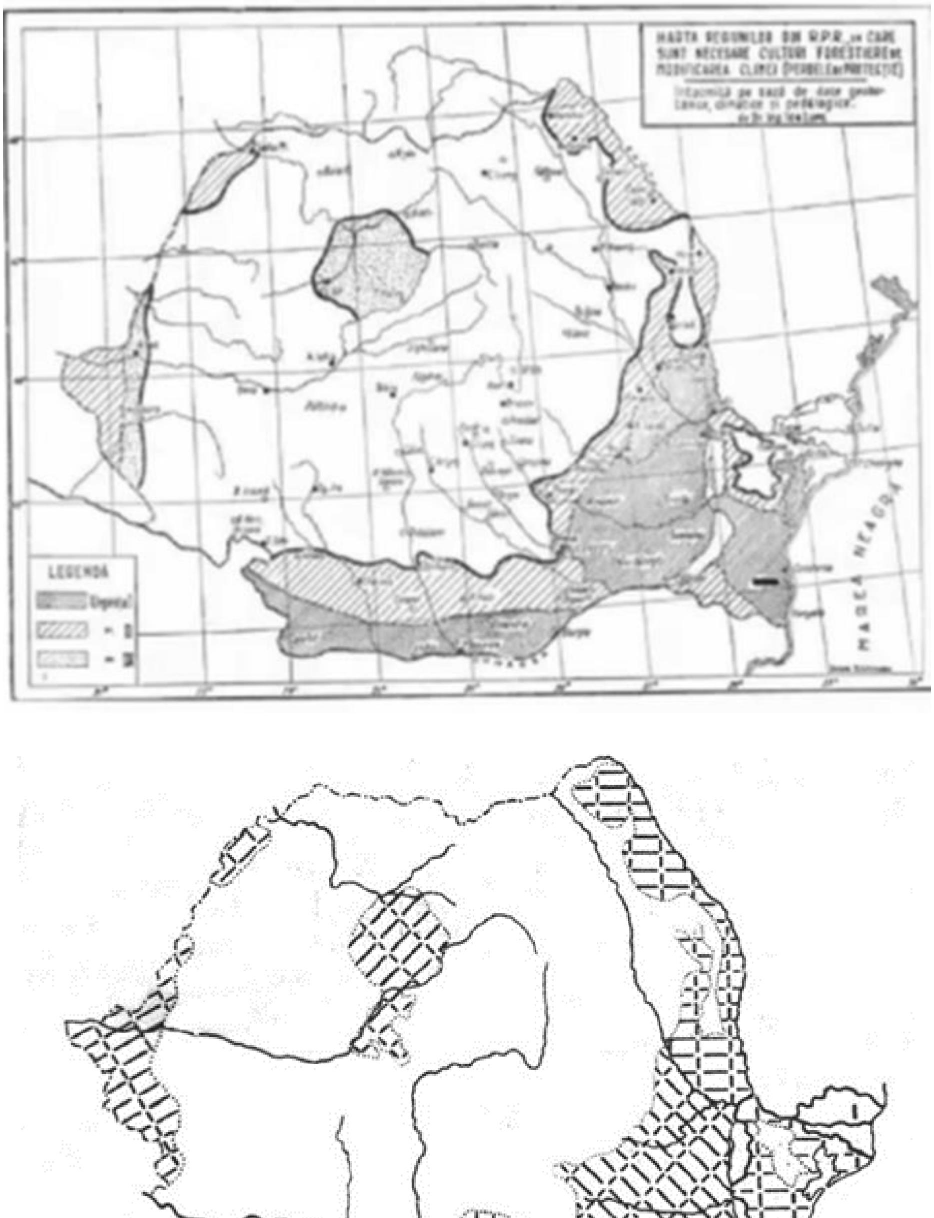


Fig. 2. Romania`s shelterbelts emergency regions

(Source: Lupe, 1952)

Situation of shelterbelts at national level show that at 7.5 million ha of arable land 300.000 ha of shelterbelts are needed, half of them in emergency I (Neșu, 1999).

The benefits of shelterbelts are listed below:

- there has been an improvement in the conditions of growth and development of agricultural crops up to a distance of 20-30 h after the forest belt and 5-12 h before it;
- the change in solar radiation in the immediate vicinity of the belts over a distance of 1-2 h was found;
- the diurnal amplitudes of the air temperature were observed to decrease by 1-4°c and by 1-2°c of the annual temperature;
- it was found that the wind speed was reduced by 31-55% in the sheltered part and by 10-15% in the exposed part;
- it was found a retention of snow on a distance of 25-30 h and the one carried by the wind from the open lands at a distance of 6-10 h;
- evaporation has been reduced by up to 30%;
- it was found that the humidity of the air at the surface of the crops increased with 3-5%;
- there has been a reduction in water runoff on the slope and erosion caused by this phenomenon;
- a reduction to deflation on sandy or light sandy soils has been found to stop;
- weeding was found to be lower;
- it has been found that bees are favoured;
- there has been an improvement in yields;
- there has been an increase in wildlife;
- it has been found that they can be sources of wood, edible fruit;
- there has been a reduction in animal pests, especially harmful insects and an increase in the number of insectivorous birds nesting in these protective forest belts.

Effectiveness of shelterbelts on agricultural crops: Increase in average production per hectare of wheat, barley, oats, corn, sunflower between 17.1% and 19.7% (Vasilescu, 2014); Increase in average production per hectare of wheat by 23%, barley by 23%, oats by 6%, rye by 19%, spring wheat by 8%, corn by 12%, hay by 20% (Kort, 1988); 39.2% increase in average production per hectare of sunflower (Mozheiko & Semyakin, 1985).

In Romania, the optimum land organisation has been expressed by Timariu, 2004 as follow: the optimal size of a farm with arable land is between 300 ha and 500 ha in the hill area, respectively between 1500 ha and 2000 ha in the plains (1000-4000 ha); The optimal size of a parcel on the farm is between 75 ha and 100 ha (1500 m x 500 m or 2000 m x 500 m).

National system of shelterbelts is regulated by low 289/2002, especially at Art.4.(2) According to this law, the construction of the national system of protective forest belts is declared of public utility; and at Art.7(3) The execution of protective forest belts is made on the basis of technical-economic studies that must include: a) technical elements necessary for the installation of protective forest belts: orientation, width and distance between protective forest belts, planting schemes, species indicated for afforestation. In the ministry order 636/2002, underline that “if the ground is flat or with a slope of up to 2% on loamy soils or up to 5% on sandy soils - the main forest belts are placed perpendicular to the direction of the prevailing wind” and “if the terrain is strongly undulating - the main forest belts are placed with priority on the level curves”.

An important element in the projection of the shelterbelts are the distances expressed in figure 3.

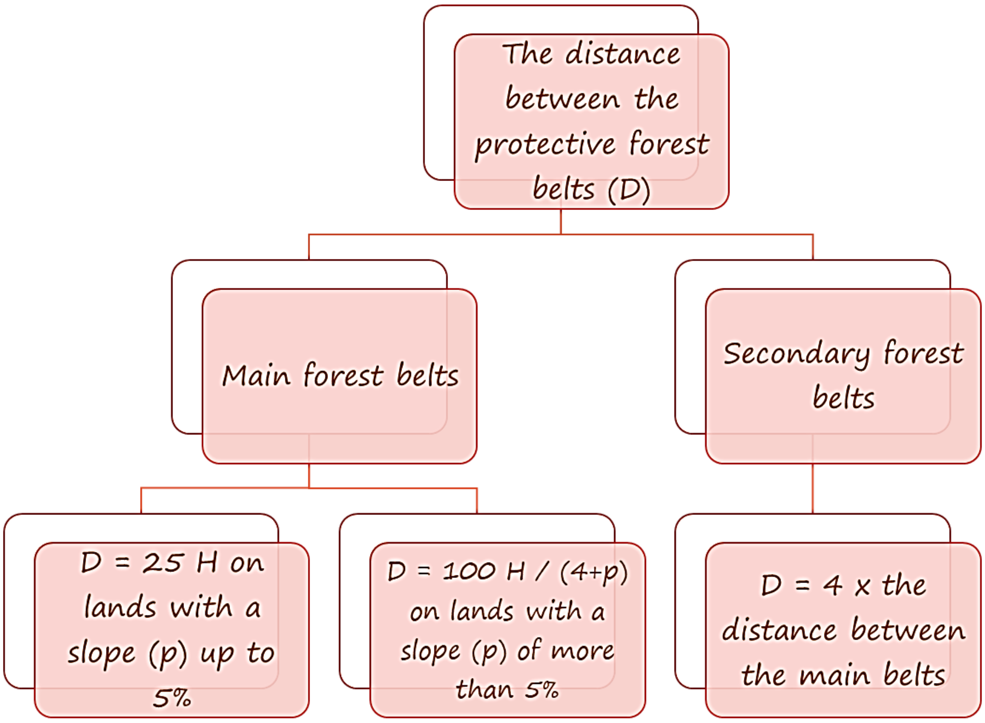


Fig. 3. Shelterbelt`s distances matrix calculation in Romania

Few characteristics can be found in the same ministry order 636/2002: in order to ensure the passage between the cultivation units of the machines, at the intersection of the forest belts in a network, openings with a width of 30 m are arranged in a zig-zag pattern, and along the main forest belts, openings of 500 to 500 m are left. 6-7 m arranged obliquely. The following scheme will be used for the establishment of the protective forest belts of the field: 500 m x 1000 m, respectively 500 m between the main forest belts and 1000 m between the secondary forest belts, thus creating modules with an area of 50 ha. The width of the main shelterbelts in areas with strong winds is 10.5 m. The width of the secondary shelterbelts in areas with strong winds is 7.5 m. The width of the main shelterbelts in areas with moderate winds is 7.5 m. The width of the secondary shelterbelts in areas with moderate winds is 4.5 m.

The close link between the design of shelterbelts and the organization of the territory is important for the success of shelterbelts installation and take in the consideration the relief on which the surface of the land to be planted is located, soil size and shape, existing soil type, the existing network of roads and drainage channels, the type of irrigation network, electricity and communication network, other obstacles (photovoltaic panel fields, oil wells, wind farms), existing protective forest belts including pre-existing shrub vegetation.

Difficulties in implementing the concept of shelterbelts in Romania came from below aspects: property structure, acceptance of farmers (allocation of 4-5% of arable land for the establishment of protective forest belts), low knowledge of funding and grant opportunities, insufficient funds needed to support projects by farmers, protective forest belts require long-term care work by qualified personnel, the competitive market that imposes a certain yield on vegetable farms. With all of that in last two decades some farmer starts to pay attention to the benefits of the shelterbelts especially in the areas where the irrigation system does not exist or the founds for that are limited (figure 4).

Fig. 4. Example of shelterbelt in Constanta area, East Romania

(Source: https://agrointel.ro/)

Taking in the consideration the aspects presented before can be formulated few conclusions and recommendations.

Conclusions.

- At least 3% of Romania's arable land requires shelterbelts;
- About 1.5% of the country's arable land must be planted immediately;
- There is specific legislation;
- There are technical rules for setting up and caring for protective forest belts;
- There are possibilities to co-finance projects from European and national funds (AFIR, Environmental Fund);
- There is a possibility that after the establishment, farmers will be subsidized for the loss of agricultural land in favour of shelterbelts (APIA).

Recommendations.

- Promoting the concept and benefits of shelterbelts;
- Awareness of the population and owners of agricultural land on the beneficial effects of shelterbelts;
- Guide farmers so that they can access existing funds;
- Subsidized interest financial support for investment projects in shelterbelts;
- Accelerate the preparation of the national shelterbelts’ afforestation plan and its implementation with priority.

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13. *** OMADR no. 198/2021

Assoc. Prof. Dr. Daniel Popa: Soil Working Technologies in a Conservative System Applied in the Conditions of Western Romania, BUAS Timisoara

Conservation agriculture (CA) includes a number of complementary agricultural practices:

• Minimal soil disturbance;

• Permanent soil coverage;

• Crop rotations and associations.

The main factor that determined the emergence and development of the new system was the degradation and excessive erosion of the soils, as an effect of conventional, intensive agriculture.

The development of various options has been accelerated by the oil crisis of the 1970s and high fuel prices, with increasing research proving that in many cases yields close to those obtained in conventional agriculture can be obtained.

The new tillage systems were referred to as "optimal systems", "streamlined systems", "unconventional systems", "alternative systems", "soil conservation works systems", etc.

IMPLEMENTATION OF CONSERVATION AGRICULTURE (CA)

First phase:

- the inversion of the soil layers is stopped;
- at least one third of the soil surface must remain covered with crop residues;
- for tillage, disc harrows, rotary harrows, no furrow overturning plows (paraplow), chisels or direct seeders are used;
- at this phase, productivity may decrease.

The second phase:

- the condition and fertility of the soil improve naturally;
- weeds and pests tend to multiply, and this should be controlled chemically or by other means.

The third phase:

- diversification of the cultivation method can be introduced (crop rotation);
- the general system gradually stabilizes
- The fourth stage
- the agricultural system is balanced and productivity can be improved compared to traditional agriculture;
- this process reduces the need to use chemicals to control weeds and pests or to increase fertility.

BENEFITS OF CONSERVATIVE AGRICULTURE

- Improving organic carbon stock, biological activity, above-ground and underground biodiversity and soil structure;
- Soil degradation - especially soil erosion and runoff - is greatly reduced, often leading to increased productivity.
- Water quality improvement
- Decreased carbon dioxide (CO_2) emissions

DISADVANTAGES OF CONSERVATIVE AGRICULTURE

- It normally takes a transition period of 5-7 years for the conservative farming system to balance. Productivity may be lower in the early years.
- If seasonal factors are not taken into account, improper application of chemicals can increase the risk of leaks due to faster movement of water through biopores.
- If crop rotation, soil cover and crop selection are not adjusted to optimal levels, larger amounts of chemicals may be needed to control pests and weeds.
- Nitrogen oxide (N_2O) emissions increase during the transition period.

- Farmers must make an initial investment in specialized equipment and must have access to seeds for cover crops, adapted to local conditions, at reasonable costs..
- Farmers need extensive training and access to specialized counseling services. Compared to traditional agriculture, a fundamental change of the approach is needed

EXAMPLES OF SUCCESS

In Europe, direct sowing of stubble takes place in about one tenth of the agricultural area in Finland and Greece, and up to five percent in the Czech Republic, Slovakia, Spain and the United Kingdom.

Almost a quarter of the utilized agricultural area of Finland and the United Kingdom and almost a quarter of the utilized agricultural area of Portugal, Germany and France are using a reduced tillage system.

DIRECT SOWING TECHNOLOGY APPLIED WITHIN THE PRINCIPLE OF CONSERVATIVE AGRICULTURE

The “no tillage” system or direct sowing (“zero tillage”) involves sowing in a previously unprepared soil, in which a narrow gutter or a channel opens, where a sufficient depth and width are needed in order to achieve a good seed coverage.

A direct drill machinery should minimally loosen and mix the soil, and place the seed in the soil, so that it has optimal germination and growth conditions. The design of the working parts of these machines must allow the work to be carried out under the conditions imposed on both dry and wet soils, in the presence of a large amount of plant debris.

ADVANTAGES OF NO TILLAGE TECHNOLOGY

- significantly decreasing the erosion risk and increasing the water supply in the soil;

- improving the movement of water and air in the soil;
- increasing the water supply in the soil;
- increasing the amount of organic matter from the soil surface;
- stimulation of biological activity;
- reduction of soil temperature, and especially large temperature variations in the first 10 cm, during the hot periods of the year;
- reducing the risk of anthropogenic compaction;
- improving the characteristics of workability and trafficability during the sowing and harvesting period;
- long-term increase in soil fertility by at least one class;
- reducing fuel consumption (by 40 to 50%);
- reduction of working hours and labour requirements by up to 60%;
- less complex system of agricultural machines
- DISADVANTAGES OF NO TILLAGE TECHNOLOGY
- requires fairly large investments
- herbicide dependent;
- some weeds are very difficult to control;
- disease and pest control is difficult;
- the quantities of pesticides used are higher compared to the conventional system;
- mineral and organic fertilisers are difficult to use;
- it is not efficient enough for some rotations;
- it is beneficial only if the soil is covered with plant debris during the vegetation period;
- it is suitable for soils with coarse and medium texture, loose and well drained;
- the farmer must have specialized knowledge;

VIII. Integrated Crop Management and Digitalization; Digitalization of Agriculture: Rationality and Risks

Johannes Munz, Prof. Dr. Heinrich Schuele: Profitability of smart farming technologies - Identification of economic success factors in small-scale agricultural regions

Digitalization of agriculture shows positive effects on farm profitability but is also considered to be of great importance when it comes to the efficient use of limited resources and countering global problems (e.g. climate change, food security). However, since the introduction of the first precision farming technologies around 1990, high adoption rates could not be observed, especially in areas where small-scale farming is dominant. Until today, farms successfully applying smart farming technologies are mainly larger operations. Therefore, this paper is dedicated to analyse economic success factors, which favour the use of digital technologies in small-scale agricultural areas, but also to highlight the limitations of digitalization in these structures.

For this research, a calculation model has been developed, that enables a holistic view of the farm. Using empirical farm data and with the help of sensitivity analysis, the economic effect of implementing 27 different digital farming technologies is presented. The results show that very small farms (< 20 ha) are at a disadvantage with capital-intensive technologies. Furthermore, it can be shown that the success of implementing digital technologies is largely dependent on external factors (e.g. weather, soil), and is determined by initial conditions (e.g. technologies available on the farm). In summary, it can be stated that farmers in small-structured areas are by no means excluded from digitalization. For very small farms, the joint use of machines or the development of low-cost technologies can be seen as a solution.

Keywords: Smart Farming Technologies, Economics, Small-Scale Agriculture, Case Study, Sensitivity Analysis

Introduction

In view of global challenges such as climate change, soil sealing and population growth, a safe and environmentally compatible food production is becoming increasingly important [1]. Adaptation strategies of conventional systems lack a holistic perspective [2,3]. One approach to achieving higher levels of productivity can therefore be seen in technological innovations [4]. Site-specific management of fields, for example, can increase productivity and minimize environmental risks (e.g. nitrate leaching) [5]. Similarly, autonomous machines can be used to address a labour shortage and provide targeted weed control without polluting the environment with herbicides [6].

Due to the high investment costs, almost only large farms have been able to use digital technologies so far [7,8]. Among farmers in small-structured agricultural regions, the opinion prevails that digital technologies cannot be used profitably [9–11]. However, large parts of Europe and Germany in particular are characterized by small-scale structures [12]. The state of Baden-Wuerttemberg was therefore selected as a model region to study the impact of digital technologies on farm profitability. The average farm size of 36,5 hectares and the high proportion of part-time farmers (65 %) are seen here as a particular challenge that needs to be addressed [13,14].

The economic impact of individual technologies in selected crops has been sufficiently investigated in previous studies [15–17]. However, investments in digital technologies are decisions that affect the entire farm. The demands placed on existing mechanization by digital technologies and the impact on overall farm profit of small farms have not yet been studied.

The aim of this paper is therefore (i) to identify factors that determine the economic success of a technology at the farm level, (ii) to show the limits of the profitability of different digital technologies through a sensitivity analysis of the results of the farms studied, (iii) and to identify opportunities for small farms to also participate in the digital transformation of agriculture.

Methods

Study area and data collection

For the calculation of the results, farm data were collected from eight farms (B1-B8, farm sizes between 11 ha and 530 ha) within the state of Baden-Wuerttemberg in spring 2021 (Figure 1). For comparison, an average arable farm in Baden-Wuerttemberg (B0) was used, which is 65 ha in size. The selection of farms reflects the conditions in the federal state very well. With this sample, very small farms (< 20 ha) can be studied on the one hand, but also farms that are large by Baden-Wuerttemberg standards (> 150 ha).

The farms surveyed vary greatly in the design of their crop rotation. As a rule, a crop rotation with cereals, corn and another field crop predominates. Farm B1 (11 ha) is run as a sideline. Farms B2, B3 and B6 are mixed farms with livestock. Here, silage corn is grown instead of grain corn. In general, only the cultivation of arable land is considered. Other work related to animal husbandry is not included in the model calculation (e.g. harvesting of straw).

Work that occurs once a year on a small scale (e.g. harvesting) is usually performed by contractors. When implementing a digital technology on a farm in the model calculation (e.g. site-specific planting), the service is replaced by self-mechanization.

During the data collection, the status of the existing mechanization on the farms was surveyed. The retrofittability of the machines depends on their age (e.g. missing functions, compatibility problems, etc.). Farms B1-B3 and B5 cannot use retrofit kits in most cases due to their outdated technology. The remaining farms can partially retrofit. Some farms are already using some digital technologies (B4, B6-B8).

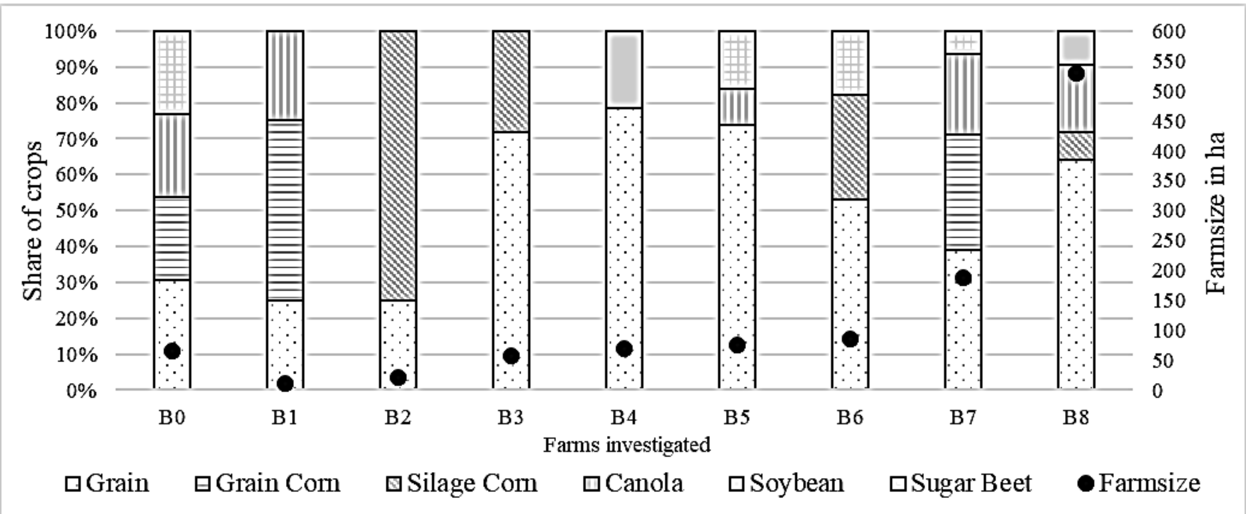


Figure 1: Investigated farms B0-B8 with shares of crops and farm size

2.2 Database and technology selection

A total of 27 technologies (T) were included in the database. For a clearer presentation, the variants of a technology were each combined into a technology group (TG). Technologies T1-T5 were combined to form the technology group TG 1 *"Automatic guidance Technologies"*, technologies T6-T9 form TG2 *"Mechanical Weeding Technologies"*, technologies T10-T13 are combined to form TG3 *"Section Control Technologies"*, T14-T17 to TG4 *"Site-Specific Soil Cultivation Technologies"*, T18-T19 to TG5 *"Site-Specific Sowing/Planting"*, T20-T24 to TG6 *"Site-Specific Fertilizing"*, T25-T26 to TG7 *"Site-Specific Spraying"* and T27 forms an independent group TG8 *"Site-Specific Manure Application"*.

Requirements for the existing mechanization were defined for each technology variant (e.g. additionally required GPS steering system, Farm Management Information Systems).

The impact of technologies on the items of the cost-benefit calculation (change in yields, price, direct costs, and impact on variable and fixed costs) was evaluated on the basis of manufacturer data and literature values.

A decision algorithm is integrated in the calculation model that takes into account the requirements of the existing technology on the part of the digital technologies (e.g. the addition of an application map for offline approaches or the retrofitting of ISOBUS devices) and differentiates whether a retrofit solution is sufficient or a replacement investment must be made.

As far as possible, the purchase prices were differentiated into three classes. In this way, the different demand for machine sizes can be adapted to the respective farm size and an under- or overestimation of the investment costs can be avoided (Class 1: < 20 ha; Class 2: 20-70 ha; Class 3: > 70 ha). This classification is based on the farm size structure in Baden-Wuerttemberg, with Class 1 primarily representing part-time farmers, Class 2 containing the farm sizes most commonly found in Baden-Wuerttemberg and Class 3 reflecting the larger farms by Baden-Wuerttemberg standards.

2.3 Economic modelling of a farm

The calculation is based on the cost-benefit calculation (1), where the direct-, variable operating- and fixed operating-costs per crop are subtracted from the revenue of each crop on the farm to obtain the profit per crop and year. The profit of each crop is then added to the total profit of the farm. Direct costs (DC)

include input materials such as seed, fertiliser and crop protection products. Variable operating costs (VC) include the variable costs of machine use and costs of services. Fixed operating costs (FC) include the fixed costs of machinery use (depreciation) and labour costs for family labour.

$$(1)\ P = R - DC - VC - FC$$

On the output side, digital technologies can increase the yield or the product price (e.g. through improvements of protein content) [8,18]. On the direct cost side, technologically induced reductions in input quantities can lead to savings [19,20]. The price of inputs is not changed by digital technologies. A change in the variable operating costs per hour can be caused by the changed cost structure of digital technologies or the self-mechanization of work steps that were previously performed as a service. Digital technologies can also lead to savings in working time or to additional steps (e.g. calibration of sensors) and thus to a change in working time overall [21]. Fixed operating costs can be affected by the purchase of new machines (change in depreciation), when working time gets affected by the use of digital technologies (change in labour costs, family worker) or other fixed costs arise (application map, learning costs/year etc.) [8].

2.4 Comparison and evaluation of technologies at the whole farm level

The calculation and selection of technologies is based on the assumption that the farmer makes the decision to implement a technology as soon as the additional benefits exceed the additional costs. For this purpose, the profit is first calculated for the status quo at farm level (P_{SQ}) and then compared to the profit with the inclusion of the implemented digital technology (P_{DTx}).

The change in profit (PC) shows how profit develops at the overall farm level when a digital technology is added (2). This comparison can be made with all technologies or combinations of technologies.

$$(2)\ PC = P_{DTx} - P_{SQ}$$

From an economic point of view, investments should be made if condition (3) is met.

$$(3)\ P_{SQ} \leq P_{DTx}\ or\ PC \geq 0\ €\ ha^{-1}a^{-1}$$

2.5 Sensitivity Analysis – Marginal farm size

To show the limits of profitability of a technology, the marginal farm size can be calculated. For the calculation, the condition shown in (3) applies, i.e. implementation is assumed as soon as the additional annual costs equal the additional annual benefits.

Results

The effects on the items of the cost-benefit calculation are shown in Figure 2 and Figure 3. All changes are presented in the unit € $ha^{-1}a^{-1}$ and indicate the change compared to the status quo (whole farm level). The farms B0-B8 are sorted according to their size per technology group (starting with the smallest farm size B1). Gaps indicate that the corresponding farm already uses the technology (TG1_B8) or cannot use it (TG8 for arable farms without animal husbandry). All items on the positive side are summed up to the additional benefit. Accordingly, the additional costs that arise with the implementation are on the negative side.

Through the formation of technology groups and the presentation of the overall farm differences in technologies within a group and between crops are no longer visible. Therefore, it cannot be excluded that individual variants within a technology group can be used economically on a farm or that the use in some crops would make sense.

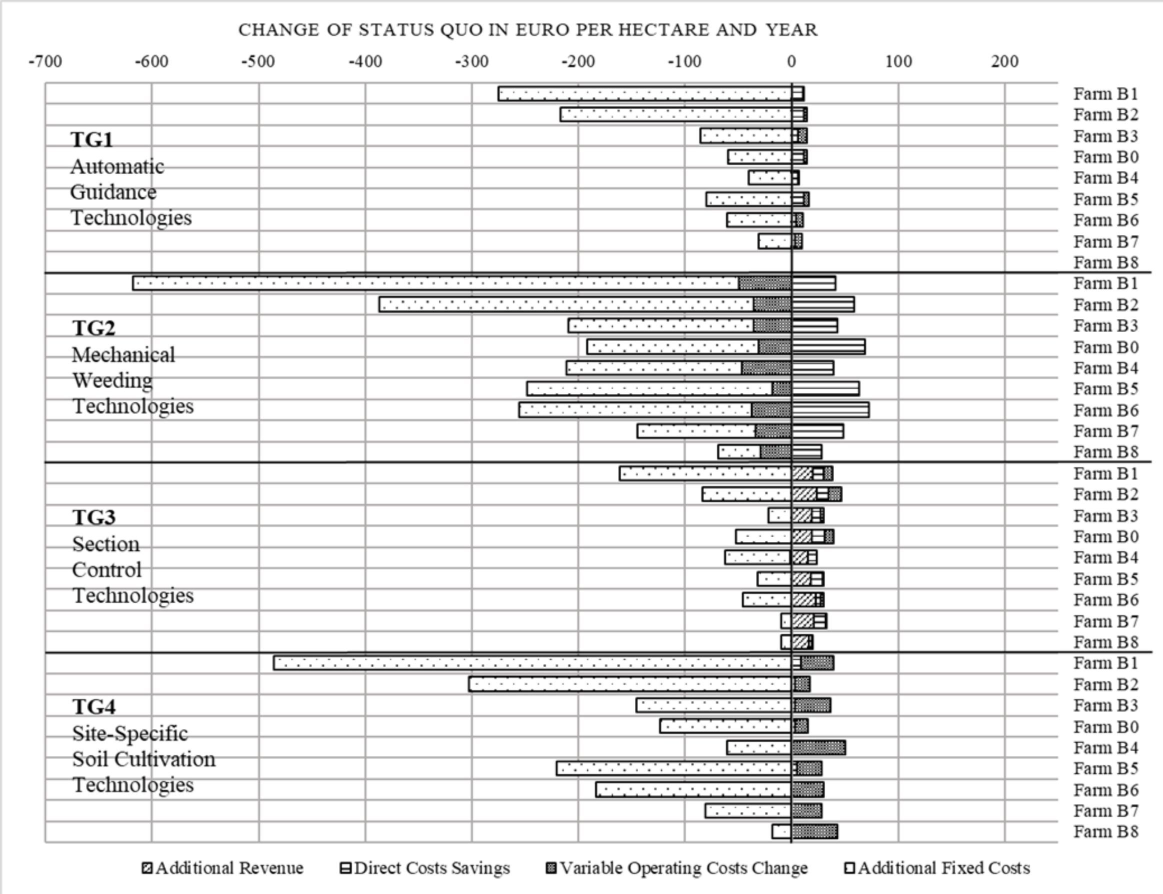


Figure 2: Technology groups 1-4 with their impact on revenue, direct costs, variable operating costs and fixed costs of farms B0-B8, each technology group is sorted by farm size. Additional costs are added on the negative side, additional benefits correspondingly on the positive side.

The technology groups shown in Figure 2 are characterized by a low level of additional benefits. On the revenue side, TG1, TG2 and TG4 cannot contribute to the additional benefit. Minor improvements (up to 50 € $ha^{-1}a^{-1}$ on B8, TG4) can be achieved on the variable cost side, especially for labour-intensive operations (TG4 - tillage) and the use of automatic guidance systems. The savings in direct costs from the use of automated steering systems are insignificant. The comparatively high savings in direct costs for TG2 (up to 72 € $ha^{-1}a^{-1}$ on B6) result from the substitution of herbicides by mechanical weed control. The greatest savings can be achieved here the more intensively a farm uses herbicides. The low economic impact of the section control technologies is caused by the comparatively low investment costs and the small influence on direct costs. The average arable farm B0 is not characterized by unusually high changes in additional benefits and costs when comparing to farms B1-B8. The desired profitability constraint (3) is only met by B3, B7 and B8 in TG3, and by B8 in TG 4.

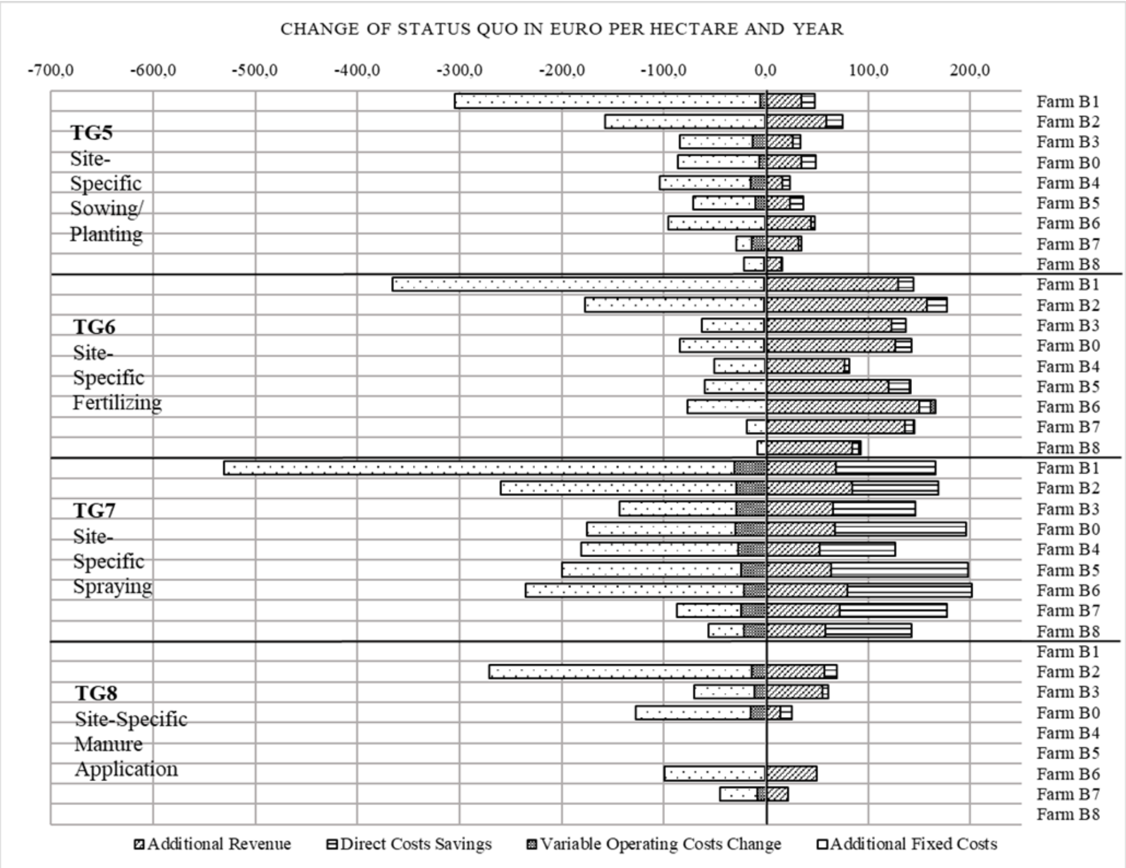
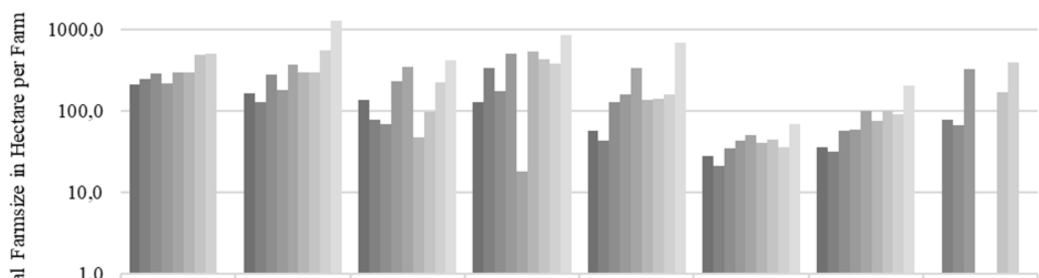


Figure 3: Technology groups 5-8 with their impact on revenue, direct costs, variable operating costs and fixed costs of farms B0-B8, each technology group is sorted by farm size. Additional costs are added on the negative side, additional benefits correspondingly on the positive side.

All technology groups shown in Figure 3 are able to positively influence the revenue side. Technology group 6 *"Site-Specific Fertilizing"* stands out in particular. Here, an increase in revenue of up to 177 € $ha^{-1}a^{-1}$ (B2) can be achieved. The amount is linked to the previous yield expectation and the intensity of management. Farms with a high yield expectation and a high production intensity also tend to achieve higher yield increases or quality improvements. The direct cost position is most strongly influenced by technology group 7. Savings of up to 134 € $ha^{-1}a^{-1}$ (B5) are caused by potentially high reductions in pesticide use (up to 80% of fungicides and 61% of herbicides). The variable operating costs are most strongly influenced by technology group 7, since in some cases time consuming aerial inspections of the fields (with drones) are necessary in advance of the operation. These operations are included in the calculation as a service with about 40 € $ha^{-1}a^{-1}$. In terms of fixed costs change, technology group 7, and in particular farm 1, is the most noticeable with an increase of 500 € $ha^{-1}a^{-1}$. The profitability threshold (3) is reached by B7 in TG5, by B2-B8 in TG6, by B3, B4, B7 and B8 in TG7 and by none of the investigated farms in TG8.

Across all technology groups, a scale dependency emerges on the side of the additional fixed costs, which leads to the fact that the technologies can only be used economically with increasing farm size. The low overall benefit for most small farms in relation to the additional costs makes the use of the examined digital technologies uneconomical if the farms want to be self-mechanized. In general, it can be observed that technologies that lead to an increase on the revenue side tend to be of economic interest for more farms, as well as technologies that lead to savings in cost-intensive inputs.



	Auto Guidance	Mechanical Weeding	Section Control	Site-Specific Soil Cultivation	Site-Specific Sowing /Planting	Site-Specific Fertilizer Application	Site-Specific Spraying	Site-Specific Manure application
Farm B1 (11 ha)	212,4	163,9	135,9	127,2	55,8	28,0	35,5	
Farm B2 (20 ha)	244,8	127,4	78,4	335,5	43,2	21,0	31,7	78,4
Farm B3 (57 ha)	285,8	275,6	68,5	176,1	128,8	34,5	55,9	65,4
Farm B0 (65 ha)	217,9	180,1	229,1	500,2	157,7	43,0	58,2	323,4
Farm B4 (70 ha)	298,3	370,8	343,2	17,9	333,9	50,1	98,8	
Farm B5 (76 ha)	298,6	293,3	46,5	526,1	134,1	40,4	76,0	
Farm B6 (85 ha)	479,1	298,7	96,0	429,3	141,0	44,0	99,0	169,2
Farm B7 (187 ha)	504,6	552,0	222,4	373,2	158,7	35,1	91,2	384,6
Farm B8 (530 ha)		1288,9	420,5	841,1	675,9	68,7	205,5	

Figure 4: Marginal farm size for each technology group and farm

The marginal farm sizes shown in Figure 4 are based on the profitability frontier (3), where all incremental costs must be at least covered by the incremental benefits. Since the calculation of the marginal farm size of the technologies depends on the additional costs and benefits, the size varies from farm to farm based on the necessary changes of the existing mechanization (additional fixed costs), the yield level and the management intensity (potential increase of additional benefit). Larger differences can be seen in technology group 4 *"Site-Specific Soil Cultivation"*. The reason for the relatively low marginal farm size on Farm 4 is the low cost of implementation and the high savings in labour time. Also noticeable is the high marginal farm size of TG2 *"Mechanical Weeding"* on farm 8 compared to the rest of the farms, due to the low savings in direct costs.

The marginal farm size is smaller, the higher the additional benefit of a technology and the lower the additional costs. Technologies that have a positive influence on several items of the cost-benefit calculation, especially on the performance side (TG6 and TG7), can reduce direct costs to a greater extent (TG2 and TG7) or technologies with low investment costs (TG1 and TG3) are in an advantageous position. Technologies that only lead to small improvements on the revenue side and direct costs or which are costly to implement should not be chosen as a starting technology. A slight increase in the marginal farm size can be observed as the size of the farm increases. This is mainly due to the intensively managed small farms in the sample, which have a high yield level and input use and can therefore achieve higher potential savings per hectare. In this case, however, this does not create an advantage for small farms, since the marginal farm size is still a multiple of the actual farm area and can often only be achieved by the larger farms.

Discussion

The changes in the positions of the cost-benefit calculation shown in chapter 3 are based on literature values and substantiated assumptions. When comparing the farms B3-B5 and B0, it becomes clear that the results differ from each other due to different preconditions despite similar farm sizes. In practice, these differences can be even more apparent if the uniformly used assumptions in the calculation model are modified for each farm. In the following subsection, various factors that can influence the success of the use of digital technologies will therefore be discussed.

Revenue side

The yield of the status quo is linked to a variety of site-related factors (e.g. soil type and yield potential, weather, genetic potential of the variety) which cannot be influenced by the farmer [20]. Since the production function per field is also not known and depends on a variety of influencing variables, it is not possible to make reliable predictions about the response of yield to site-specific management [21,22]. The farmer's influence on the change in yield is therefore very limited. Only the amount of fertiliser and the spatial distribution of fertiliser in the field can be controlled. However, due to the law of diminishing marginal returns, it can be assumed that farms at high yield levels and farms that meet already high quality requirements (e.g. B1, B2 and B6) cannot expect particularly large increases here [23]. The same low level of influenceability applies to the height of the product price, which is essentially determined by the market [20]. Only the qualities produced can be changed to a small degree. This change is again subject to environmental influences and can therefore only be controlled to a limited extent by the farmer and the use of technology.

Direct cost side

The input quantities could be changed almost arbitrarily by the farmer, but there are upper limits (laws and regulations) and lower limits (e.g. personal preferences, yield expectations) that restrict the flexibility of the farm manager [24]. Digital technologies can influence the use of inputs to a small extent, but in most cases only a redistribution of the input quantity is carried out, so that no saving effects can be realized with these technologies [25]. Intensively managed farms have a small advantage per hectare compared to extensively managed farms as far as savings can be achieved. The influence of unshaped fields was not taken into account in this calculation, but can be of considerable importance, especially for TG 3 "*Section Control*" [26].

Variable operating costs side

Additional variable operating costs can be influenced by the use of the examined technologies only to a small extent, since these costs are technically determined. An enormous savings potential on the variable cost side arises if a farmer can replace non-family labour on a large scale [27,28]. This replacement of labour by capital is not possible in the studied arable farms with mostly 1-2 family labourers and the small amount of time saved through the use of the studied digital technologies.

Fixed cost side

Farmers are severely limited in their ability to reduce the position of additional fixed costs. The decisions made in the past about the purchase of machines determine the cost of implementing a digital technology (especially learning costs and investment costs). Problems related to the evaluation of these costs are diverse. On the one hand, they are linked to the competence and experience of the farmer, but on the other hand, they are also linked to factors that cannot be directly influenced by the farmer, such as compatibility problems due to different manufacturers or missing interfaces [15]. Reliable data on learning costs are lacking and could only be considered with great uncertainty even when collecting data from farmers who already use digital technologies [21]. The learning costs per year account for only about 2.5-3.0 % of the annual depreciation (with up to 6 h/year TG2, i.e. 60 h over the 10 years lifetime of the equipment). The assumption made in the calculation to depreciate learning costs over the service life (see also Godwin et al. [8]) will hide the fact that more time has to be spent especially in the first year, i.e. higher costs are expected in the first year.

In the longer term, investment costs can be expected to decrease as the technologies are further developed, and thus more technologies will be available to farmers [29,30]. The service life of digital technologies remains uncertain. There is a lack of data on the robustness of these technologies. Whether investment subsidies will lead to over-mechanization, especially of small farms, needs to be investigated more closely. It is undisputed that the reduction of investment costs through subsidies will lead to a reduction of additional costs and thus the minimum input areas can be reduced.

Overall, the additional fixed labour costs put small farms at a distinct disadvantage, as they tend to use existing technology for longer and a more cost-effective retrofit solution is often not possible for their outdated technologies. Some of the operations that are outsourced to contractors cannot simply be self-mechanized because the necessary know-how or manpower is lacking, thus creating a far greater hurdle to the use of digital technologies for small farms [31].

Marginal farm size

In general, it can be assumed that the hard limits drawn for Figure 4 are probably softer in practice and that especially technology-friendly farmers and farms with advantages in terms of implementation effort (e.g. if only activations are required) might decide to implement, even though the additional costs are not fully covered by the additional benefits [32].

The consideration of soft factors (e.g. farmer's preferences) and other possible benefits of digital technologies that are difficult to quantify (e.g. positive environmental effects) was intentionally excluded. Changes in this area could lead to small farms being able to use digital technologies from an economic point of view with the help of subsidies or the compensation of environmental services [33].

In most cases (e.g. TG1-TG5), even a doubling of the farm size will not be sufficient from an economic point of view to be able to use the technologies economically. Although a progression of structural change will be inevitable, it can be assumed that small farms will still be able to hold their position in 10 years [34]. Cooperation's between several farms or performing the operation as a service could be a solution to use digital technologies and minimize fixed costs per hectare. Technologies that can be easily deployed across farms, such as TG2, TG4, TG5, and TG7, are of particular interest. For very small farms (B1/B2), it is not advisable to use the technologies across farms, because otherwise too many farms would have to coordinate the use of the machines [31]. Nevertheless, these farms are not excluded from using these technologies. In this case, it makes sense to outsource this work to a service prove provider [31,33]. In the case of technologies that are permanently installed in the farmer's tractor (TG1) or are usually available as additional equipment in the farmer's machinery anyway and only need to be activated (TG3), the sharing of machinery is also not attractive.

Conclusion

With the help of a model calculation and data of eight farms, this paper was able to substantiate the low adoption rates of digital technologies in small-structured agricultural regions from an economic point of view. Especially very small farms (< 20 ha) are at a disadvantage when it comes to the implementation of capital-intensive technologies. It could be shown that technologies that make changes on the output side or influence large direct cost positions tend to be profitable even for smaller farms. The economic success of digitization varies greatly between farms and depends on a variety of factors (e.g. existing mechanization and environmental factors). The reluctance of farmers to adopt digital technologies can be attributed to the uncertainty of the benefits that can be achieved and the difficulty of monitoring success. The decision about an implementation must therefore be made individually for each farm. The results of the model calculation also show that some technology groups (e.g. TG2 "Mechanical Weeding Technologies") cannot be profitably implemented even on large farms. Due to the continuous further development of technologies, it can be expected that the digital technologies offered will become more affordable for farmers over time. If additional positive environmental benefits can be achieved with the use of digital technologies that are not rewarded by the consumer, the investment costs for the farmer should be reduced with the help of financial support from the state. Overall, however, the scale-dependent use of the technologies also gives hope for widespread use in small-structured agricultural regions with the help of service providers, who generally achieve high utilization of the machines and thus low costs per hour of use.

Acknowledgements

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Dr. Heike Sauer: Staatliche Lehr- und Versuchsanstalt für Gartenbau Heidelberg „Vegetable production in Baden-Württemberg – Structures and Challenges“

Baden-Württemberg is a State in the south-west of Germany with an area of 35.751,46 km² and 10,7 Mio. inhabitants (about eights of the inhabitants in Germany). 1,4 Mio. ha are used for agricultural production in Baden-Württemberg. 11.382 ha are open field vegetable production and 385 ha production under glass and plastic. What factors are favourable for growing vegetables in Baden-Württemberg? The climate is very mild in the regions Upper Rhine Valley, Neckar Basin and Lake Constance. Good soil conditions (deep loess loam soils) makes it possible to cultivate all kinds of vegetable. Proximity to consumers through population centres gives good chances to direct marketing. Regional products have a good image and efficient operational structures (cultivation and marketing) help growers. Disadvantages are the small-scale cultivation structures by real division and shortage of space or competition for space, especially in conurbations.

Tab.1: Vegetable production in Baden-Württemberg (Statistisches Landesamt, 2020)

Year	**2008**	**2012**	**2016**	**2020**
Vegetable production in ha	**10.468**	**11.029**	**12.057**	**11.767**
Vegetable production in glashouses and unter plastic tunnel in ha	***473***	***444***	***418***	***385***
Vegetable Production open field ha	**9.995**	**10.584**	**11.640**	**11.382**
Spargel asparagus ha	2.169	2.480	2.787	2.568
Salate lettuce ha	2.050	2.319	2.303	2.222
Feldsalat corn salad/lamb salad ha	**647**	**685**	**717**	**715**
Weiß- und Rotkohl head cabbage ha	785	812	780	799
Möhren/Karotten carrots ha	**775**	**858**	**1.005**	**1.029**
Speisekürbisse squashes ha	395	566	728	815
Zuckermais sugar corn ha	691	796	1.062	971
Speisezwiebeln onions ha	522	354	471	486

The most cultivated vegetable in Baden-Württemberg is asparagus, especially in the region Breisgau-Hochschwarzwald near Freiburg, followed by lettuce in all regions and carrots mostly in Rhein-Neckar-Kreis. Head Cabbage is cultivated for industry in the region Heilbronn, but also as a regional traditional vegetable with the name 'Filderkraut' in the region Stuttgart (Fildern). In the region around Lake Constance vegetable production in glasshouses plays an import role. New glasshouses with high technical standards have been built. Tomatoes, cucumber, lettuce and corn salad are the most grown vegetables in the protected area. Pot Herb production with an area about 45 ha also is remarkable. Baden-Württemberg is the state with the widest area of protected vegetable production in Germany and therefore biological pest control has a long tradition with cultivation of tomatoes and cucumbers. Organic farming takes place on around 1713 ha. The region Freiburg is one of the starter regions for organic vegetable production.

How will vegetable production develop in future? Regionalisation of producers und marketing are one of the aims, fitting very well in the farm to fork strategy of EU. Since many years the quality sign „Qualitätszeichen Baden-Württemberg" und „Bio-Zeichen Baden-Württemberg" is a quality label with indication of origin of Baden-Wuerttemberg and a hallmark for products grown and processed in Baden-Wuerttemberg according to basic and supplementary requirements.

Protected geographical indication (PGI) emphasises the relationship between the specific geographic region and the name of the product, where a particular quality, reputation or other characteristic is essentially attributable to its geographical origin. Examples are the head cabbage ‚Filderkraut' or the onion ‚Höri Bulle'. The campaign: „Natürlich von Daheim" wants to support this regional development, and with it the trend towards regional sales markets. Increasing demand of regional Bio-Produkts caused initiative Aktionsplan „Bio aus Baden-Württemberg" with the aim to strengthen organic production in Baden-Württemberg. The recently enacted law to promote and protect biodiversity defines the aim to bring up organic production to 30-40 % of the whole agricultural production in Baden-Württemberg until the year 2030. This goal also applies to vegetable production.

Dr. Heike Sauer: Organic farming and hydroponic cultivation systems, Staatliche Lehr- und Versuchsanstalt für Gartenbau Heidelberg: Research at the State Horticultural College & Research Station Heidelberg

The State Horticultural College & Research Station Heidelberg was founded 1952. Today about 60 employees are working there. Structurally State Horticultural College & Research Station belongs to the ministry of food, rural affairs and consumer protection in Baden-Württemberg and the funding is mostly done by the state. The tasks und fields of activities are the qualification of ‚Gärtnermeister/garden masters' in landscaping, ornamentals and vegetable production and training in arboriculture, professional training of horticultural companies and applied research in horticulture. The main topics of research are organic production, biodiversity and climate protection with the aim to develop sustainable horticulture. Two examples of the year 2021 shall give a view inside research work at LVG Heidelberg.

1. Organic versus hydroponic production – which cultivation systems results in more sustainability? In 2021 spring production of lettuce was compared under

the aspect of water consumption with organic and hydroponic cultivation. Therefore lettuce was planted at the end of January and the second planting was at the beginning of February. A part of the lettuce was cultivated in soil in a plastic greenhouse with organic production, the other part in a glasshouse with the hydroponic nutrient film technique system. The salads were harvested, when they reached the weight of 250 g. The lettuce in organic production needed a little more cultivation time because of lower cultivation temperature in the greenhouse. Salads in both cultivation variants were marketable. The red colour of the lettuce was more intensive in the organic variant. The reason is the influence of UV-light in plastic greenhouses. The demand of water per kg fresh weight was with 12.5 l or 14.2 l in nutrient-film-technique in comparison to 52.2 l or 49.4 l with organic production in soil absolutely reduced. In summary: The salad production in hydroponic nutrient-film-technique can reduce water consumption till 76 % und this system will be an alternative cultivation method in the case of water shortage. In further experiments will be compared, how the consumption of nutrients or energy demands for heating will influence ecological foot print with both systems.

2. Comparison of organic mulch with technic mulch films: Which influence will be expected on development of the plant, on yield, plant health and water demand? How is the reaction of different tomato varieties? How will the following culture be influenced? The data of cultivation were the following: The trial took place in a Rovero plastic greenhouse with a planting of the tomatoes on 13.04.2021. The plastic mulch was a technique mulch film ‚Bändchengewebe‘ Polypropylene and for the organic mulch a vetch-rye-mixture was used and distributed in the tomato culture two times on 28.04 and 10.05.2021.

The following results could be achieved: The yield of the first harvest at 25.06.2021 was not relayed by organic mulch. There was no effect on yield of the different tomato varieties between the two mulch treatments. The amount of irrigation of the organic mulch variant was reduced and therefore the plants showed a reduction of yield in the same height. The organic mulch variant did not need fertilisation during cultivation time, as organic mulch set enough nitrogen free to be used by the plants. In summary: Organic mulch is a good possibility in tomato cultivation to replace technique mulch with the further advantage to provide nutrients like nitrogen and therefore to perform a sustainable production system.

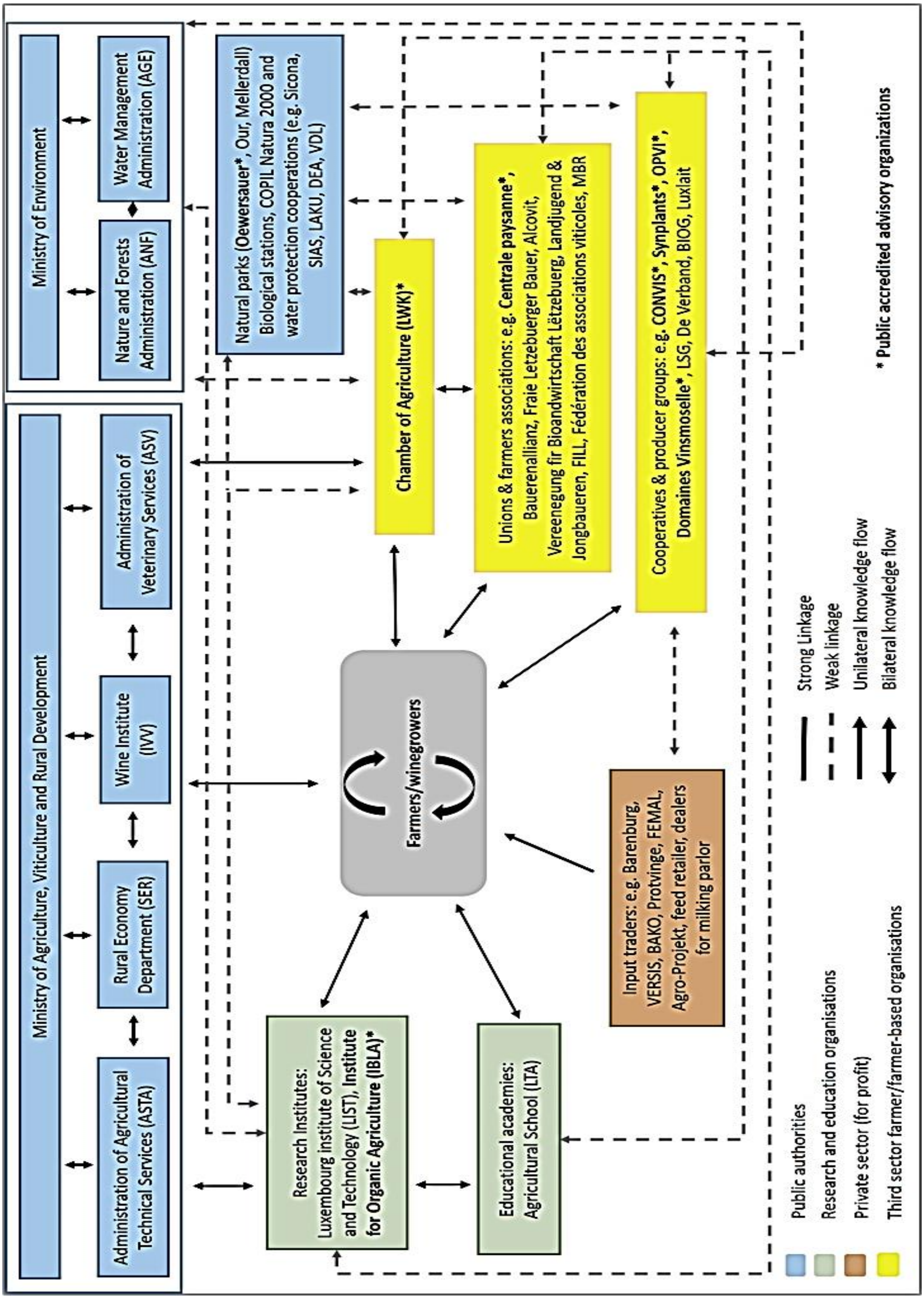
Dr. Stéphanie Zimmer: Insights of the Agricultural Knowledge and Innovation System (AKIS) and advisory services in Luxembourg, Institut für Biologësch Landwirtschaft an Agrarkultur Luxemburg a.s.b.l. (IBLA)

Luxembourg is characterized by a utilized agricultural area (UAA) of 131,592 ha, representing 51 % of its territory, which in turn can be divided into arable land (47.1 %), permanent grassland (51.6 %), and vineyards or other cultivated land (1.3 %). A total of 4.4 % of the UAA is organically farmed. In 2019, the sector encompassed 1,872 agricultural farms having an average farm size of 70.3 ha. In terms of farm type and economic size, most farms in Luxembourg are specialised in grazing livestock (1220 farms in 2019 equalling 65.2 % of farms). This can be further distinguished into 530 specialised cattle – dairying farms, and 363 specialised cattle – rearing and fattening farms. The agricultural sector employs 3,342 annual work units (AWU) of which 68 % were covered by family members. The contribution of agriculture to the GDP is low with 0.2 %.

For a relatively small country like Luxembourg, the agricultural sector is very diverse and its AKIS well positioned and good connected. The Luxembourgish AKIS (Fig. 1) includes actors from the categories public authorities, research and education organisations, private sector (for profit) and third sector of farmer/farmer-based organisations. In Luxembourg eight advisory organisations are recognised as PAAO. The MAVRD is in charge of the accreditation of these organisations. Besides the PAAO, the AKIS of Luxembourg is composed of two research institutes, an agricultural school as well as different unions & farmers associations, cooperatives & producer groups, and input traders. The linkage of all these actors with the farmers and winegrowers is strong. Nevertheless, the network between the different AKIS actors and especially between the eight PAAO could be stronger. PAAO do not sufficiently cooperate. The PAAO of viticulture make an exception as they have a good and close cooperation, whereas the PAAO of agriculture have no substantial cooperation in their specific day-to-day advisory activities. The best linkage between actors is achieved within research and dissemination projects, such as variety trials, on-farm field trials or EIP projects. At the heart of these projects and the therewithin created networks are the primary producers. Outside of such projects, each actor pursues its own objectives; there is a lack of coordinated collaboration and knowledge flow between actors to promote innovation and capabilities to meet future challenges of the agricultural sector.

While the MAVRD is in charge of the accreditation of the PAAO and their individual advisors for the different advisory modules, the LWK is mandated with its coordination. This gives it a double role, as itself is a PAAO in Luxembourg. In the expert interviews, it was pointed out, that this double role is unfortunate, as there is no real separation of powers. The content of the advisory modules, funding rates and maximal funding height as well as minimum qualifications of providers are fixed in ministerial regulation. Experts' opinion is that the modules system inhibits innovation and collaboration between the PAAO, as a competition situation is created.

The eight PAAO employ 44 accredited advisors: 12 women and 32 men. The advisors all meet at least the minimum qualification requirements (Bachelor's degree or equivalent). Time spend for teaching and training of the advisors is limited, mainly due to the difficulties with financing of such activities. There exist some possibilities to receive public funding through the MAVRD for further training. The LWK is also in charge of the coordination of these programmes. This results again in issues with regard to separation of powers, as it is also eligible to receive funding through these channels. The soft skills training co-financed by the MAVRD was appreciated by the participants, mainly because of the networking opportunity they provide for the advisors of the different PAAO, who have little contact in their daily work.


Ministry of Agriculture, Viticulture and Rural Development
Administration of Agricultural Technical Services (ASTA)
Rural Economy Department (SER)
Wine Institute (IVV)
Administration of Veterinary Services (ASV)
Ministry of Environment
Nature and Forests Administration (ANF)
Water Management Administration (AGE)
Natural parks (Oewersauer*, Our, Mellerdall) Biological stations, COPIL Natura 2000 and water protection cooperations (e.g. Sicona, SIAS, LAKU, DEA, VDL)
Research Institutes: Luxembourg institute of Science and Technology (LIST), Institute for Organic Agriculture (IBLA)*
Educational academies: Agricultural School (LTA)
Farmers/winegrowers
Chamber of Agriculture (LWK)*
Unions & farmers associations: e.g. Centrale paysanne*, Bauerenallianz, Fraie Letzebuerger Bauer, Alcovit, Vereenegung fir Bioandwirtschaft Lëtzeburg, Landjugend & Jongbaueren, FILL, Fédération des associations viticoles, MBR
Cooperatives & producer groups: e.g. CONVIS*, Synplants*, OPVI*, Domaines Vinsmoselle*, LSG, De Verband, BIOG, Luxlait
Input traders: e.g. Barenburg, VERSIS, BAKO, Protvinge, FEMAL, Agro-Projekt, feed retailer, dealers for milking parlor
Public authorities
Research and education organisations
Private sector (for profit)
Third sector farmer/farmer-based organisations
Strong Linkage
Weak linkage
Unilateral knowledge flow
Bilateral knowledge flow
* Public accredited advisory organizations

Most frequently individual advice was used as an advisory method. Due to the COVID-19 pandemic a shift from individual face to face advisory on the farm to individual advisory via telephone or via digital apps was described. Clients of the PAAO are mainly farmers with small/medium-scaled farms to large commercial farms (>100ha).

With regard to advisory topics, a focus on production technologies could be determined, mainly regarding crop production. Given that more than 50 % of the Luxembourgish UAA consists of meadows and pastures and that the main farm type is specialised grazing livestock farms, it is surprising that the focus of advisory in Luxembourg is not on livestock and grassland production.

As further challenges ecology and environment protection, knowledge on markets and farm viability, mitigation and adaptation to climate change, and specific technological knowledge (e.g. farming practices, production technologies) were named. The intensified focus on environmental topics and the herewith coming regulations were also mentioned in the expert interviews. Another topic that came up is the digitalisation and the pertaining challenges farmers have encountered in recent years and are likely to encounter in the future.

In the new module system implemented in 2016, the financing of the advisory services is switched from direct payments of the PAAO and the accredited advisory to service based financial system: farmers can take advantage of a catalogue of modules for which they receive between 50-100 % financial support to cover the costs. The content of the advisory modules, the funding rates and the maximal funding amount as well as the minimum qualifications needed of providers are defined in a ministerial regulation. This change has led to financial difficulties for the PAAO as funding rates for the different advisory modules are too low and overhead costs are not included in the calculation of the hourly wage. Furthermore, the new system has led to a higher bureaucratic burden for the PAAO and its reduction was mentioned as a future challenge. The rigidity of the new system has also led to difficulties in organising dissemination and knowledge transfer activities for farmers, due to the lack of funding possibilities within the module system. The instruments to fund research and dissemination project were described as not practical due to long decision processes and administrative burdens.

A lack of possibilities to consult farmers according to their needs was criticised by the advisory experts, as every advisory activity needs to be imbedded in an existing and to the respective organisation accredited module. When the content of the modules was initially formulated, the aim of the MAVRD was to maintain the existent amount of funding for the respective PAAO in an effort to continue to support them, rather than focusing on farmers' knowledge needs. The different experts all presented visions and possibilities on how to improve the current advisory system to meet future challenges. These included ideas on how to move towards a better cooperation between AKIS actors, a more holistic approach of advisory, a better adaptation to currently relevant topics and an innovation-promoting system.

This abstract is based on the AKIS report of Luxembourg: Zimmer, S., Stoll, E., Leimbrock-Rosch, L., (2020), AKIS and advisory services in Luxembourg. Institute for Organic Agriculture Luxembourg (IBLA), Altrier, Luxembourg.

Dr. Vér András: The Hungarian agricultural knowledge and innovation system; University of Györ, Hungary

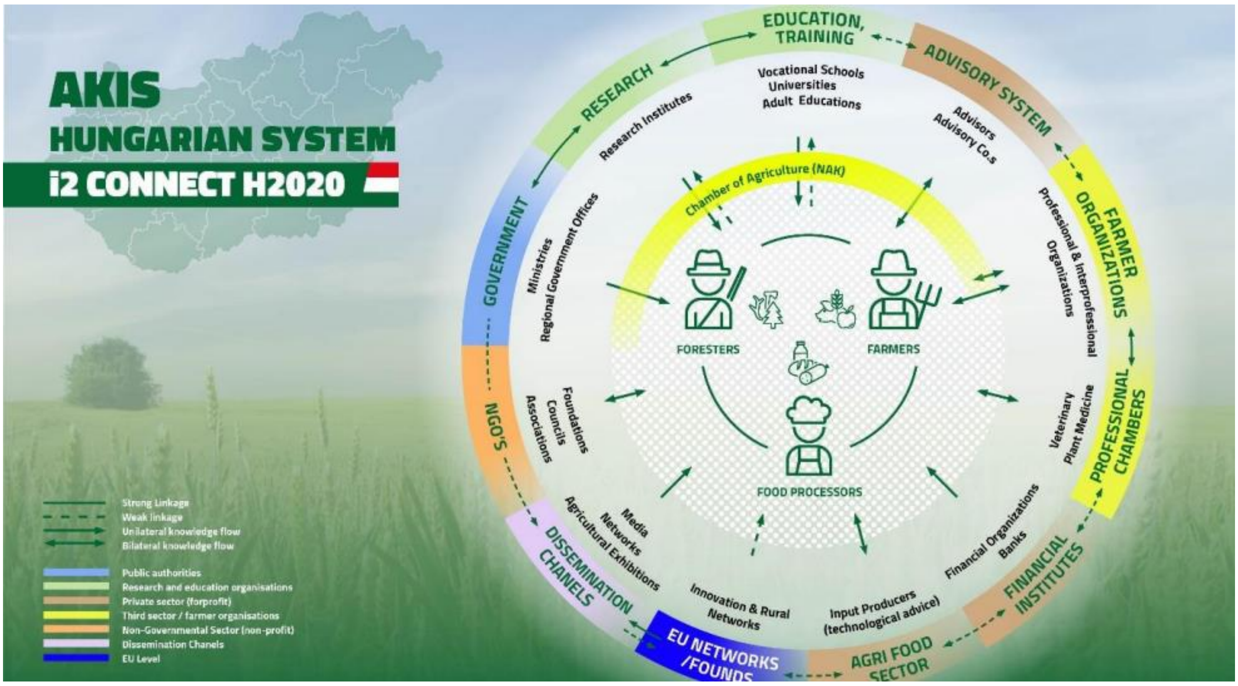
The study contains the general characteristics of the Hungarian agricultural and forestry sector and AKIS as well as the historical development of the advisory system. The organizations providing advisory services, policy issues, methods of knowledge transfer as well as the advisory organizations that make up the FAS and their operation are presented in detail.

The Hungarian AKIS has a rather heterogeneous structure. In addition to the various ministries, actors in the advisory system, participants in education and research, professional chambers, advocacy organizations, farmers' organizations, media and information channels, NGOs and various EU networks play a decisive role. The Hungarian Chamber of Agriculture plays a key role in AKIS, especially in the field of protection of farmers' interests, as well as in the generation and dissemination of information. Advisory services, which are brought together by the National Advisory Centre (OSzK), have a prominent role in the transfer of knowledge and the practical application and dissemination of innovations. OSzK plays a coordinating, recording and controlling role within the framework of the Hungarian Farm Advisory System, among its tasks and actors. According to the register, 1,100 advisors provide advisory services in Hungary, and it is important to note that the Hungarian Chamber of Agriculture employs 610 village agronomists, who, among other things, provide information and help chamber members regarding issues related to their activities. Agricultural advisory activity has a long tradition in Hungary and the quality and methodology of knowledge transfer has developed dynamically in recent years as well. The advisory system has undergone significant changes in recent decades.

The central coordination of the Hungarian AKIS (Agricultural Knowledge Transfer and Innovation System (in Hungarian: ATIR)) is currently being developed, however, the identification and brainstorming of the actors of the system is already realized through the Agricultural Advisory System. As far as the future is concerned, coherence in cooperation will expectably strengthen given that there is a need and intention for it both from the governmental, professional and social sides. The actors of AKIS: farmers/foresters/food producers, advisors, researchers, agricultural producer organizations as well as governmental and non-governmental organizations, in-school and out-of-school educational institutions, networks, media, other services, etc., i.e. all those who produce or transfer knowledge.

At the governmental level, the Ministry of Agriculture (AM), the Ministry of Innovation and Technology (ITM) and the Ministry of Human Resources (EMMI) as well as the background institutions supporting the work of the ministries are the main AKIS actors. Horizontally, the operational tasks of research and innovation are performed by the National Office for Research, Development and Innovation (NKFIH); the sustainable development and international networking of the research infrastructure is supported by the National Research Infrastructure Committee (NKIB). The following higher educational institutions play a relevant role in the efficient operation of AKIS: Hungarian University of Agriculture and Life Sciences (MATE), University of Veterinary Medicine, University of Debrecen, University of Nyíregyháza, University of Sopron, University of Szeged and Széchenyi University. These institutions are maintained by the state or foundations. Agricultural vocational schools covering the whole country and maintained by the Ministry of Agriculture, as well as institutions participating in adult education are also of paramount importance. Other actors of the AKIS system are farmer and producer professional and inter-professional organizations and associations that unite the individual Hungarian agricultural and food supply chains (e.g. milk, poultry, pig, cereals, fruit and vegetables, sheep, herb, etc. sectors). AKIS operates directly and/or indirectly from public, private and EU funding. In this respect, actors include financial institutions (financial and financing organizations, e.g. banks, credit institutions). It is also necessary to mention the EU-supported networks (Innovation Networks: EIP-AGRI OCS/FCS, LEADER, ENRD), the media, and other information channels (social sites, trade fairs, etc.), and the operation of non-governmental organizations (foundations, councils, associations). One of the most important elements of knowledge dissemination is the media and other multimedia channels, be it online media, social networks or paper-based publications, but also national and international events and fairs, where AKIS actors can meet and talk to each other in person. The role of NGOs primarily strengthens the relationship between consumers and producers through personal presence. Horizontally, the interests of those active in all areas of the agri-food economy are represented by the Hungarian Chamber of Agriculture (NAK), from production through processing to trade, given that membership of the chamber is mandatory in Hungary. NAK also plays an important role in knowledge transfer by, inter alia, organizing the training and examination of advisors, carrying out coordination tasks related to advisory activities, and establishing, keeping and publishing a list of advisors and advisory organizations, keeping contact with agricultural and rural development advisory organizations of the EU Member States (Magyar Közlöny, 2019). In addition to NAK, two professional chambers also play a significant role in the field of knowledge transfer: one is the Hungarian Chamber of Professionals and Doctors of Plant Protection (MNMNK) and the other one is the Hungarian Veterinary Chamber (MÁOK). MSzR operates within the framework set by law, with the coordination of the National Advisory Centre operating within the Hungarian Chamber of Agriculture. FAS basically means regulation and coordination related to advisory activities, but the National Agricultural Advisory Committee (NATaB) is part of the system. The Commission has the power to propose and give an opinion on the coordination of certain tasks related to agricultural and rural development advisory service. The members of NATaB are appointed by the Minister of Agriculture on the proposal of NAK. The aim of the chamber's proposal was that all actors involved in the advisory system are represented in the committee, from the decision-making level, through agricultural higher education, research, professional and advocacy level to those involved in practice. Based on the composition of the membership, it can be said that NATaB practically covers the actors of AKIS.

The current structure of the Hungarian AKIS.



Source: AKIS Country Report Hungary (2020)

Prof. Dr. Johannes Jehle: Contribution of biological control to integrated crop management, Julius Kühn Institute, Germany

Integrated plant protection follows the concept of combining plant breeding, cultivation measures and physical, biological as well as chemical methods for an efficient and environmentally friendly pest control. As part of the European efforts to reduce the use of chemical pesticides, biological control plays an increasingly important role in plant protection practice. Also, biological control methods are of particular importance in organic production, where the application of chemical pesticides is not allowed. Biological control recruits a broad spectrum of organisms and biological substances: naturally occurring bacteria, fungi and viruses, predatory and parasitic insects, predatory mites and insect pathogenic nematodes but also plant extracts can be used to produce healthy plants and to avoid environmental damage. Biological control comprises three disciplines 1) Conservative Biological Control means to protect and enhance naturally occurring macrobial and microbial antagonists of plant pests and diseases. 2) Classical Biological Control relies on the introduction of non-indigenous antagonists and is mainly used in controlling non-indigenous, invasive pests. 3) Augmentative Biological Control includes the repeated release of industrially produced micro- and macro-organisms or natural substances. As a component of integrated plant protection measures, biological control methods need to be carefully designed for the specific needs and characteristics of the living organisms used as plant protectants.

Dr. Sabine Zikeli: Cover Crops and Other Measures to Increase Soil Fertility, Centre for Organic Farming, University of Hohenheim

Introduction

Cover crops are grown between two main crops in order to improve soil fertility, reduce leaching of nutrients and erosion, and help to control pest and diseases. They can be used in different cropping systems, such as perennial crops like fruit orchards, in arable farming systems and horticulture. In many cases, cover crops are not harvested but incorporated into the soil. However, cover crops can also play an important role in integrated crop-livestock systems, providing high quality feed, mostly for ruminants (Franzluebbers and Stuedemann, 2015).

Several other terms exist that are used as synonyms for “cover crops” addressing more specific targets of cover crop use:

Catch crops – focus on nutrient uptake and prevention of leaching
Living mulches – focus on the companion crop function to the main crop
Green manures – focus on the fertilization function (tilled before seeding / planting of the main crop)

Depending on the main target of the cover crop, different plant species with widely differing characteristics can be used. For example, if nutrient uptake and the conservation of nutrients in the plant biomass is the main target, cover crops that develop quickly large amounts of biomass like rye grass (*Lolium perenne*), mustard (*Sinapis alba*) or rye (*Secale cereale*) should be used. The same species are also suitable to prevent erosion. If it is important to break disease cycles, it is important to use species of plant families that are not used as main crops, e.g. blue tansy (*Phacelia tanacetifolia* from the plant family of *Boraginaceae)*. If increasing the nitrogen (N) supply is the main target, leguminous species can be used, e.g. white clover (*Trifolium repens*) or different grain legumes (field peas (*Pisum sativum*) or field beans (*Vicia faba*).

Fig. 1a) Mixed cropping of winter rye (*Secale cereale)* and hairy vetch (*Vicia villosa*) as frost tolerant cover crops

Fig. 1b) Mixed cropping of buckwheat (*Fagopryum esculentum*) and blue tansy (*Phacelia tanacetifolia*) as non-frost tolerant cover crops

Furthermore, in temperate climates, farmers can chose between winter hardy cover crops (Fig. 1a) such as rye, white clover or hairy vetch (*Vicia villosa*) and non-frost tolerant crops (Fig. 1b) like buckwheat (*Fagopyrum esculentum*) or mustard in order to ease the incorporation of the biomass in spring and reduce the risk of regrowth of the cover crop within the main crop.

In organic farming, due to restrictions in fertiliser use (prohibition of the use of mineral N-fertilisers), leguminous cover crops play an important role in fertilisation strategies to increase N supply in the cropping system by enhancing biological N fixation. This is even more important in stockless organic farming systems as perennial leys with forage legumes have no economic benefit and are often excluded from the rotations (Watson et al. 2002).

The current paper will therefore mainly focus in the role of cover crops to maintain and increase soil fertility.

Cover crops to prevent nutrient leaching

Excess amounts of N in agricultural soils are a serious threat to different environmental compartments: N leaching and N in run-off may result in the contamination of ground- and surface waters and high N contents in the soil may lead to nitrous oxide (N_2O) emissions contributing to the increase of greenhouse gases in the atmosphere. For natural and semi-natural terrestrial and aquatic ecosystems, N inputs via rain and into surface water pose a serious threat for biodiversity (Umweltbundesamt, 2021).

For these reasons, research on the reduction of N emissions from agro-ecosystems has been done for many years. In temperate regions with high rainfalls during autumn and winter, the use of cover crops is one of the key strategies to minimize N leaching and N_2O emissions from agricultural soils. In particular, the use of non-leguminous cover crops results in decreased N leaching (e.g. Asekgaard et al. 2011, Valkama et al. 2015). For the Nordic countries, Valkama et al. (2015) found in a meta-analysis a reduction of N leaching by 50% when rye grass was used while no change was observed when clover species were grown compared to a fallow treatment. Other authors, e.g. Tonitto et al. (2005), found a reduction of 40% of N leaching even for leguminous cover crops compared to bare fallow in intensively fertilised systems. However, the use of non-leguminous cover crops may come at a cost and may result the reduction of yields, while the use of leguminous cover crops may even lead to yield increases.

Based on the current findings, cover crop use is a strategy to reduced N leaching. However, soil properties (e.g. soil texture) that influence leaching risks as well as climatic conditions have to be taken into account when choosing a fitting cover crop for a certain location.

Cover crops as a nitrogen source

Leguminous cover crops serve as an N source in (organic) rotations enhancing the internal N cycle of the farm. Such cover crops can be integrated in a rotation as a pre-crop before the main crop or as an intercrop, a so-called living mulch. Currently, the use of legumes as pre-crop in the rotation is much wider spread as the use of living mulches still pose several management challenges, particular in annual crops: Living mulches compete for light, nutrient and water with the main crop, which often leads to yield reductions.

However, the use of living mulches in perennial cropping systems, e.g. in fruit orchards or vineyards is easier to manage, as growing periods of the living mulch (often grain legumes) are short and competition with the main crop is of less importance due to the size and the well-established rooting system of the latter. In such systems, many options exist in order to find the appropriate timing of seeding of the cover crop (often peas or field beans) and it's termination and incorporation for a given location as fruit trees have high demand for N, particularly during flowering and fruit formation in spring. Therefore, the timing of mineralisation of N from the living mulch is of key importance. Legume grains contain 5 to 6 % of N in the dry matter (DM) with narrow C/N ratios of 8 to 13 (Möller and Schultheiß, 2014) which is higher compared to animal manures but much lower than N concentrations in commercial fertilisers which are commonly used in organic fruit growing systems, for example horn grit with 13 to 14% N (DM). If the cover crop is sown already in autumn of the previous year (e.g. winter peas), additional N may be provided to the system as the pea seedlings may even start to fix additional N leading to a further increase of the potentially available N. In field trials in an apple orchard no differences could be found between treatments with commercial fertilisers permitted in organic farming and fertilisation with winter and spring peas as living mulches (target N fertilisation: 20 kg N ha^{-1}, Lepp et al. 2022). Therefore, leguminous living mulches are alternatives for current commercial fertilisers that are considered contentious inputs in organic farming due to their origin from conventional agriculture (e.g. horn grit, vinasse from conventional sugar beet production, Demeter e.V. 2021). However, mineralisation of leguminous living mulches depends strongly on the site conditions like soil temperature and soil moisture at the time of their incorporation. Therefore, fertilisation strategies based on grain legumes as living mulches are more demanding when it comes to farmer's knowledge and adaptability of management practices in the field then current fertilisation strategies based on commercial fertilisers.

In arable farming or in horticulture, grain legumes or small seeded legumes like clover species are often used as pre-crops for the main crop. Via incorporation and mineralization of the leguminous cover crops, N and other nutrients become available for the subsequent crop. Thus, the fertilization strategy with leguminous cover crops consists of a combination of plant N uptake, green manuring, and biological nitrogen fixation (BFN, Willumsen and Thorup-Kristensen, 2001). In addition, growing leguminous cover crops offers other ecological and economic advantages. The commercial fertilisers often used in organic vegetable production, such as solid manure, lead to nutrient imbalances in the long term, as their nutrient compositions often do not match the nutrient requirements of the vegetable crops. Thus, P surpluses can occur over time (Möller, 2018). Other aspects of using leguminous cover crops are the reduction of costs for commercial fertilisers and the reduction of the use of contentious inputs in organic farming.

An increase in on-farm N supply is particularly important in organic vegetable production, as many vegetable crops have a high N requirement. Highly demanding crops e.g. white cabbage or broccoli, therefore benefit from the N supply by leguminous cover crops used as green manures (Haas, 2004). However, an additional fertilisation with other fertilisers (e.g. farmyard manures, commercial fertilisers like horn grit or spent brewer's grains) is necessary to fulfil the high N demand of these crops. A combination of a reduced horn grit fertilisation with winter peas or winter field beans as cover crops resulted in yield levels similar to a full horn grit fertilisation in late white cabbage in Germany (Stein et al. 2021).

However, the planting of vegetables is highly variable at times. Therefore, the question arises as to which cover crops can be used for which location and at what times they should be incorporated in the soil, in order to generate the greatest possible benefit (Thorup-Kristensen and Dresbøll, 2010). This leads to further research needs for different regions in Europe to develop appropriate management strategies for different cover crops that fit the local conditions.

Transfer mulch as a new use of cover crops

In addition to animal manures and grain legumes, leguminous perennial leys like clover grass are the most important source of N on organic farms in temperate regions. Such forage crops are indispensable for weed control and the maintenance of soil fertility. However, in organic farming systems with low numbers of livestock or no livestock at all, perennial leys have no economic benefit and farmers tend to shorten the growing period to only one year. In addition, the biomass cuts are no longer removed but mulched for economic reasons. Moreover, the farms lack a mobile fertiliser that can be used flexibly depending on the needs of the crops similar to animal manure on organic farms with livestock. As the number of stockless or vegan organic farms will increase in the future, the role and use of clover grass needs to be reconsidered and new fertilisation strategies for such farms have to be designed in order to increase the N-efficiency of these farming systems and to maintain or even increase soil fertility.

In order to circumvent this problem, so-called clover-grass-based transfer fertilisers (freshly cut biomass referred to as “cut-and-carry” or clover-grass silage) are now being used more frequently on farms, on one hand to increase the N-efficiency of clover-grass use at farm level, and on the other hand, to produce a mobile fertiliser that is produced on-farm and which enables a targeted redistribution of nutrients.

Removing the cut clover grass biomass increases BFN as mulching of the perennial leguminous leys as a negative effect on N-fixation: The clover grass mulch has a narrow C/N ratio that quickly releases N resulting in a reduction of symbiotic N-fixation (Heuwinkel et al. 2005, Stinner et al. 2008). To solve this problem and to use the clover grass biomass as a fertiliser, four management practices are currently considered and tested in organic farming systems in Central Europe:

- Transfer mulches: Removing of the cut biomass and transferring it directly to another field (“cut-and-carry”) or producing silage with the cut biomass in order to fertilize other fields later in time
- Using clover grass biomass as a feedstock in biogas production and using the biogas digestates as a fertiliser
- Fodder-manure cooperations with neighbouring farms including the return of animal manure
- Production of pellets from clover grass biomass

The management practice of transfer mulching (either as silage or as cut-and-carry) is easy to integrate in existing organic crop rotations and does not require investments like construction of a biogas plant or of drying and pelleting facilities. In addition, no external cooperation partner is needed, contrary to fodder-manure co-operations or for the joint running of biogas plants or drying facilities for pellets by several farmers. Silage or cut-and-carry are usually applied with a manure spreader and then incorporated in the soil to accelerate mineralisation. Using silage instead of cut-and-carry gives more options to farmers, as cut-and-carry is usually available in late spring/early summer. In this period, many cereals are already too far developed to allow for additional applications of solid manures. If clover grass biomass is made into silage it can be stored and applied as a fertiliser in autumn or very early spring, when crop demand exists and fertilisation is possible for technical reasons.

Legume based fertilisers contain 3% N, 0.5% phosphorous (P) and 3% potassium (K) kg^{-1} (DM, Möller and Schultheiß, 2014) which is in the range of cattle manure and higher than in compost from green waste or household waste. However, as shown in Fig. 2 for a field trial with potatoes fertilised with different clover grass based fertilisers, spring application of silage and cut-and-carry may lead to a delayed mineralization resulting in lower yields compared to other fertilisers. If silage is applied in autumn similar to farmyard manures, this problem can be avoided. In this case, no statistically significant difference was detected between the traditional fertilisers, composted farmyard manure, and clover silage. Timing of silage application is therefore is a key issue to optimize nutrient availability from transfer mulches.

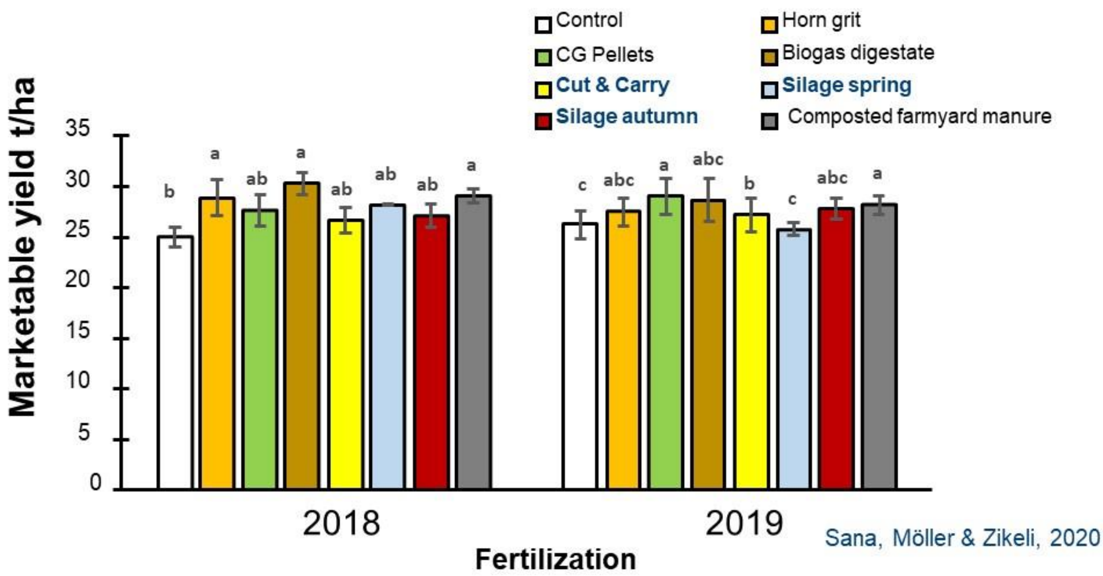


Fig. 2: Fertilisation effects of different clover grass based fertilisers on the yield level of organic potatoes in Southwest Germany.

Conclusion

The benefits of cover crops to prevent nutrient leaching, N_2O emissions, and erosion, as well reduction of weeds and pest and diseases are widely acknowledged in research and agricultural practice. The same is found for their use to increase soil fertility, in particular for leguminous cover crops as green manures. However, if those cover crops are used to reduce the inputs of either mineral N fertilisers in conventional agriculture or contentious fertilisers in organic agriculture, rather knowledge intensive fertilisation strategies are needed to fully exploit the potential of leguminous cover crops and to avoid yield losses. Therefore, research and extension play an important role to further intensify the use of leguminous cover crops in conventional and organic agriculture.

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