SUSTAINABLE SUNFLOWER SUPLY CHAIN

ORGANIC TRADE FOR DEVELOPMENT

OT4D/PPP Project: Sustainable and climate resilient sunflower value chain and corresponding innovative climate resilient production systems

FEASIBILITY STUDIES

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FEASIBILITY STUDY ON SMALL SCALE FARMER INTEGRATION FOR HYBRID SEED PRODUCTION

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This feasibility study considers all relevant factors, including economic, technical, legal, and scheduling considerations, to ascertain the likelihood of completing the task successfulness.

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I General

The areas under organic production and the size of the organic food market are increasing. Currently, 1.2% of the world's agricultural land is under organic production (more than 58 million hectares of organic agricultural land including conversion areas) and Europe is the second largest organic production region, covering 23% of global organic production. The total surface under organic production in Europe increased by 21% between 2010 and 2015 to 6.2% of the total agricultural land.

Further growth of surfaces is expected. Growing surfaces under organic farming indicates great interest of consumers in the production of high-quality food, nature conservation and human health preservation. Wheat, maize, barley (barley malt) and sunflower are produced on the world's largest organic farms, the size of which extends to several thousand hectares. Sunflower (Helianthus annuus L.), one of the most important crops, could have great economic and nutritional importance in organic food production.

Sunflower is grown for its seed, which contains 48-52% of oil, but also for its by-products (meal) rich in proteins, carbohydrates, minerals and other important components in the preparation of animal feed. Sunflower heads can be used as fodder, and the entire plant can be used for silage.

Due to a fast formation of residual soil organic matter, sunflower can be used in organic production as a green fertilizer. In addition, sunflower is used as bird food, snack, as an ornamental plant, and for biodiesel production.

II Seed Production

Agricultural production, especially seed production, is extremely important because of the fact that 95% of food is produced from plants through seed reproduction. Production and processing of high-quality hybrid seeds is aimed at obtaining sufficient quantities of sunflower seeds to meet the sowing requirements. Sunflower seed production includes production and cultivation of all seed categories, production control, drying, processing, packaging, sampling, seed testing and certification (declaration), trade, storage, transport and distribution or storage until the new sowing period. Market demands also influenced the development of sunflower hybrids for special purposes - edible hybrids, hybrids with high oleic acid content, hybrids resistant to chemical preparations, hybrids used as bird feed, decorative sunflowers, etc. The main goal of organic sunflower sowing system is to produce genetically and physically pure seeds which are physiologically mature and as healthy as possible. The produced seeds should be of high quality, genetically identical to inbred lines of sunflowers, i.e. the hybrid created and registered by the breeder. According to the data from the Ministry of Agriculture, Water Management and Forestry of the Republic of Serbia, the average annual area under conventional sunflower seed production was 1924 ha in the period 2009-2018.

The average estimated annual production of processed seeds and the average estimated yield of processed seeds per hectare (1.03 t ha^{-1}) have been achieved, while organic production of hybrid sunflower seeds has not yet been established.

Current conditions in Serbia require that organic sunflower seed production develops in undisturbed environments. Organic production stems from the basic standards formulated within IFOAM (International Federation of Organic Agriculture Movements, founded in 1972), while the EU documents (Regulation EC 834/2007 and its accompanying regulations), *Codex Alimentarius* from 2001 (FAO/WHO), as well as Serbian legislation - *Law on Organic Production* (Official Gazette of RS, No. 30/10), Rulebook on control and certification in organic production and methods of organic production (Official Gazette of RS, No. 48/11) and *Rulebook on the control of seed production, the content and method of keeping records on the production of seedlings of agricultural plants and the report form on the production of edible mycelia and medicinal mushrooms* (Official Gazette of RS, No. 45/05) are all based on these principles. Today, the areas under sunflower production are increasingly being disturbed by industrialization and climate change. Consequently, farmers alter their cultivation practices and introduce new genotypes, while changing irrigation, fertilization and sowing time, and transitioning from the conventional to an organic production system due to the cost of the production and the safety of their products.

Since sunflower is one of the main crops used in the production of edible oils in many countries, the need for the development and seed production of new sunflower hybrids is dire. Unlike conventional, organic production relies on a balance within the soil-plant-animal-man system and aims to preserve the health of all living creatures, the agro-ecological system and the natural cycle. Organic agriculture is a system of crop production management which preserves and improves biodiversity (diversity of plant and animal life), circulation of matter in nature, and biological activity of soil. Organic agriculture has great and lasting importance for environment protection because it preserves biodiversity. The yield of sunflower, like any other crop, depends on agroecological conditions, choice of hybrids and applied cultivation practices.

Cultivation technology (choice of pre-crops, tillage, fertilization, sowing, cultivation practices and harvest) is based on the knowledge of biological characteristics of a hybrid, i.e. parent components, and requirements of growth in a specific environment. The most important biological characteristics include the length of vegetation, growth and development dynamics, phases of morphogenesis, dynamics of root system growth and properties, methods and dynamics of yield formation, absorption and metabolism of nutrients, adaptability and resistance to stress, diseases and pests.

Sunflower is suitable for growing under organic production systems due to a low demand for mineral elements and no major technical barriers posed by its production technology. Sunflower is tolerant to water stress and can therefore be planted in non-irrigated plots, although irrigation is recommended in sunflower seed production. Sunflower has high environmental plasticity though it generally requires warm and moderately humid climate. Despite the demands for heat, light and fertile soils, sunflower has a wide growing area because of its resistance to drought, temperature fluctuations and low temperatures in initial stages of vegetation. Thanks to its ability to utilize soil moisture and nitrogen reserves better than other species, as well as its productivity and high-quality by-products, sunflower is favoured in organic agriculture. The results achieved in organic agriculture, environment protection and rural development improve the quality of life of human population in a given territory, which can be an excellent example for agricultural producers in rural areas throughout the territory of the Republic of Serbia.

Use of existing possibilities in Serbia is at its starting point. Sunflower cultivation and technology of hybrid seed production includes cultivation practices by which current environmental conditions are altered to suit the needs of sunflowers and secure the best use of seed yield genetic potential. Particularly important is that all cultivation practices are governed by soil preservation and improvement. For this reason, organic production is based on crop rotation and production systems must comply with the type of production and soil fertility.

III Cultivation practices in organic sunflower seed production

Plot selection

Sunflower thrives on many soil types, but the best results are acheved on fertile, drained soils, with a deep layer of humus and neutral soil pH, such as chernozem, peat and alluvium. Shallow and skeletal soils are not suitable, whereas sandy soils should be avoided. Due to a well-developed root system, which penetrates deep into the soil, sunflower requires a deep subsoil layer. High nitrogen content in soils is not well tolerated by sunflower because such conditions promote the development of lush leaf mass and heads, excessive water is consumed, and such plants have poor resistance to unfavuorable conditions (drought, diseases). Sunflowers must not have been grown on selected plots for at least five years, while soybeans and rapeseed for at least three years prior to sowing. Plots should have a spatial isolation of 1.5 km from other sunflower crops and wild sunflower plants. Weed-free plots, preferably under an irrigation system, should be selected.

Crop rotation

Organic crop production includes crop rotation (rotation of crops in time and space). Crop rotation is the main cultivation practice in organic farming systems, with multiple benefits - maintaining soil fertility, i.e. contribution to soil structure, nitrogen and humus content, regulation of diseases, pests and weeds, reduction of nutrient loss through leaching, prevention and minimization of erosion. Crop rotation has a special role because it significantly reduces the occurrence of diseases, pests and weeds and supports the preservation of biodiversity in organic crop production. Sunflower does not tolerate monoculture. Wheat and other small grains, as well as corn, are good starter crops for sunflower production. Forage and leguminous crops should occupy significant surfaces in crop rotation. Forage crops and legumes occupy 30-50% of the crop-bearing areas, which creates a stronger connection between agriculture and animal husbandry.

Tillage

Tillage is one of the main issues of organic production, since successful organic production relies on high supplies of organic matter, good structure and a favorable water-air regime in the soil. The aim of tillage is to maintain soil biogenicity during vegetation, secure a favourable water-air regime, and accumulate soil moisture reserves. Pre-sowing tillage must ensure the quality of sowing - uniform sowing depth, fast and uniform sprouting, sufficient waterflow and less evapotranspiration. Conversion to sustainable agriculture and use of natural resources as rationally as possible relies on reduced tillage, mainly conducted for soil conservation purposes.

Tillage is reduced as a rule, but if applied it aims to improve soil fertility. For this reason, subsoilers are used in organic agriculture to loosen the soil. Preparation for organic sunflower production includes ploughing at the depth of 25-30 cm in November. Pre-sowing soil tillage is carried out in early spring before sowing, using a seeder at optimum soil moisture. Final tillage is carried out before sowing in the second pass, when sprouts and weeds are destroyed. Pre-sowing preparation consists of leveling the surface to form a loose soil layer of up to 10 cm. Heavy soils should be ploughed to a greater depth in spring, before pre-sowing tillage. Weeding should be carried out as needed.

Fertilization

Fertilization with 50 kg/ha of N, 60-80 kg/ha of P and 70-80 kg/ha of K is recommended on fertile soils during ploughing or pre-sowing tillage, and with 30-60 kg/ha N at 6-7 leaves or in combination with B during butonization for better results (ploughing stage - Guanito 6:15:3, Italpollina 4:4:4, Nervosol Complex NPK 4:3:4, Organic Fertilizer; pre-sowing stage - Fertorganico, Fertil, Bioazot Top; top dressing at butonization stage - Fitobor 10, Fertileader Gold). Nitrogen should be incorporated into the soil before sowing. The results of soil analyses should guide the growers in determining the dose of the fertilizer.

Great importance is given to organic fertilizers (manure, compost, green manure, vermicompost, wood, ash, plant solutions and other by-products in food technology and industry, biological nitrogen from symbiotic and non-symbiotic nitrogen fixation, natural mineral fertilizers) in organic sunflower production. Organic fertilizers are indispensable for improving physical, chemical and biological soil properties. The conversion period should be used to increase the content of organic matter in the soil by applying manure, compost, green fertilization and other measures. When applying organic fertilizers, beneficial soil microorganisms are also introduced and activated.

For the best results, manure should be applied during ploughing or the next day. ploughing-down of manure immediately after spreading gives 100% results, while it decreases 6 hours after spreading to 80%, 24 hours after spreading to 70%, and four days after spreading to 50%. In organic sunflower production, soil should be fertilized with 30-50 t ha^{-1} manure every 4-5 years.

Green manure (alfalfa, clover, rye) is mainly used in organic production of sunflower, whereby 10-30 t ha^{-1} of organic matter or 100-300 kg ha^{-1} N is introduced into the soil after flowering, when crops are green and have the largest mass.

Sowing

Depending on the state of the plot and the required chemical analysis (including the control of land use in the previous 3 years and production program), the transition (conversion) to organic crop production should last 2 to 3 years. If they meet other requirements, plots which were not used for two years can be used for organic farming immediately. Basic seed for the production of C1 seed category, i.e. hybrid seed must not be treated with pesticides and must be produced conventionally. In addition to meeting the phytosanitary requirements, seed must also be certified. Chamomile, horseradish, garlic or nettle tea gives good results in seed disinfection. Sowing is carried out in a 10:2 ratio. Two rows of paternal lines and ten rows of maternal lines are sown simultaneously or biphasically (depending on the hybrid). Interrow spacing should be 70 cm, or up to 80 cm for easier removal of paternal line rows, depending on the available machinery.

Intrarow spacing for both paternal and maternal lines should be 16-22 cm, depending on seed germination, so as to achieve an assembly of about 60,000 plants/ha of both parental lines. Sowing depth should be at 3-5 cm depending on the time of sowing, the quality of the pre-sowing tillage and soil type. Sowing should be in the direction north-south for easier control during flowering, because sunflower heads keep their position towards the east. Pneumatic seed drills must first be completely cleaned of other seeds and used. Sowing should be as early as possible, though not before soil temperature reaches 8˚C, which is during early or mid April in Serbia, or late March if the spring is warmer. Seeds should be treated with repellants (Kunilent R 12, Germ Mask, Sulfonated fish oil and garlic extract) to avoid the risk of bird attacks before sowing. It is important not to allow irregular arrangement of the crops; if duplicate seeds appear, thinning or correction of the assembly should be carried out before elongation at 2-3 pairs of leaves.

Cultivation

Protection from diseases and pests in organic production involves an application of indirect (preventive) and direct protection. Indirect protection includes crop rotation, selection of tolerant hybrids or cultivars, optimum plant density, moderate and appropriate fertilization, timely sowing. Direct protection includes the use of biopesticides based on the use of microorganisms and products of their metabolism - toxins, crystals, spores, antibiotics - which have an antagonistic effect on diseases and harmful insects, but are safe for humans and animals. These preparations consist of bioinsecticides, biofungicides and bioherbicides. Mechanical (hoeing, cultivation, harrowing) and biological practices are applied for protection against weeds, diseases and pests. The lack of effective weed control strategies is one of the main obstacles to obtaining higher yields in organic production of all crops, including sunflowers. Increasing plant density is one option to suppress weed emergence which affects yields. Combat against weeds can be carried out by irrigation before planting and soil tillage, so that the crop gains an advantage in time for development. Weed control in organic sunflower production can be done by interrow cultivation and mulching, hoeing, or mowing before weeds produce seed.

The crop must be weed-free during the entire growing season. During fertilization, it is necessary to incorporate soil bioinsecticides (Ogriol), especially if small grains preceded because an attack of white grubs and wireworms can be expected. If sowing is acrried out in phases, the space intended for maternal lines should be prepared prior to sowing if soil surface layer is in poor condition or if weeds are found. The best time for the first inter-row cultivation is at 2-3 pairs of leaves. An inter-row cultivator is used at a depth of 6-8 cm in order to break up the cover soil and loosen the top soil layer for better water supply and weed control. Interrow cultivation of organic sunflower should be done 3 to 4 times, while hoeing should be done 1 to 2 times.The most effective form of control of pests in sunflower organic production is crop rotation, while a solution made of potatoes, garlic, horseradish and tomatoes is used against attacks by rabbits or roe deer. Pods are ground, soaked in water, left for 10 to 25 days to ferment, and then used as a daily treatment of sunflower plants.

To obtain a healthy crop, one or two treatments with biofungicides are needed if conditions are suitable for pathogen development; the first treatment in the buttoning phase (tractor sprayers can be used), and the second after fertilization (Cuprablau Z, Cuprablau Z ultra, Champ Flow, Blauvit, Blue Jet 50 DF, Funguran OH, Microthiol special disperse, Webesan) using high clearance sprayers or drones to apply biopesticides.

The quality of irrigation water is essential in organic production due to an increased demand for food safety. Water from various sources (rivers, streams, natural and artificial reservoirs, groundwater, and increasingly from waste water) is used for irrigation. The quality of the water varies significantly between the mentioned sources. Salts found in higher concentrations are harmful and pose risks for plants, animals and humans. Biological content of water must first of all be inspected for the presence of bacteria harmful to fruits (Salmonella spp, Escherihia coli) which can be found if polluted water is used for irrigation. In organic production, irrigation water must be I or II class. Irrigation, as a bioagrotechnical measure, is carried out in compliance with the basic standards of IFOAM and Codex Alimentarius, especially in relation to biological cycles of matter circulation and soil conservation. If possible, irrigation of 30-40 mm should be carried out on two or three occasions (more if necessary), preferably before flowering and after fertilization.

Immediately after fertilization, the rows of paternal lines must be removed for aeration and reduction of disease attacks, to prevent the mixing of seeds in the harvest and seed scattering which can cause an emergence of wild plants in the next vegetation. Crops must also be protected from bird attacks after fertilization.

Supplementary pollination

Since sunflower is a cross-fertile (95%) entomophilous plant, it is necessary to secure the presence of a sufficient number of pollinating insects. It is recommended that 2-3 beehives be present on 1 ha and that they be properly distributed around the plot, thereby gaining a double benefit - the production is safer and, since sunflowers are among the most important honey-bearing plants, high yield of honey is obtained. Seed yield largely depends on fertilization. Beehives should be set up two to three days before flowering of maternal lines, and must remain on mercantile crops unless bees were at another place or closed for 48 hours, which is difficult to check.

Genetic purity of seed

Before budding and immediately before flowering, it is necessary to remove atypical plants in maternal and paternal rows, as well as removing wild plants in spatial isolation. Atypical plants are:

- excessively developed plants (hybrids) – taller plants with a thicker stem and larger leaves,
- branched plants in maternal lines,
- single-head plants in paternal lines,
- plants with an atypical leaf colour,
- unhealthy plants.

During the growing season, fertile plants from the maternal line should be removed daily in early morning hours. This is done by cutting off the heads and laying it face down to the ground so that they are inaccessible to bees, and then whole plants are pulled out and laid between the rows. Otherwise, such plants remain green and obstrue mechanized harvesting because they increase moisture content of the harvest material. Fertile plants are easily recognized by the black color of their anthers which are absent in sterile plants. Until harvest, removal of weeds and diseased plants, especially the quarantine ones, must be continued.

Dessication

In case of an untimely harvest, which can cause losses due to diseases, lodging, bird attacks or grain shedding, desiccation can be carried out with a 5% acetic acid solution. Depending on the hybrid, dessication can start when grain moisture drops below 35%.

Harvesting

Before harvesting, thoroughly clean the harvester and transport vehicles with a compressor or vacuum cleaner. It is best to start combine harvesting at a moisture content of 12-14%, which depends on the weather conditions, plot size and available capacity. Harvesting at grain moisture below 9% must not be allowed due to a risk of increased grain breaking and peeling. Reduce revolutions to a maximum of 400-500 per minute at a moisture content of 12-14%; lower moisture content decreases the number of revolutions. Secure maximum distance between the drum and the sub-drum, and adjust the opening of the screen so as to prevent multiple execution. An adapter for sunflower or corn should be used with some alterations. Remove tear-off rollers and mount the knives and the counter knife on the drive chains. Seeds must be transported to the reception center in closed vehicles immediately after harvesting.
The Rulebook on control and certification in organic production and organic production methods defines that if conventional production and organic production methods are applied at the same time, the producer is obliged to a spatial demarcation between areas under conventional and areas under organic production, i.e. to set up a hedge or other physical barrier to ensure demarcation.

Note: Some general principles of the organic sunflower seed production are listed here, while specific measures are applied during production depending on the specific conditions in the field.

IV Conclusion

Organic agriculture is developing rapidly in response to an increasingly poluuted environment, deterioration of food quality and increasing threats to human health. Consumption of organically produced food in developed countries is on the rise, while the supply cannot meet the growing demands. The developing countries such as Serbia, with optimum environmental conditions in rural areas, have the possibility to increase organic food production, place it on the international market, and obtain a much higher profit compared to the export of conventionally produced foods. Notably, organic products have a 25 to 30% higher price compared to conventionally produced foods. Foods obtained organically from unpolluted sources are in great demand in polluted countries. Our country is rich in clean natural resources (above all soil and water), which represent an opportunity for safe, organic production of sunflower seeds.

To prove that a product is organically produced, an agricultural producer of sunflower seeds must undergo a certification process, i.e. seed inspection and certification. The long-term goals are to offer organic hybrid sunflower seeds in addition to cultivation technology development. By introducing new NS hybrids into the production developed in accordance with the main principles of organic production, organic food users and producers will obtain significant quantities of organic products under high demand on domestic and world markets, increase exports and ensure the quality of the obtained products. Serbian government has also made efforts to protect Serbian traditional products and encourage organic production in the scope of various projects. All this effort may not be enough because research shows that yields in organic agriculture are lower than those of conventional agriculture; however, human health is a priorityt. On the other hand, new regulations reduce the number of pesticides and abolish many active substances in the conventional production of hybrid sunflower seeds, which makes it difficult to combat the existing and the new pests and diseases due to sudden climate changes. All this leads to the conclusion that there is an opportunity in Serbia to initiate and later increase the surfaces under organic sunflower seed production.

Four inspections are mandatory in the production of sunflower hybrid seeds:
- The first inspection is carried out at the stage of 6 to 7 pairs of leaves in order to determine the spatial isolation.
- The second inspection is carried out at full buttonization in order to determine the purity of the crop (removal of atypical plants).
- The third inspection is carried out at flowering in order to remove fertile plants in the male sterile component.
- The fourth inspection is carried out at physiological maturity in order to determine crop uniformity, the characteristic features of the typical plants of a hybrid line and evaluate seed yield.

Spatial isolation during the production of hybrid seeds must be at least 1500 m.

A crop of sunflower hybrid seeds will not be recognized as seed if:
- spatial isolation is lower than prescribed;
- crop was sown on a plot where sunflowers were present in crop rotation in the previous 5 years;
- in the flowering phase more than 1% of fertile plants have anthocyanin or are atypical for the production of lines and hybrids based on CMS;
- atypical plants above 0.3% are not removed before flowering;
- more than 0.5% of fertile plants are found in sterile form in the production of CMS lines and hybrids based on CMS male sterility at flowering;
- more than 1% of plants with atypical seeds are found in the production of parental components and hybrids at physiological maturity.

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ПРАВИЛНИК О КОНТРОЛИ И СЕРТИФИКАЦИЈИ У ОРГАНСКОЈ ПРОИЗВОДЊИ И МЕТОДАМА ОРГАНСКЕ ПРОИЗВОДЊЕ: http://www.minpolj.gov.rs/download/Pravilnik-o-kontroli-i-sertifikaciji-u-organskoj-proizvodnji-i-metodama-o....pdf

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ЛИСТА РЕГИСТРОВАНИХ СРЕДСТАВА ЗА ИСХРАНУ БИЉА И ОПЛЕМЕЊИВАЧА ЗЕМЉИШТА КОЈИ СЕ МОГУ КОРИСТИТИ У ОРГАНСКОЈ ПРОИЗВОДЊИ: http://www.minpolj.gov.rs/download/Lista-sredstava-za-ishranu-bilja-i-oplemenjivaca-zemljista-koji-se-mogu-koristiti-u-organskoj-proizvodnji-na-dan-07.04.2022.-godine.pdf

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SUSTAINABLE SUNFLOWER SUPLY CHAIN

FEASIBILITY STUDY ON SUNFLOWER SEED HULLS USSAGE IN CIRCULAR ECONOMY

by Igor Jezdimirović

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SUSTAINABLE SUNFLOWER SUPLY CHAIN

This feasibility study considers all relevant factors, including economic, technical, legal, and scheduling considerations, to ascertain the likelihood of completing the task successfully.

Contents

I Introduction

The concept of circular economy represents a regenerative economic system that aims to ensure a sustainable development of the global economy. The main goals of the circular economy are to reduce waste, minimize emissions of harmful substances, increase energy efficiency and enable long-term circulation of production materials. The circular economy is based on the idea that a circular model can be just as profitable as the previous linear model based on the paradigm: take from the nature - produce/use - throw away.

Unlike the traditional way of doing business, the circular economy places special emphasis on innovative thinking in all production processes, which results in extending the life of products and the possibility of recycling the already used products. In this way, consumers get certain satisfaction when using products and services, while at the same time ensuring environmental protection. This does not imply giving up on the achieved production results, but on the contrary – it allows for the maximization of profits and better utilization of production capacities while at the same time preserving natural resources.

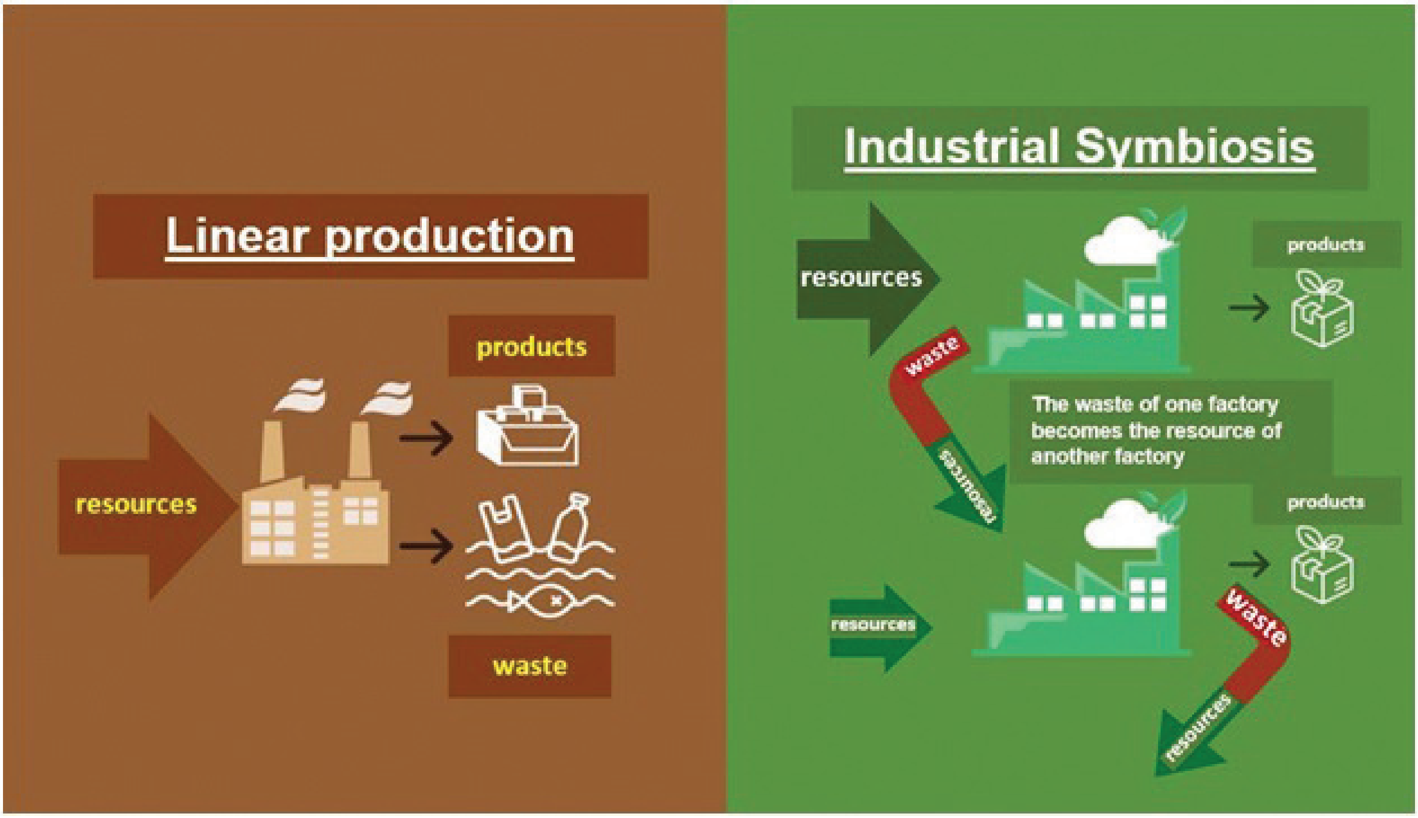

Figure 1. Linear and Circular Economy

The circular economy occupies a special place in agricultural production, which represents one of the major polluters in terms of the total emission of gases with greenhouse effects and the negative impact on natural resources. According to the latest data from 2020, agricultural production at the global level accounts for 23% of the total emission of harmful greenhouse gases (GHG) (IPCC, 2020).

Despite the complexity of the processes typical of agricultural production, it can be said that agriculture is very suitable for introducing the principles of circular economy as many products that are seen as waste in the traditional production model can be further utilized for energy production. Energy production based on biomass, which represents a surplus in plant production, and utilization of methane from livestock production, as well as production of compost or vermicompost using organic waste, are just some of the many possibilities of utilizing the by-products of agricultural production.

In accordance with the above-mentioned examples, the aim of this study is to find economically viable (i.e. in accordance with the principles of the circular economy) technical and technological solutions regarding the utilization of residual sunflower seed hulls in the agricultural company called "TIRA LLC" from Šimanovci, Republic of Serbia.

Bearing in mind the structure of the whole research study, this particular document represents just one part of it, with special reference to the legal regulations related to waste management and circular economy in the Republic of Serbia, as well as production features of sunflower seed hulls. The paper also aims to offer a possible solution regarding the utilization of by-products of sunflower production.

II Legal regulations in the Republic of Serbia

The concept of circular economy in the Republic of Serbia is relatively new, which means that the public is just getting acquainted with the principles and examples of this approach. Pre-accession funds of the European Union (EU) represent a significant incentive for the introduction of business methods in accordance with the principles of the circular economy. Therefore, the harmonization of national standards and regulations related to environmental protection, which derive from the economic policy of EU countries, is of particular importance.

The key document for the development of the circular economy of the EU countries was adopted in 2015 by the European Commission (EC), with the aim of widening the scope of new legal framework by incorporating investments that encourage the transition from traditional economy (linear economy) to circular economy. By doing so, the plan is to achieve the most efficient utilization of available resources, reduce environmental pollution, achieve financial savings and create new business opportunities where waste from one industry would become raw materials for another industry. This package of European regulations aims to contribute to the reduction and better disposal of waste, energy savings and reduction of resource consumption by 2030 (*Mitrović et al., 2017*).

The afore-mentioned legal regulations have been complemented by a document from 2017 entitled "Manifesto for a Resource-Efficient Europe" which clearly emphasizes that "*in a world with growing pressures on resources and the environment, the EU has no choice but to go for the transition to a resource-efficient and ultimately regenerative circular economy*" (MEMO/12/989). With the aim of complying with the EU legal regulations, the Republic of Serbia has accepted the recommendations of the EC regarding the circular economy, with the first step being the introduction of amendments to the Law on Waste Management ("*The Official Gazette of the Republic of Serbia", nos. 36/2009, 88/2010, 14/2016 and 95/2018 – as amended*).

Namely, the amendments to the law prescribe a number of measures within the framework of strategic documents, as well as a number of independent measures that represent significant support to the prevention of waste generation. The measures pertain to the design, production and consumption of products. The aim of these measures is to bring about the reduction of waste in the early stages of production by extending product life cycle, by reducing the number of hazardous substances in products, as well as by enabling the "easier return" of a product into life cycle after it becomes waste. The principle of prevention is one of the most important pillars of the circular economy and of sustainable development in general.

The amendments to the law have also introduced a new priority in the hierarchy of waste management, namely, the so-called preparation for re-use. This priority has been supported in the amendments to the law through a series of independent measures that the competent authority is obliged to undertake, referring to the introduction and strengthening of the product reparation system. Preparation for re-use implies the process of returning products or product parts that have become waste to the life cycle, with minimal investment. The new legal solutions have also introduced a number of independent measures related to improving the volume and the quality of recycling, through the establishment of a separate waste collection system, as well as a number of measures that should be elaborated in greater detail in strategic documents, and which should refer to the reduction of disposal of biodegradable waste to landfills by encouraging composting and anaerobic digestion. What is new in the legislative framework is the introduction of the terms "by-product" and "end-of-waste status", which mean the return of materials to production, i.e., the return of waste to the life cycle.

The amendments to the law detail the procedure by which any substance obtained in the production process, the aim of which was not to obtain that particular substance, is immediately entered into the register and given the status of a by-product. In this way, the law prescribes the procedure and conditions under which a substance acquires the status of a substance that can be further used as a raw material. The law envisages the following conditions for obtaining the status of a "by-product":

- that the substance in question was derived in the manufacturing process, but that the primary goal of that manufacturing process was not the creation of that substance;
- that its further usage is possible without further processing;
- that the usage of that substance is unquestionable;
- that it is a permitted substance, meaning that it does not endanger people's health or the living environment.

Mandatory documentation to be submitted with the application has also been prescribed. The burden of proof of fulfillment of all the prescribed conditions lies solely with the owner of the substance. After proving that all conditions have been fulfilled, the substance gets registered in the register. The register of by-products is a new type of register introduced by the latest amendments to the law. As part of the entire process of proving the status of a by-product, the law envisages the application of the guidelines prescribed by the European Union.

Legislation also elaborates the specific conditions and the whole procedure according to which waste can, after undergoing some repair and recovery operations, be entered into the register and receive the label "end-of-waste status", which means that it can be returned to the life cycle and used as raw material.

The law also prescribes the conditions for acquiring the end-of-waste status. The conditions for acquiring the end-of-waste status imply that the object or substance in question is typically used for special purposes, that there is an existing market and demand for such substances or objects, that the substance or object in question meets the technical requirements for special purposes and the conditions prescribed by the standards for those products, and that their usage does not have any harmful effects on human health and the environment.

The amendments to the law further distinguish and elaborate two procedures for assessing compliance with technical requirements and standards for products. The first procedure is performed by the owner of the waste substance himself/herself, the result of which is a formal self-declaration statement. The second procedure is carried out by the ministry responsible for environmental protection, based on which a Declaration of Product Conformity is made, all in accordance with the Law on Technical Requirements and Conformity Assessment for Products (*"The Official Gazette of the Republic of Serbia", No. 49/2021*).

In terms of the circular economy, the by-product can be said to be one step closer to the circular economy when compared to the end-of-waste status, because with the by-product, the raw material is obtained with a smaller investment. On the other hand, acquiring the end-of-waste status implies the undertaking of some repair and re-use operations first, in order to return the waste back into the life cycle.

The obligations of local self-governments contained in the amendments to the law, pertaining to the selection and separate collection of waste, are also a prerequisite for further strengthening of the important components of the principles of the circular economy. Currently, the Republic of Serbia follows the traditional production model and, evidently, a very poorly organized waste treatment system, estimated at 5-7%. Furthermore, the share of primary energy generated from renewable sources is about 21%, and there is a very low level of awareness of sustainable development and circular economy, characterized by the absence of an educational body dealing with circular economy and legislation (Mitrović et al., 2017). Therefore, the promotion of the circular economy accompanied by a positive example from practice would surely have multiple significance for the economy of the Republic of Serbia.

In addition to the direct benefits from efficient waste management for manufacturers, which would be manifested through the obvious improvement of production results, it is extremely important to set an example of good practice that would definitely encourage other manufacturers to shift to the concept of a circular economy. In this way, we wish to give a significant incentive for competent institutions to persevere in the process of introducing a modern and efficient business concept that, in the long term, would ensure a better standard of living for the entire population while preserving natural resources.

III Characteristics of the sunflower seed hull

Sunflower plants, along with soy and rapeseed, represent one of the most important oil crops in the world. In addition to participating in the production of edible oils, sunflower plants occupy a special place in the food industry due to the increasingly widespread use of dehulled sunflower seeds. Namely, dehulled sunflower seeds can be used as baked, raw, salted, unsalted, with the addition of various spices and, as such, have found their place in the production of numerous food products such as: special types of bread, cakes, ice cream, chocolate, various spreads, etc. (Dimić et al., 2017). It is possible to distinguish between two main types of sunflowers seeds: confectionery and oil-type seeds. Therefore, depending on the purpose of the produced sunflower seeds, the chemical composition, morphological and technical-technological characteristics of both the hull and the kernel itself differ accordingly.

Generally speaking, the confectionery sunflower seed type is characterized by larger dimensions and heavier grains compared to the oil type. The confectionery type of sunflower seed is characterized by a greater mass of the hull compared to the oil-type seed, while the oil type of sunflower seed is characterized by a larger share of the kernel mass in the total mass of the grain. Thus, it can be concluded that if we have a confectionery sunflower seed type as a predominant type in our sowing structure, this will result in significant amounts of sunflower hulls as a by-product, which according to the principles of the circular economy can be used as raw material for further processing. The average share of sunflower seed hull in the total mass of sunflower seed grain is 20-40%, depending primarily on the hybrid variety, as well as on the type of sunflower seed. Available studies and scientific publications related to the physical and chemical properties of the sunflower seed, mainly refer to the oil type of sunflower seed, having in mind its much wider usage in conventional agricultural production.

Nevertheless, certain characteristics do not show major deviations depending on the observed type of sunflower seed. The biggest deviation in terms of morphological properties between the confectionery and oil type is the share of sunflower seed hull in the total mass of the grain, where in the confectionery type the observed share can be up to around 40%. That being said, in the continuation of the study we will present the main properties of sunflower seeds with a special focus on the sunflower seed hull.

Physical and chemical properties of the sunflower seed hull

The sunflower is an annual plant from the aster or daisy family (lat. the family Asteraceae or Compositae). It is characterized by strong branched roots that penetrate deep into the ground, which in agrotechnological terms means that it tolerates drought better than other agricultural crops, primarily corn and wheat. In today's economic environment, due to the Ukrainian crisis and the insufficient amount of fertilizers on the market of agricultural inputs, the presence of sunflowers in the sowing structure of agricultural farms has proven to be an excellent choice as a means of overcoming the current crisis and achieving positive business results.

The sunflower stalk, depending on the hybrid variety, is between 1.5 and 3.5 meters high. After harvesting, sunflower stalks are usually chopped and plowed into the soil, which further enriches the soil with organic matter. The sunflower seed consists of a hull and a kernel, where the kernel is most often further processed and used for the production of sunflower oil. In addition to the production of sunflower oil, the dehulled sunflower seeds can also be used as raw, so they have their usage in the food industry. Regardless of the further use of kernel as the main product, the sunflower hull is a by-product that, through further handling, can be used as a raw material for some other type of production, most often energy production.

Figure 2. Sunflower seed (Source: https://www.agroportal.hr/ratarstvo/1714)

Based on the chemical and physical properties of the sunflower seed hull, it is possible to single out several different ways of further usage, which are primarily determined by its characteristics. The color of the sunflower seed hull, depending on the hybrid variety, can be white, black or striped. An overview of scientific publications related to the physical characteristics of sunflowers grown on the territory of Vojvodina, revealed that the number of seeds per plant, depending on the type of hybrid, is up to 1,500. The average weight (mass) of 1,000 seeds is about 80 g, the test weight (hectolitre mass) ranges from 45 to 50 g, while the realized yields range from 3 t/ha to 5.5 t/ha, which is the actual genetic potential of the plant for certain hybrid varieties. Table 1, presented below, provides insight into the physical properties of sunflower seeds.

Table 1. Physical properties of sunflower seeds

Property	**Values**
Number of seeds per plant	around 1,500
Weight (mass) of 1,000 seeds (g)	around 80
Test weight / Hectolitre mass (g)	45-50
Yield of sunflower (t/ha)	3.5-5.5

Source: Dimić et al.., 2017

As already mentioned, the share of sunflower hull in the total weight (mass) of sunflower grain ranges from 20 to 40%. The aforementioned share is somewhat bigger in the confectionery type of sunflower seed, which opens new possibilities for further utilization of sunflower hulls, which, in turn, means better utilization of available resources, and all this in accordance with the main principles of the circular economy.

Figure 3. Sunflower seed hull (Source: https://body.ba/)

When it comes to the chemical properties of the sunflower hull, it is possible to single out several components that participate to a greater or lesser extent in its composition, regardless of the type of sunflower. Due to the differences that exist between sunflower hybrids, the participation of their constituent elements can be best represented using intervals. First of all, there is a dominant share of raw fibers (cellulose), which ranges between 49 and 67%. On the other hand, nitrogen-free extracts account for between 25 and 40% of the total chemical composition. In addition to the above, the share of oil in the sunflower hull ranges from 2 to 5%, protein from 3 to 6%, waxes from 0.3 to 0.4%, while the share of unsaponifiable matter is between 22 and 24%. Table 2, presented below, provides insight into the chemical structure of the sunflower hull.

Table 2. Chemical composition of the sunflower seed hull

Chemical substance	**Share or proportion in percentages**
Oil	2-5%
Proteins	3-6%
Unsaponifiable matter	22-24%
Cellulose	49-67%
Nitrogen-free extracts	25-40%
Waxes	0.3-0.4%

Source: Authors own representation

Nutritional and calorific values of the sunflower seed hull

Sunflower seeds have a pronounced calorific value, so 100 g of sunflower hulls contain up to 600 calories. Table 3, presented below, provides an insight into the nutritional values of the sunflower seed, with values calculated as per 100 g of sunflower seeds. Obviously, fats dominate, followed by proteins and carbohydrates, while sugars and fibers are also present in smaller amounts

Table 3. Nutritional values of the sunflower seed per 100 g of sunflower seeds

Chemical substance	Value
Proteins	21 g
Carbohydrates	20 g
Sugars	2.6 g
Fiber	9 g
Fats	51 g
Of which saturated fats	4.5 g

Source: Author's own representation

In addition to the above, the sunflower is rich in B complex vitamins, vitamin E, beta carotene and vitamin B6. When it comes to minerals, the sunflower contains copper, magnesium, selenium, zinc, manganese, potassium and phosphorus.

On the other hand, the calorific value of the sunflower hull depends on the moisture content, so a lower percentage of moisture is accompanied by a higher calorific value. Depending on the moisture content, the average calorific value ranges from 12,900 to 18,200 J/g. When it comes to the average heating values required to burn sunflower hulls, quite logically, a higher moisture content results in greater heating values required for combustion. Depending on the moisture content, the average heat of combustion ranges from 14,700 to 19,750 J/g. Table 4, presented below, provides an insight into the average heat of combustion and the average calorific value expressed in J/g according to the different moisture content of sunflower hulls.

Table 4. Average heat of combustion and average calorific value for the corresponding moisture content of sunflower hulls

Moisture	Average heat of combustion (J/g)	Average calorific value (J/g)
32.0 (%)	14,700 – 15,300	12,900 – 13,400
16.0 (%)	17,750 – 18,050	16,050 – 16,400
9.0(%)	19,350 – 19,750	17,800 – 18,200

Source: Maj et al., 2017

Organic production of sunflower

Generally speaking, organic production represents a system of ecological management of crop production that pays special attention to the improvement of biodiversity, natural circulation of matter and biological activity of the soil. Bearing in mind the characteristics of sunflower and the reduced need for mineral fertilizers compared to other field crops, it can be said that sunflower is very suitable for organic agricultural production. More significant differences compared to conventional sunflower production are present when using plant protection products.

Although organic sunflower production requires a higher level of work organization, as well as continuous learning about the principles of organic production, the direct benefits are very obvious, bearing in mind that the prices of organic agricultural products are higher by 25 to 30% compared to products from conventional production. Additionally, if one takes into account the planned diverting from the traditional way of doing business towards doing business in accordance with the principles of the circular economy, organic sunflower production gains special importance due to numerous possibilities for manipulating by-products such as sunflower hulls.

It is important to point out that in terms of the physical and chemical properties of sunflower hulls, as a raw material suitable for further utilization, the method of agricultural production has no decisive influence. Therefore, regardless of the method of sunflower cultivation, the manipulation and further utilization of sunflower hulls remain unchanged. Nevertheless, the willingness to organize organic sunflower production clearly indicates the ability to fully respond to all the principles of the circular economy. In this way, we arrive at the conclusion that after the production of organic sunflower, the next logical step is the handling of the sunflower seed hulls so as to utilize the available resources to the greatest possible extent and provide additional energy sources which are in line with the principles of environment preservation and protection.

IV Economic viability of using sunflower seed hulls

The economic viability of using sunflower hulls depends on numerous parameters related to the way of using the observed sunflower hulls, the available quantities, as well as the available resources on a certain farm estate or in a particular agricultural enterprise. Since sunflower hulls are often used for the production of additional energy, the demands for heating may be quite significant for such a farm or agricultural enterprise.

The idea of using by-products of agricultural production, such as sunflower hulls, is based on the need for better utilization of available resources with the acquisition of only the most necessary elements. Since in the process of sunflower production we get sunflower hulls as a by-product, two ways of its further manipulation are possible, which primarily depend on the available quantities. If the available quantities are small, possible investments in additional facilities that would serve for the manipulation of sunflower hulls can significantly increase fixed costs, further burdening the company's financial results. Under such circumstances, the only cost-effective solution would be further distribution of the obtained by-products that can be used as the input raw material for further processing in another production system. On the other hand, if the quantities of available sunflower hulls are at a satisfactory level, there is a possibility of reducing the existing costs with better utilization of the available production capacities.

Generally speaking, better utilization of the available production capacities can be achieved through a higher degree of utilization of storage space, as well as labor force, which would improve the productivity of work in that production system. Depending on the chosen method of processing the obtained sunflower hulls, the reduction of costs would primarily be achieved through the reduction of costs intended for the purchase of inputs. In this way, if livestock production is present in that production system, savings would be achieved by reducing the cost of purchasing animal feed (specifically: sunflower meal). Savings in plant production are possible if the existing by-product would be used as organic fertilizer. Additional savings can be expected if the available quantities were used as input raw materials for some other form of production, such as, for example, mushroom production. However, as examples from practice most often show, the best effects are achieved through the production of thermal energy (or heat energy), which significantly reduces the costs otherwise incurred for heating.

However, if we wish to use sunflower hulls as an input raw material for the production of heat energy, it is necessary to have larger quantities of this by-product. Buying the necessary technological equipment, i.e., boiler automation system, can present an additional problem as it is a relatively big investment, which in today's business conditions represents a special challenge in itself.

In accordance with the above, in order to make a final decision regarding the further manipulation of sunflower hulls and in order to make a realistic calculation of the economic viability/profitability of using the observed by-product, it is necessary to collect the relevant information regarding the organization of agricultural production on a farm or in an agricultural enterprise. The key information includes the following:

- The volume of sunflower production, i.e., the average share of sunflower in the total sowing plan on a multi-year level;
- Available quantities of sunflower hulls;
- Available storage space;
- Current practice related to sunflower hull manipulation;

To the mentioned list of necessary information, it is important to add a detailed sowing plan for the observed production system, all in accordance with the business plan for the next period, as well as the need for thermal energy during that calendar year. For example, the possible presence of livestock production can trigger the decision to use sunflower hulls as feed for livestock, the observed market niche can trigger the decision to use sunflower hulls in the production of shiitake mushrooms, whereas the existence of significant quantities of sunflower hulls can make us decide to use it in the production of heat energy, etc.

V Possible solutions regarding the usage of sunflower seed hulls

As already mentioned, the further processing of sunflower hulls depends primarily on the characteristics of sunflower production on the observed farm or agricultural enterprise. In the majority of cases from practice, sunflower hulls find their application as raw material for the production of thermal energy. In addition to the above, sunflower hulls can be used for feeding domestic animals, for the production of organic fertilizers, specifically compost, as a substrate for the production of mushrooms, etc. To sum up, different possibilities regarding sunflower hull utilization can be systematized according to different technical and technological solutions, as presented in Table 5 below:

Table 5. Possible solutions regarding the usage of sunflower seed hulls

Usage of sunflower seed hulls	Purpose
Burning of sunflower seed hulls	Production of thermal (heat) energy
Briquetting of sunflower hulls	Production of thermal (heat) energy
Pyrolysis	Production of thermal (heat) energy
Production of organic fertilizer (compost)	Poultry bedding / plant food
Mulching	Plant protection in vegetable farming and gardening/ horticulture
Substrate production	Mushroom production

Source: Author's own representation

In the continuation of the text, we will give a brief overview of different technical and technological solutions regarding the manipulation of sunflower hulls.

Burning of sunflower seed hulls

In the developed countries of Western Europe, there is a high awareness of the necessity of reducing harmful emissions during the process of burning different energy sources such as: coal, oil, natural gas, etc. Depletion of fossil fuel reserves and deterioration of the environment have repeatedly been cited as leading problems when using conventional energy sources. Bearing in mind the principles of circular economy, it is necessary to pay special attention to the new possibilities that sunflower hull processing offers in terms of replacement of conventional energy sources.

The oldest and also the simplest way of producing energy from biomass is combustion. The advantages of using biomass as an alternative energy source is the reduction of greenhouse effects because carbon dioxide from the atmosphere binds to biomass. Although the biomass burning process also causes harmful substances, their participation is 90% lower compared to conventional energy sources. Generally speaking, biomass as an energy source participates with 10-14% in the total energy supply and is the fourth most important energy source after coal, oil and natural gas. As such, biomass is used for the production of electricity or, most often, thermal energy, as fuel for the transport sector, or raw material for the chemical industry (Marković and Spasojević-Brkić, 2010).

In order for biomass (in this case: sunflower hulls) to be burned with the purpose of generating some form of energy, it is necessary to have a boiler automation system of appropriate capacity. The capacity of boilers in which the sunflower hulls can be burned primarily depends on the available amount of sunflower hulls and the existing heat energy and/or electricity needs. Hence, the investment in facilities and the installation of necessary equipment depends on the chosen technical-technological solution. As the residues from plant production present a by-product which certainly exists in the business system, if the necessary quantities are available, that would bring a significant reduction in the overall cost of purchasing energy sources. In this way, it is possible to achieve considerable savings, which have a positive impact on the financial results of the entire business system.

The first large-scale boiler in our region, which uses sunflower hulls as fuel, was installed in Sremska Mitrovica in 2012. The nominal production of the boiler is 18 MW, while the maximum hourly consumption of the boiler is 4,400 kg/h for sunflower hulls. The estimated annual consumption is between 6,200 and 7,000 tons of sunflower hulls.

As we speak about the consumption of sunflower hulls for the production of thermal energy in industry or on farm estates, the entire process must be viewed from the aspect of the use of agricultural production residues in general, taking into account the harvest residue of crops such as wheat, corn, soybeans, barley, rye and oat. The reason why it is not a good idea to analyze the importance of sunflower hulls in isolation, independent of the remains of other agricultural crops, is the available amount of sunflower hulls. Bearing in mind the characteristics of agricultural production and the necessary presence of crop rotation, it is highly improbable that one farm or agricultural company has sufficient quantities of sunflower hulls and sunflower harvest residues that can solely be relied on in the process of heat energy production.

Direct burning of biomass can be performed in the reconstructed energy plants using liquid fuels (heating oil and mazut) and solid fuels or by combustion in plants that use various kinds of biomass as basic fuel. The total costs of the energy plant system on the example of a 1 MW boiler, together with the appropriate facility are in the range: 250,000 - 400,000 EUR, while the total costs of an equivalent energy plant which works on heating oil or gas are around 150,000 EUR. Although investments in energy plants that rely on biomass are initially higher, the achieved benefits are long-term ones, because after the investment costs are paid off, the costs of the inputs necessary for the production of thermal energy are significantly reduced.

It is generally believed that the funds invested in these programs become profitable within three to four years, while the economy of the overall business of the user increases. In this way, fuel procurement costs are reduced down to a minimum, because the necessary supplies come from one's own waste raw materials. This brings economic as well as technological security of the user. When we talk about the technological security of users, we primarily mean greater energy self-sufficiency of technological processes, which greatly reduces the risk of overall production. As a final step in the development of combustion technology, it is possible to start a specialized production of biomass intended exclusively for the needs of energy production. The economic benefits of this process are the subject of numerous analyses, and there are already developed solutions for its assessment (Walsh & Becker, 1996).

Briquetting of biomass

While direct burning of biomass is the process by which investors ensure their own supply of thermal energy, the process of briquetting biomass is intended for the supply of other users (mainly the individual sector). In order for biomass to become suitable for this form of usage, its energy needs to be concentrated (compressed) and converted into a shape and size suitable for manipulation and transport. In this way, the use of biomass becomes available to a larger number of users. In other words, it becomes a commodity that can participate in market transactions with additional processing, transportation and turnover costs. For these reasons, this procedure is applied only where biomass cannot be used near its place of production, i.e. the place of collection, since it is most often created as a by-product.

The technological and technical procedures for the production of briquettes from biomass have been solved in practice both in the world and in our home country, but the question of their economic efficiency and competitive advantage compared to other energy sources is still uncertain, which is why they are still in the phase of testing and justifying suitability for practical application.

Equipment and processes for burning pellets and briquettes do not differ significantly from those intended for burning wood. However, pellets and briquettes are of uniform dimensions, so it is easier to automate these processes. Research in the world is also moving in the direction of developing systems intended for obtaining energy in rural areas, while striving for the maximum autonomy of the system (Bass, 2001). In this case, we are talking about small fireplaces intended for individual households. Alongside with such research work, there are also research studies that combine the biomass production in plantations with briquetting technologies based on high-volume production (Hitoshi et al., 2001).

The main advantage of sunflower hull briquettes compared to other energy sources is that 1 ton of briquettes can replace 1.6 tons of wood fuel, 530 m3 of gas, 500 liters of diesel fuel, or 785 liters of heating oil. Also, the burning of briquettes is considered more energy efficient, because the ash content is about 3%. An additional advantage is that sunflower hull ash is not considered waste, but can be used as a fertilizer in vegetable farming and gardening (horticulture).

The wholesale price of sunflower hull briquettes is around 100 EUR per ton, while the retail price is slightly higher and reaches the price of up to 0.2 EUR per kilogram.

On the other hand, the production costs of briquettes and pellets depend on the type of raw material, the method and techniques of collection, transportation and storage, the type of pressing line, pressing technology, the type of packaging, the performance of the production line, the number of hired workers, the value of the construction facility and equipment, interest on loans, etc. The final product is most typically obtained as a combination of different types of raw materials, so the costs for the installation of the necessary equipment also vary.

On the example of the company "Varotech" from Mladenovo, near Bačka Palanka, the total value of the investment in a briquetting production plant with a capacity of 15 tons/hour was EUR 1,100,000.00. The price of the briquetting press machine of the Danish manufacturer was about EUR 140,000.00, other equipment cost about EUR 150,000.00, the cost of buildings/ facilities was about EUR 300,000.00, while the construction of the electrical substation cost about EUR 30,000.00. To the total value of the investment, it is necessary to add the price of the necessary machinery, which consists of tractors, balers, loaders, forklifts and trucks. The production price of briquettes in the factory is around 90 EUR/ton. The mentioned production price of briquette per unit of measure is approximately the same even for smaller production capacities, with the fact that smaller producers ensure their competitive position on the market by packing briquettes in smaller sacks (30 kg) and selling them at a retail price which is higher per unit compared to the wholesale price.

Pyrolysis

Pyrolysis represents the thermal decomposition of fuel into liquids, gases and coke residue, without the presence of oxygen. It usually happens without water. The pyrolysis products can be used as fuels, with or without prior upgrading, or they can be used as raw materials for the chemical industry or the materials sector. Due to the nature of the process, the yield of useful products is high compared to other processes. Pyrolysis products are increasingly being refined and therefore can be used with greater efficiency. The pyrolysis process involves the use of fuels such as: coal, animal and municipal waste, food waste, paper, cardboard, plastic, rubber and biomass. There are three basic types of pyrolysis processes that differ in terms of temperature and biomass residence time, namely: slow, fast and flash pyrolysis.

In addition to the above, it is important to point out that there are several types of reactors for pyrolysis. The most commonly used are the bubbling fluidized bed reactor, the rotating cone reactor, the circulating fluidized bed reactor, and the vacuum pyrolysis reactor (Brankov, 2016).

In more specific terms, pyrolysis of agricultural biomass should be viewed from the aspect of thermal processes of conversion of agricultural biomass aimed at energy production, which relies on alternative sources. Therefore, the investment in facilities and the necessary equipment depends on the available amount of biomass, in this case sunflower hulls, which is most often combined with other by-products of agricultural production.

The pyrolysis of agricultural biomass is considered a complex process for obtaining heat energy. At the Institute for Agricultural Technology of the Faculty of Agriculture in Novi Sad, an experimental plant for the gasification of corn husk has been built and the initial results of this research have been obtained. The goal of this research was to obtain gaseous fuel from solid biofuel using a gas generator. It has been found that the lack of gasification (gas generation) of biofuel implies an increased amount of loss during fuel conversion. For this reason, this form of biomass utilization has not yet found significant application in practice, so at this point it is better not to make economic assessments of the feasibility of investing in plants in which thermal energy will be produced on the basis of pyrolysis.

Sunflower seed hulls as organic fertilizer (compost)

In addition to energy production, sunflower hulls can be used as organic fertilizer. Most often, if there are smaller quantities of sunflower hulls available, i.e. not sufficient to serve as an alternative source of energy, the sunflower hulls are, instead, used as organic fertilizer and, as such, widely applied primarily in vegetable farming and gardening/horticulture. There are several ways of converting sunflower hulls into organic fertilizer, one of which is the production of compost.

Compost represents organic matter which has decomposed aerobically. Organic matter gets decomposed through the action of various microorganisms and, thus, turns into organic fertilizer that plants can easily absorb.

Compost serves as a growth medium, or as a porous, absorbent material, which retains moisture and soluble minerals, providing protection to the nutrients necessary for most plants to thrive. When making sunflower hull compost, it is recommended to mix it with manure or chicken droppings. Accordingly, sunflower hulls can be used as bedding in poultry farming, which results in the mixing of sunflower hulls and chicken droppings. Microorganisms that break down cellulose, which is contained in the sunflower hull, need a large amount of nitrogen to maintain their vital activities. In this way, the presence of manure will cause certain chemical reactions, and the hull will be processed into organic fertilizer readily available for plant nutrition.

When it comes to the possible use of sunflower hulls as bedding in poultry farming, it is necessary to point out that the choice of material for making bedding largely depends on the price, but also on the region where the production is organized. Therefore, if significant quantities of sunflower hulls are available, it can be used as an adequate substitute for pine shavings, which is considered the best bedding solution for raising poultry, but is unavailable on the market for many producers in Europe. The advantage of sunflower hulls as poultry bedding is reflected in their low percentage of humidity, the appropriate pH value, as well as the morphological characteristics that do not damage the foot pads of farmed poultry. The disadvantage of sunflower hulls as bedding is the need for additional shredding, which increases the cost of handling this type of by-product. Another disadvantage is its relatively slow absorption of moisture. If the bedding is dry, then it is 3-5°C warmer than the air in the room, whereas if it is wet, then it is 2-3°C colder than the air in the room. The depth of the poultry bedding for young poultry ranges from 6 to 15 cm, and due to the need for replenishment during breeding, it will eventually be about 20 cm thick (or deep) at the end of breeding. Bedding requirements during one cycle range from 0.5 to 0.7 kg per chicken.

In order to make the highest quality bedding used in poultry farming, it is most often formed in combination with other by-products of agricultural production, such as straw, corn cobs, etc. The price for 1 kilogram of poultry bedding is around 0.1 EUR per kilogram. The preparation of sunflower hulls for poultry bedding involves shredding and possibly packaging. The price of a small-capacity biomass chopper (15 kg/min) is around EUR 1,000.00. On the other hand, packaging can be done in jumbo bags of different capacities, the price of which ranges from 2 to 7 EUR/bag.

Therefore, in addition to the use of sunflower hulls as bedding in poultry farming, an additional benefit can be achieved by further utilization of manure mixed with sunflower hulls as an organic fertilizer. Speaking of that, it takes 1 year for compost to mature. As a result, we get a crumbly, dark brown substance, called humus. Humus is introduced into the soil at a depth of 7-10 cm, after which it enriches the soil and improves its structure. Finally, the price of chicken manure on the market is around 20 EUR/t.

Mulching

In addition to producing compost, sunflower hulls can also be used as a material for mulching plants. Similar to the application of compost, mulching is most often used in vegetable farming and gardening. In particular, sunflower hulls are considered one of the most suitable materials for mulching plants. The covering of soil by mulching is a method aimed at soil protection, especially for the underground part (roots) of the plant from low temperatures, if it is used in the autumn-winter period. This drastically reduces the risk of the plant dying at the first cold or frost. If, on the other hand, it is used in the summer period, mulching prevents the loss of moisture from the soil through evaporation, and thus water remains in the soil and is available to the plant. Another aspect to consider is reduced weed growth. Thanks to mulching, weeds can neither breathe properly nor receive light. This prevents their survival, favoring the growth of the desired crops without the risk of competition. Mulching also reduces leaching of nutrients, keeping them closer to the crop roots, improving their phytosanitary conditions and preventing the presence of bacteria, viruses and soil nematodes. It also positively affects the volume, health, quantity and quality of plant production.

When applying sunflower hulls to the surface layer of the soil, it is to be expected that the hulls will slowly begin to decompose, and after the decomposition, the soil will be enriched with useful microelements. However, when mulching, especially with sunflower hulls, it is necessary to be careful because a lack of nitrogen in the plant is to be expected. Compost production and mulching with sunflower hulls is mainly used on smaller farms, oriented towards the production of vegetables and gardening/horticulture.

The cost of preparing sunflower hulls for subsequent mulching includes practically only the packaging of the said biomass in appropriate bags. As already mentioned, depending on the available quantities of sunflower hulls and the bags of different dimensions, the price per jumbo bag ranges from 2 to 7 EUR.

Sunflower seed hulls as a substrate for mushroom production

Sunflower hulls can also serve as a substrate for mushroom production. The use of sunflower hulls in the production of mushrooms implies the making of a substrate, which contains sunflower hulls in addition to straw and sawdust. In this way, the production of mushrooms is carried out in boxes, bags, pallets or shelves filled with the previously formed substrate.

However, it is necessary to keep in mind that the use of sunflower hulls to createa substrate for the production of mushrooms is most often typical of agricultural households which organize the production of mushrooms as a supplementary source of income. The manipulation of large amounts of sunflower hulls in the process of mushroom production is related to the industrial production of mushrooms. The retail price of the substrate for the production of mushrooms is around EUR 0.3 per kilogram, but we have to bear in mind that the substrate includes other ingredients besides sunflower hulls, so we cannot properly evaluate its share in the total value of the substrate.

VI Business operations of "TIRA LLC"

"TIRA LLC" has been engaged in the import of raw materials, as well as their dehulling, selecting, baking and packaging for many years, both for its own needs and for providing various services to third parties. When we analyze in particular the processing of sunflower seeds, in the past period the company has been developing cooperation with a large organic sunflower producer with the idea of exporting the final product to the Swiss market. If everything goes as planned, the annual quantities would amount to around 48,000 kg of sunflowers. In addition to the sunflower hulls, during the selection and dehulling of the other raw materials, secondary fractions that can have their own use value appear.

In order to obtain the most accurate data on the products created after the selection and dehulling process, "TIRA LLC" carried out, for the needs of "LOGIN EKO", a test selection and dehulling of 1000 kg of sunflower plants on 11 November 2022. Based on the obtained results, the following conclusions and estimates have been given about the products that would result from the dehulling of 48,000 kg of sunflowers.

During the selection of organic sunflower kernels, 7% of the total mass were small fractions which were not suitable for dehulling.

The fractions obtained during the selection process are classified according to their size expressed in millimeters:

- 0.20% of fractions with the size of 10 mm
- 2.90% of fractions with the size of 2.75 mm
- 2.20% of fractions with the size of 3 mm
- 0.80% of fractions with the size of 3.20 mm,
- while 0.90% of the total quantity can be accounted for by dust, difference in measurement, breakage, etc

After the selection, 93% of the remaining quantity was dehulled and the following results were obtained:

- 49.78% of sunflower kernels
- 39.68% of sunflower hulls
- 1.18% of waste from the gravity table
- 0.91% of sortex waste
- 8.44% of the quantity can be accounted for by various dust, broken fractions and differences in measurement.

From all of the above, it can be concluded that the biggest limitation in dealing with sunflower seeds is storage space, so "TIRA LLC", when providing the service of dehulling sunflowers, obliges clients to take over all other side products together with the kernels.

Looking at the obtained data, we can expect with great certainty that the planned annual production of 48,000 kg in the selection process would give:

- 44,640 kg of sunflower kernels suitable for dehulling
- 96 kg of 10 mm fractions
- 1,392 kg of fractions with a size of 2.75 mm
- 1,056 kg of fractions with a size of 3 mm
- 384 kg of fractions with a size of 3.20 mm,
- 432 kg accounts for waste dust and broken fractions, with the calculated difference in measurement

After dehulling, the following quantities are expected to be obtained:

- 22,224 kg of sunflower kernels
- 17,712 kg of sunflower hulls
- 528 kg of waste from the gravity table
- 408 kg of sortex waste
- 3,768 kg of various dust and broken fractions, including the differences in measurement.

As has already been stated, the planned annual production amounts to 17,712 kg of sunflower hulls, which would be packed in jumbo bags with a capacity of 110 to 115 kg. The total required number of jumbo bags would thus be 177. Therefore, the main reason why "TIRA LLC" obliges its partners to also take the resulting by-products after dehulling sunflowers is the limited storage space. An additional problem is that the truck used for transportation can only fit about twenty of the mentioned jumbo bags at a time, so the transportation process is complicated and demanding - both logistically and economically. There is also the possibility of using a tipper truck, in which greater quantities of sunflower hulls could be placed and transported, but in bulk. In that case, the issue of further manipulation and storage of sunflower hulls would have to be resolved, but the number of trucks and transport tours would be smaller - because sunflower hulls have a large volume, but a small weight.

Bearing in mind the fact that "TIRA LLC" is not engaged in the production of sunflower, but only provides dehulling services, it is necessary to make a detailed plan for the further manipulation of waste generated in the dehulling process, which depends primarily on the sunflower supplier, who has the obligation to take all the residual fractions which remain after the selection and dehulling process. Here it is necessary to take into account the following calculation: with the dehulling capacity of 400 kg/h, for 8 working hours, the achieved daily quantity can amount to 1,270 kg of sunflower hulls during the campaign, i.e. about 12 jumbo bags per day, which implies that a fast and efficient way of taking over and transporting sunflower hulls are of great importance for the smooth and normal functioning of business activities.

VII Conclusion

Bearing in mind the different ways of using sunflower hulls as a by-product of plant production, the conclusion is that the best effects are achieved by using it for energy production purposes. In the Republic of Serbia, there are numerous examples of the use of sunflower hulls for the purpose of energy production, primarily for thermal, i.e. heat energy. In this way, we achieve savings in terms of the procurement of certain energy sources, and we can better utilize the available production capacities while increasing the productivity of labor force on farm estates or in agricultural enterprises.

Before investing in the necessary facilities and equipment it is necessary to develop the appropriate technical and technological solutions, as well as to perform an economic feasibility study aimed at quantifying the benefits of using agricultural biomass. In that regard, it is almost impossible to create a single general model for energy production within a business system. Rather than that, the right technical and technological solution must be found and an economic feasibility study must be carried out in accordance with the specifics of the production facility which will be dealing with further utilization of sunflower hull.

For specific answers regarding the economic profitability of the continued utilization of sunflower hulls, it is first necessary to have precise information regarding the available quantities of sunflower hulls over a longer period of time, the amount of storage space available, the annual needs for thermal energy, and also the participation of plant waste of other agricultural crops.

One of the most commonly used solutions in practice is the use of sunflower hulls for the production of thermal energy. However, in order to implement such a project, it is necessary to dispose of larger quantities, which is not the case with "TIRA LLC". With respect to this fact, the possibility of heat energy production must be excluded.

An additional challenge for the company's operations in the coming period is potential cooperation with small agricultural producers, i.e., agricultural farms. One of the organizational solutions can be the acquisition and installation of a mobile sunflower hull separator, which could be used to perform the dehulling of sunflower seeds by going to the agricultural producer's farm. In this way, the sunflower hulls would remain on the farm of the agricultural producer and would not be subject to further handling of "TIRA LLC". Speaking of that, the price of a mobile separator by a Chinese manufacturer costs around EUR 5,000, but here it is necessary to further consider the shipping costs and, generally, the possibilities of ordering such a machine and its regularly scheduled service and maintenance.

On the other hand, although the organizational solution set up in this way could solve the problem of manipulation of sunflower hulls from the company's point of view, it is not expected that agricultural producers will find their interest in terms of engaging external persons who would provide dehulling services for them. The main reason that leads to this assumption lies in the characteristics of the sunflower itself or, more specifically, its morphological characteristics. Namely, because of their high oil content, sunflower seeds are not recommended to be stored for a longer period of time, unless the storage is organized in specially equipped silos. Instead, they should be delivered to oil mills or large buyers in a relatively short period of time after harvesting.

Therefore, it is not a common practice to store sunflower seeds for a long period of time, as is the case with wheat or corn. Also, the question arises as to what small agricultural producers would do with the sunflower hulls that would remain on their farm, given that the remaining quantities would not be sufficient for any further utilization, such as heat energy production. Therefore, a much simpler solution from the point of view of agricultural producers is to sell the available quantities to oil mills or sunflower trading companies, because in this way they can benefit from the entire quantities of sunflower together with the by-products.

From the perspective of "TIRA LLC" company's business, the current practice of requiring clients to take over sunflower seeds as the main product as well as all other by-products seems to be the most effective one. In the case of choosing to retain the sunflower hulls, it is necessary to consider the option of obtaining biomass also from other by-products created during the dehulling of other raw materials. In this way, larger amounts of plant waste would be generated, with which it would be more reasonable to organize further manipulation.

Moreover, further analysis of the market offers the possibility of a more diversified disposal of waste generated after dehulling sunflowers through cooperation with farms that organize the production of vegetables, mushrooms, poultry, etc. In addition to the above, it is also possible to consider the option of marketing the available quantities to producers of thermal energy or briquettes. However, even in such a situation, it is necessary to provide the appropriate storage space, and also to define the price of plant waste that would be acceptable for the company, that is, that would not additionally burden the business.

In the case of briquetting sunflower hulls, the value of the investment in the necessary equipment and facilities depends on the available quantities and the possibility of placing the produced quantity of briquettes. The production cost of 1 ton of briquettes is around 90 EUR/ton, while the wholesale price of manufactured briquettes is around 100 EUR/ton, or 0.2 EUR/kg in retail.

By analyzing the possibilities of further manipulation of sunflower hulls, it has been established that if sunflower hulls are to be used for the production of organic fertilizer, it is best to mix them with chicken manure. This practically means that the sunflower hulls should first be used as bedding in poultry farming. In order to make the highest quality bedding used in poultry farming, sunflower hulls are typically combined with other by-products of agricultural production, such as straw, corn cobs, etc. The price for 1 kilogram of poultry bedding is around 0.1 EUR per kilogram. Preparation of sunflower hulls for poultry bedding involves shredding and possibly packaging. The price of a small-capacity biomass chopper (with capacity of 15 kg/min) is around EUR 1,000.00. Packaging can be carried out in jumbo bags of different capacities, the price of which ranges from 2 to 7 EUR/bag,whereas the price of the formed chicken manure is around 20 EUR/ton.

If sunflower hulls are used for mulching plants in vegetable farming and gardening, it has been established that the preparation of sunflower hulls for subsequent mulching involves practically only the packaging of the said biomass in appropriate bags. As already mentioned, depending on the available quantities and having the appropriate bags of different dimensions, the price per jumbo bag ranges from 2 to 7 EUR.

When it comes to the utilization of sunflower hulls for the production of substrate for mushroom growing, it has been established that this way of manipulating sunflower hulls is more suitable for agricultural farms where agricultural production is already organized and where mushroom production is just an additional business activity. This is explained by the fact that the sunflower hulls participate only as one part of the total mass of the required substrate, so further calculation related to sunflower hulls is not so significant.

The same can be said about the use of sunflower hulls in the pyrolysis process, as part of the thermal energy production. Since, in our region, there is no recorded case of using sunflower hulls in the pyrolysis process, this method of utilizing sunflower hulls remains a theoretical consideration. Given that the research carried out so far has mainly been focused on technological solutions for the manipulation of agricultural biomass as a whole, it is not possible to perform a detailed calculation related to the use of sunflower hulls in the pyrolysis process.

When it comes to other by-products obtained after the dehulling of sunflower hulls, which comprise tiny fractions, the only solution is to use this type of waste as organic fertilizer (depending on their degree of purity) or possibly as an additive in the process of burning biomass, all with the aim of producing heat energy.

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Vojvodina organic cluster

SUSTAINABLE
SUNFLOWER
SUPLY CHAIN

FEASIBILITY STUDY ON SMALL SCALE FARMER INTEGRATION FOR MERCANTILE SEED PRODUCTION

MSc Tanja Vujanov, Miloš Rajković PhD and Jovana Kremenović

Feasibility study responsible part:
Vojvodina Organis Cluster

www.vok.org.rs

This feasibility study considers all relevant factors, including economic, technical, legal, and scheduling considerations, to ascertain the likelihood of completing the task successfully.

Contents

I Potential risks for integration of small-scale farmers in mercantile sunflower production

Due to the delay in the start of the OT4D/PPP Sustainable and climate resilient sunflower value chain and corresponding innovative climate resilient production systems project several occurrences led to the fact that individual organic farmers (small scale) were not able to produce confectionary sunflower in vegetation season 2022 according to the set criteria.

The following facts have led to a shift in the possibility of sunflower production by individual farmers for the 2023 growing season. The fact that sowing plans must be submitted by farmers to a competent ministry by March of the current year; the fact that sunflowers sowing dates are from the beginning of April (even end of March in some years, if weather conditions allow); unpredictable growth in prices of agricultural products under the influence of the situation in Ukraine, as well as huge growth in input prices and services from the beginning of 2022.

The above are also possible risks for vegetation season 2023, together with the fact that the smallest amount for the finishing process required by the processor company Tira is 10 tons per producer meaning that, if we take into account that yields are from 1.5 to 2 tons per hectare, each producer needs to allocate between 5 and 7 hectares of land. However, in conversation with the Tira company, a solution was suggested allowing individual producers to deliver and process even a smaller quantity than 10t, provided that they do it on the day when the confectionary sunflowers of the LoginEko company are unshelled and packed.

Price competition with neighbouring countries can be a potential risk considering that subsidies for crop production in Serbia are not high. The delivery schedule (possibility for more than one delivery to buyer) is also a potential risk having in mind that majority of the individual producers do not have their own storage.
Bio Suisse certification and adaptation can be an additional investment for farmers, so they demand guaranteed purchase, meaning agreement signing. Eventual trainings, which are also foreseen by the project, will be needed.

The financial incentives foreseen by the project for certification and storage, however, help producers to opt for sunflower production, despite their claim that sunflower cultivation is not profitable compared to corn and soybeans. A further concern of theirs is that the placement or alternative use of sunflowers, in case they do not meet the standards and requirements of the Halba company, is not as certain as when they produce some other field crops.

II Identified potential farmers from VOC members

VOC members database indicates farmers engagement in vegetables, fruit growing and field crops growing. VOC informed all members that the OT4D/PPP Sustainable and climate resilient sunflower value chain and corresponding innovative climate resilient production systems project has been approved and would be implemented during 2022 and 2023 with a possibility of extension.

Farmers engaged in field production were interviewed first, and vegetable producers second. Agroforestry possibilities attracted fruit producers as they saw a possibility to grow sunflower in the inter-row space. Vegetable growers are increasingly switching to field crops farming due to a lack of manpower.
The table below shows farmers who are interested, after interviewing VOC members from the database, in mercantile sunflower production in May.

Table 1. Farmers interested in mercantile sunflower production

Individual vegetable producers	**Individual fruit producers**
Vozar Vladimir Aćimović Dušan Balanji Šandor Jović Spomenko Čikoš Arpad Kuzmanović Sanja Bogdanov Jelena	Dolovac Milenko Đukić Dušanka Stanković Maja Mujkanović Nurdin
Individual field crop producers	**Companies producing field crops**
Berenji Laslo Farago Janoš Juršić Ignjat Kuzmanović Svetozar Maljković Rade Mamužić Josip Petrov Zoran Farago Goran Stojanović Svetlana Tružinski Sabolč Kenjereš Emil	Global seed, Čurug LoginEko, Zrenjanin Ecoland farms, Telečka

Table 2. Producers not interested in sunflower production

Individual field crop producers that are not interested in sunflower production	**Place of production**	**Area of organic production (ha)**	**Organic production only**	**Why they are not interested**
Berenji Laslo	Bački Vinogradi	18	Yes	Doesn't have adequate machinery, crop production is on area of 6ha, and his choice of production are spelt and wheat.
Farago Janoš	Orom	10	Yes	Non profitable, low price in general considering more investment costs compared to the oats, wheat, flax, corn and soybeans.
Maljković Rade	Banatsko Karađorđevo	11	Yes	Sunflowers attract weeds, he sows oats to eradicate the weeds, and corn and soybean because he has guaranteed placement.
Mamužić Josip	Ljutovo	5	No	Sunflower production requires a lot of investment, it is risky and uncertain.
Petrov Zoran	Veliko Središte	1.30	Yes	Has animal husbandry, so produce for feeding livestock.
Farago Goran	Novi Kneževac	2.07	Yes	There is no free area, they produce fruits and Sage (Salvia officinalis)
Kenjereš Emil	Kanjiža	10	Yes	Switched to fruit production

Table 3: Producers interested in sunflower production

Individual field crop producers interested in sunflower production	Place of production	Area of organic production (ha)	Organic production only	In which area they can sow sunflowers (ha)
Jurišić Ignjat	Šuljam	3	Yes	2-3
Kuzmanović Sanja	Čenej	3.5	Yes	0.6-1
Stojanović Svetlana	Kikinda	7	Yes	2
Tružinski Sabolč	Njegoševo	64	Yes	10
Maja Kumbarić	Seleuš	75	Yes	10
Mile Jović	Čurug	2.8	Yes	2.2

Table 4: Companies interested in sunflower production

Companies producing field crops interested in sunflower production	Place of production	Area of organic production (ha)	Organic production only	In which area they can sow sunflowers (ha)
LoginEko	Zrenjanin	3.500	Yes	300
Global seed	Čurug	1.900	Yes	200
Ecoland farms	Telečka	55	Yes	10

III Eligibility for Bio Suisse certification

International Certification Bio Suisse AG (ICB AG) is the certification body for products of operations producing outside Switzerland for the Bio Suisse market, and it is done by several certification bodies in Serbia. Products can only be traded as BIOSUISSE ORGANIC in Switzerland if the entire chain of companies involved possesses Bio Suisse certification: from the farming operation and storage facilities to the processors, traders and exporters, meaning that the processing company, TIRA doo, also needs to certify their processing line. Contract warehouses must also be inspected according to Bio Suisse standards. Bio Suisse certification is based on EU organic certification. Therefore, the inspection date for the EU organic inspection is decisive. From the date of that inspection, the Bio Suisse certificate is generally valid for about 1.5 years, meaning that one certification can be enough through the duration of the project. For permanent certification, Bio Suisse inspections must take place annually.

A number of producers from Table 1 owns or used to own an EU certificate, and those are the farmers that are considered most eligible for Bio Suisse certification. The most important differences between Bio Suisse certification and certification according to the EU 834/2007 (or an equivalent) standard are:

- Farming operations must be fully converted to organic farming for Bio Suisse certification. The management of the operation may not also run a non-organic farming operation or non-organic agricultural production unit – not even at a different location (Information note).
- At least 7% of the utilized agricultural area must be set aside as an ecological compensation area (Information note), and the quality of the ecological compensation area will be assessed.
- As a rule, the same crop may not be cultivated for two years in a row in the crop rotation (information note), and there must be a share of at least 20% soil-building crops in the rotation.
- Permanent crops must have green cover throughout the year.
- The fertilizer limits for nitrogen (N), phosphorus (P) and potassium (K) are lower, depending on the crop. Synthetic chelates are prohibited.
- Plant protection products are permitted as per appendix II of the EU organic regulations, with the exception of synthetic pyrethroids, bioherbicides and plant growth regulators. Use of sulphur (S) and copper (Cu) is restricted, and where the use of copper is permitted, the limits are lower.
- There is a general prohibition against air freight.
- Very few substances are permitted for storage protection. Storage areas must be completely empty of organic products during and for at least 24 hours after fumigations with a permitted substance (with the exception of CO_2/N disinfestation treatments). (Information note)
- Summary of the Bio Suisse standards and guidance: https://icbag.ch/resources/Merkblaetter-2022/ENG/A_ENG_Summary-of-the-Bio-Suisse-Standards_2022.pdf
- Information note for operations outside the Switzerland: https://international.bio-suisse.ch/en/import-with-bio-suisse/documents-and-downloads.html
- Other Bio Suisse information notes on other topics can be found here.

Identified surfaces

As a rule, vegetable and fruit growers grow on 1-10 (rarely 20 ha), while field crop producers usually have 10-100 ha (and more). Bearing in mind crop rotations, other market flows and the fact that the smallest amount for the finishing process required by the processor company Tira is 10 tons per producer, and if we take into account that yields are from 1.5 to 2 tons per hectare, each producer needs to allocate between 5 and7 hectares of land as possible surfaces for mercantile sunflower production in 2023, and the following years are from 30-100 ha regarding small scale farmers.

Examination of farmers' crop rotations

As annex to this document, certificates of organic farmers with a list of crops and total production surface for farmers who agree to next year's production and make an agreement with Halba will be added.

Farmers' current market flows

Most of the farmers have contractual cooperation with certain domestic companies and processors, or market chains. Some of the farmers export abroad upon agreed cooperation, mainly fruits and field crops (soybean, cereals…). If placement and profit are guaranteed, increasing the area would not be an issue.

Previous experience in confectionary sunflower production

As confectionary sunflower is a small part of the overall sunflower production not only in Serbia, but also all over the world Serbian farmers have not produced it on bigger surfaces. They are, however, experienced in growing sunflower for oil production.

Agro-technic differences within confectionary and oil type sunflower are not significant (usually row space and crop protection depending on the hybrid and its resistance to certain pathogens and other requirements), so their modest experience in confectionary sunflower production is compensated by their extensive experience in sunflower oil production and by expert advice from the Institute of Field and Vegetable Crops and will, therefore, not present a problem.

Storage capacities and suitable transport channels for local needs

Two of the selected farmers have their own storage capacity (Jurišić Ignjat and Tružinski Sabolč) with the possibility to store other producers' goods as well. Due to the price and capacity for transport, the best option for small scale farmers is selling at one shipping tour. The LoginEko Company is building their own warehouse capacities and will have an option to store other organic farmers' products in the following years. According to Bio Suisse certification, contract warehouses must also be inspected. There are storage capacities already used by farmers in all major places, so there is an option to use contracted warehouses for farmers that are located near one another. From the aspect of transport costs, the minimum area for cost-effective production is 5 ha per producer.

IV Conclusion
(negotiating production conditions, contract signing possibility, arranging delivery and payment conditions, shortlisting farmers that are most eligible for producing)

In the conditions of global changes and risks, guaranteeing the minimum price of the final product is something that is unknown and the first question all farmers will raise, and this issue should be addressed the most. Finding a model to influence and modify prices in line with market changes is key to trust and increased production. If negotiations start on time and production contracts are made for the next year, individual organic farmers will be able to produce sunflower, a Gricko hybrid, at around 50 ha in total. The plans and agreements for the next season (2023) must be made as early as September 2022. At this point the list of possible farmers is narrowed down to six small scale farmers as most eligible for next year's production, but detailed conversations with HALBA representatives will increase the possibilities for other farmers also.

If the terms of redemption are satisfying vegetable, producers will be willing to consider establishing certain surfaces under confectionary sunflower. However, for some of them this would mean additional investments for buying, adapting or renting machinery. The state subsidies for the purchase of machinery are available to them, but should be planned this year. Individual organic farmers are located relatively distant from one another, dispersed throughout the territory of Vojvodina, so logistics in terms of transportation to warehouse and the processor TIRA doo needs to be carefully organised, in order for costs to be as minimal as possible.

The economic, social and political situation in Serbia is stable, but events in the world affect everyone.

FEASIBILITY STUDY ON DEVELOPMENT OF AGROFORESTRY PRACTICE IN VOJVODINA PROVINCE, REPUBLIC OF SERBIA

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National Institute of the Republic of Serbia, Institute of Field and Vegetable Crops

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This feasibility study considers all relevant factors, including economic, technical, legal, and scheduling considerations, to ascertain the likelihood of completing the task successfully.

Contents

I General characteristics of Vojvodina Province

Vojvodina is the Autonomous Province in Republic of Serbia and occupies an area between 44o 38’ and 46o 10’ northern latitude and 18o 10’ and 21o 15’ eastern longitude. It is the northernmost part of Serbia, bordered by Croatia to the west, Hungary to the north, and Romania to the east.

Vojvodina is located in the south-eastern part of the Carpathian (Pannonian) Basin, encompassing the confluence area of the Danube, Sava, Tisa (Tisza) and Tamiš (Temeş) rivers (Popov et al., 2012). More than 60% of this lowland area is covered by loess and loess-like sediments at terraces and loess plateaus (Markovic et al. 2008). Beside four lowland geomorphological units (sandy area, loess plateaus, upper Pleistocene, alluvial terraces and alluvial plains), the most distinctive landforms of the Vojvodina region are two mountains: Fruška Gora Mountain, which is situated between the Danube and Sava rivers, and Vršačke Mountains, which are located in the south-eastern part of the region close to the border with Romania.

Vojvodina is situated in the south-eastern part of the Pannonian (Carpathian) Basin, the plain that remained when the Pliocene Pannonian Sea dried out. Consequently, Vojvodina is rich in fertile loamy loess soil. Regarding the distribution of soil types, as much as 60% of the of the Vojvodina Province soil is chernozem, considered ideal for crop production due to physical and chemical properties. Other fertile soil types with considerable areas include hydromorphic black soils (16%), and the alluvial soils (9%) (Skoric et al., 1985).

Out of the total area of the Vojvodina Province (21,506 km2), the agricultural land takes 16,940 km2 or 80%. Vojvodina is a typical rural region in which ploughed land and gardens cover 90% of the agricultural land (STAT. YEARB. SERB., 2020). Agriculture is a priority economic sector in Vojvodina. The share of agribusiness in the total industrial production is 40%, which is 30% in the total exports of Vojvodina. Fine chernozem soils make Vojvodina the main agricultural resource of Serbia; the region supplies much of the country’s wheat, maize and soybean (STAT. YEARB. SERB., 2020). Many cash crops are also grown there, notably sugar beets and oilseeds, which are processed by regional enterprises.

The climate of Vojvodina is moderate continental, with cold winters and hot and humid summers, wide range of extreme temperatures and unequal distribution of rainfall per months, which leads to different aridity types. The average annual temperature is about 11 °C. Summer temperatures are between 21° C and 23° C and winter around -2° C. However, temperatures can be extreme to the extent that that the difference between the highest and lowest temperatures amounts to over 70° C. The average annual amount of precipitation in Vojvodina ranges from 550 to 600 mm, where extremely rainy periods at the beginning of summer (June) and periods without or with a small amount of precipitation (October and March) can be distinguished (Malinović Milićević et al., 2018). Potential vegetation is mostly replaced by crops at lowland zone. Vojvodina has a population of about 2 million inhabitants (about 27% of Serbia’s total).

II Overview of organic production of the Vojvodina Province

Areas under organic plant agriculture

In R. Serbia has natural potentials for the development of organic production, as well as an institutional and legal framework since 2000. According to data of 2019 year (Simić, 2020), organic agriculture covers a total of 21,265 ha, of which 5,350 ha are meadows and pastures (Figure 1). This share is only 0.61% in relation to the total used agricultural land in the Republic of Serbia. This share is very small compared to the world average, and especially compared to the European average. Cereals and fruits are mostly grown in the Republic of Serbia. However, considering the amount of produced berries and export potential, Serbia is not a negligible player in organic production in Europe.

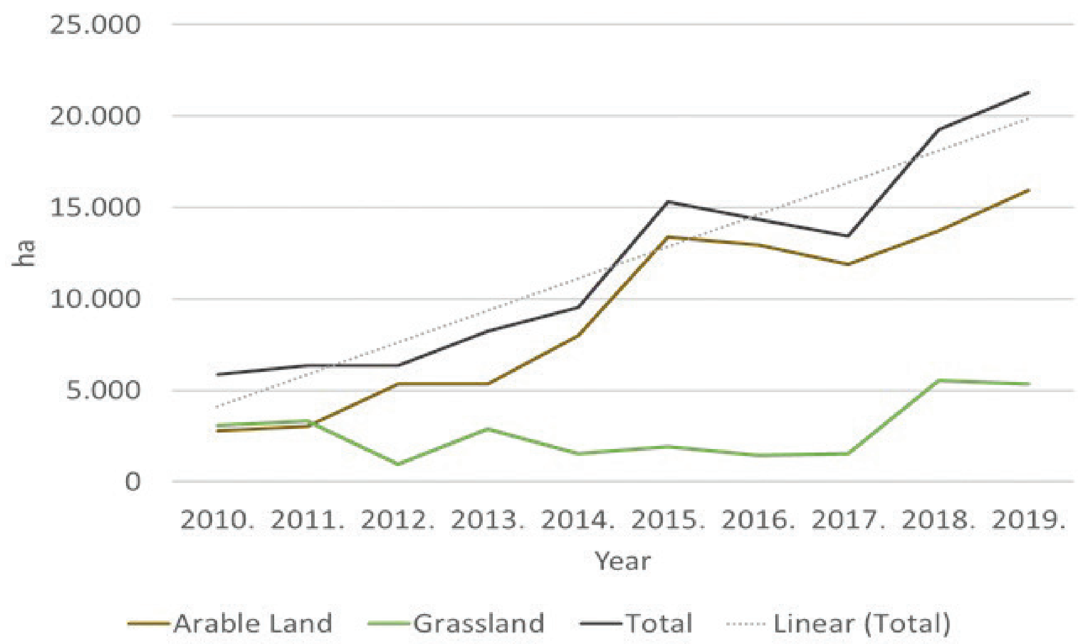


Figure 1. Land areas under organic agriculture in Serbia

Representation of organic plant production by regions of the Republic of Serbia in 2019 shows that it is most represented in two regions: Vojvodina on 8,470 ha (39.8% of the total organic area in Serbia), and Southern and Eastern Serbia on 8,440 ha (39, 7%) (Table 1).

Table 1. Areas under organic agriculture by Region in 2019

Region / Plant category	Beograd ha	% of organic Serbia	Šumadija and West Serbia ha	% of organic Serbia	South and East Serbia ha	% of organic Serbia	Vojvodina ha	% of organic Serbia
Cereals	5.44	0.11	160.43	3.35	708.63	14.80	3,914.31	81.74
Industrial plants	0.01	0.00	0.00	0.00	842.39	37.78	1,387.15	62.22
Vegetables	3.53	1.92	42.14	22.88	23.90	12.98	114.59	62.22
Fodder plants	0.33	0.02	122.36	6.81	112.76	6.27	1,562.47	86.90
Fruit	28.46	0.53	3,174.81	59.63	1,924.46	36.14	196.64	3.69
Medicinal plants	0.03	0.01	45.93	17.77	168.82	65.30	43.75	16.92
Other	5.95	0.45	137.81	10.35	455.01	34.16	733.33	55.05
Total arable area	43.75	0.27	3,683.48	23.14	4,235.97	26.62	**7,952.25**	**49.97**
Meadows and pas-tures	2.16	0.04	626.49	11.71	4,203.72	78.57	517.62	9.68
TOTAL AREA	**45.91**	**0.22**	**4,309.97**	**20.27**	**8,439.69**	**39.69**	**8,469.87**	**39.83**

In 2019 year, half of the total arable area is located in the region of Vojvodina, followed by the region of Southern and Eastern Serbia (26.7%), then the region of Šumadija and Western Serbia (23.1%). This is somewhat consistent with the distribution of arable land in conventional agriculture, where the largest number of farms in the Vojvodina region are specialized in arable production.

In 2019 year, meadows and pastures spread dominantly in the region of Southern and Eastern Serbia with as much as 78.6% share, then in the region of Šumadija and Western Serbia with 11.7% share, while in the region of Vojvodina there is only 11.7% (517 .6 ha) of total areas of meadows and pastures in the Republic of Serbia.

Based on the observation of the growth and decline of areas under organic production, in the period 2010-2019, through specific indicators (conversion period, organic status, arable land, meadows and pastures, plant species, regional representation) constant fluctuation and instability in production can be observed, especially in areas under meadows and pastures. In the surface structure, meadows and pastures for balanced plant production are missing, especially in the Vojvodina region.

Structure of plant production

In the region of Vojvodina, within the region itself, cereals are grown the most on 3,914.3 ha, followed by fodder plants on 1,562.5 ha and industrial plants on 1,387.1 ha. In relation to the entire Republic of Serbia, in 2019, organic fodder plants make up 87% of the area of the Republic of Serbia, followed by cereals with a share of 82%, industrial plants and vegetables with 62% each, while the area under fruit is only 3.7%.

Fruit is dominantly grown in the regions of Serbia: in Šumadija and West Serbia 59.6%, and South and East Serbia 36.1%, of the total area under fruit in Serbia. Together, these two regions account for 96% of organic fruit growing in Serbia.

In summary, the areas under organic plant production are in a growing trend, but this increase is still small compared to the natural potential of the Republic of Serbia and the needs of the domestic and foreign markets.

Export

Serbia currently exports over 99% of organically produced food. Around 90 % of production is exported to EU. The total amount of exported products in 2021 is 17,622 t.
The highest value, of 45 million euros, was achieved in 2021 in the export of frozen organic fruits, of which the largest part was frozen berries:

- frozen raspberries - 32.6 million euros,
- frozen blackberries - almost 5 million euros,
- frozen blueberries - 1.8 million euros.

In addition to berries, R: Serbia also exported frozen cherries (3.4 million euros) and plums.

Of the 33 countries to which R. Serbia exported organic products in 2021, the highest values were exported to the following countries:

1. Germany – 18.25 million euros – 31.8% of the total export value
2. USA – 7.75 million – 13.5% of the total export value
3. The Netherlands, almost 7 million euros – 12% of the total export value
4. France – 4.25 million euros – 7.4% of the total export value
5. Poland – 3.5 million euros – 6.1% of the total export value
6. Canada – 3.49 million euros – 6% of the total export value
7. Austria – 3.4 million euros – 5.9% of the total export value
8. Italy – 2.8 million euros – 4.9% of the total export value
9. Belgium – 1.3 million euros – 2.26% of the total export value
10. Switzerland – 1.17 million euros – 2% of the total export value

After frozen fruit, Serbia mostly exported organic dried fruits – strawberries, raspberries, plums, blueberries, blackberries, currants, in the total value of 6 million euros, followed by fruit concentrates and purees (in the total value of 3.15 million euros).

Number of farmers, group certification

Group production, especially of fruit in central Serbia, and association of producers in export-oriented group certification, along with production organizers, proved to be key factors in the development of organic agriculture in the Republic of Serbia. The number of subcontractors is significantly higher than the number of producers holding certificates and makes up about 90% of the total number of producers.

It is evident that there is a small number of producers who have a directly concluded contract with authorized control organizations (certificate holders), in contrast to the number of producers who, as subcontractors, are part of group production. This model has proven to be successful in our country and in most cases it is a production intended for export. During 2021, the total number of producers in Serbia (certificate holders plus subcontractors) was 6,421. Of that number, there were 616 certificate holders, and 54 of them had group production with 5,805 subcontractors. In Vojvodina, out of 616 certificate holders, a total of 125 producers had primary production in 2021 (primary production represents number excluding processors and exporters).

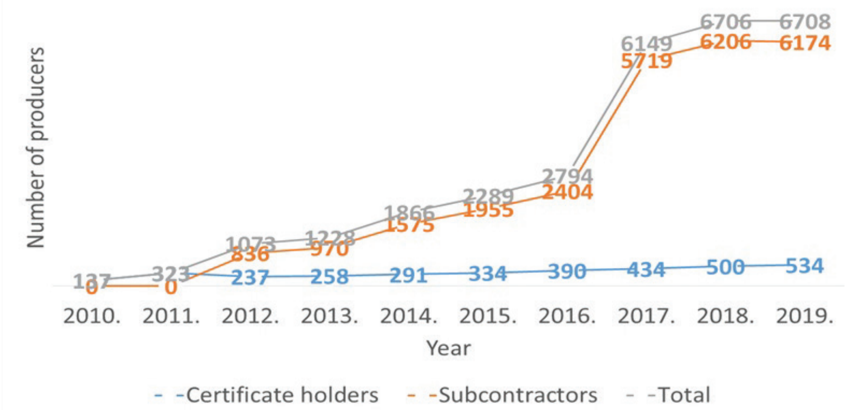


Figure 2. Number of organic producers of period 2010-2019

In accordance with domestic regulations, group organic production in Serbia was prescribed for the first time in 2011. Since then, the number of organic farmers as subcontractors has grown exponentially (Figure 2). In accordance with EU regulations for organic production, this type of organization of organic producers was allowed only for third countries and was not applied in EU member states. With the adoption of the new Regulation EU No. 848/2018 of the European Parliament and the Council, the application of which begins on January 1, 2022, group production will be allowed in EU countries, with the conditions under which a subcontractor can be a member of group production being specifically defined.

In accordance with Serbian national regulations, the producer and owner (organizer of production) may, for the purposes of carrying out organic production, conclude a contract on cooperation with other producers, i.e. subcontractors, who carry out the same and/or similar type of organic production at production units located in the same geographical area.

III The afforestation of the Vojvodina Province

The forest cover in the Republic of Serbia is significantly lower than the European average, and the region of Vojvodina is the least forested. Based on the most frequently published data, the area under forests in Vojvodina amounts to 7.1% of the total area of Vojvodina. The total area of forests and forestland covers 175,136.05 ha which accounts for 8.1% of the total area of Vojvodina. However, the forest area comprises 140,717.68 ha, so that actual level of afforestation amounts to only 6.51%[1]. The most commonly cited number of 7.1% represents the number between the actual forests and forestland covers (Table 2).

Table 2. Forest ownership structure in Vojvodina (source: Vojvodinašume)

Owner	**Area [ha]**
Public Company "Vojvodinašume"	130,589
Private forests	5,567
Water management companies	7,575
Agricultural organisations	5,989
Local communities	722
Military Institution "Karađorđevo"	2,243
Company National Park "Fruška gora"	22,450
Total	**175,135**

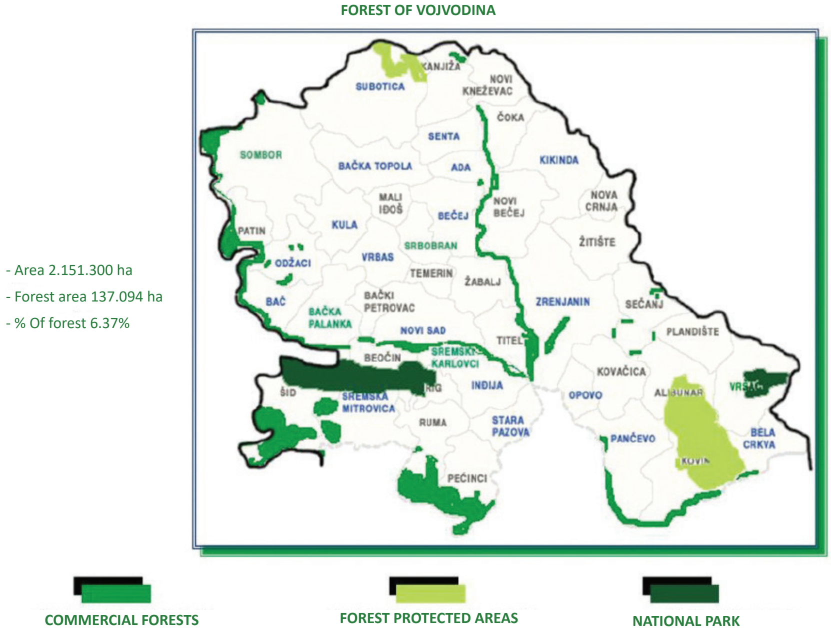
Vojvodina is the area with the lowest degree of forest cover in Europe. To reach the standards of 0.16 hectares per citizen the woodlands in Vojvodina shall be increased from actual value of 193,621 hectares to the values of 308,045 hectares (Marinković et al., 2020).

In addition to the low forest cover, the distribution of forests and non-forest greenery is not uniform throughout the territory (Ivanišević et al., 2008). Forest vegetation in Vojvodina is primarily concentrated in narrow belts along the rivers, as well as in two mountainous regions and two sandy areas, which are recognized as protected natural resources. These areas include the narrow sites along the river courses of the Danube and Tisza, the mountain of Fruška Gora, Vršac Hill, and the Deliblato and Subotica sand dunes. (Picture 1).

1 https://www.vojvodinasume.rs/en/sume/

The major forest stands are situated on Fruška gora and Vršačke Mountains, on Deliblato and Subotičko-horgoška Sands and along the river inundations. Outside these areas, there is almost no forest stands, or there are in small, less then hectare, fragments. The least afforested areas are areas of intensive agricultural production. According to Dožić (2006), there are parts of Vojvodina where there is not a single tree within a radius of 10 to 25 kilometres (Pekeč at al., 2008). One third of the municipalities and cities in Vojvodina have less than one percent forest coverage.

These areas have all characteristics of steppe regions: poor precipitation, hot summers and cold winters, negative wind influence (wind erosion) (Ivanišević, et al. 2008). The process of evaporation is considerable because of absence of forests, causing significant losses of water in soil that is need by agricultural crops and forest stands. Low percentage of forest cover supports numerous negative consequences that will be difficult to repair in the future. The protection and preservation of ecosystems of Vojvodina are directly dependent on the establishment of different forms of forest and non-forest greenery stands, like: forests for protection, windshalter-stands, hunting resorts and different forms of horticultural orchards (Ivanišević, et al. 2005).



Picture 1. Forests in Vojvodina*, Source: Ivaniševiće et al., 2008*

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Within research Marinković et al. (2020) which provided on more than eight hundred projects of land consolidation has shown that only in a few of them the shelterbelts were foreseen and no one of them was realized as designed. The reasons are mostly connected with the resistance of participants in land consolidation to give up of their land for shelterbelts building, with lack of capacities for seedlings providing and with the insufficient attention paid to this issue in legal regulation.

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Legal regulation in field of agroforestry and shelterbelts

The practice of agroforestry is not recognized in Serbian legislation. Agroforestry can be indirectly interpreted within the framework of the legislation governing forests and agricultural land:

- Forest Law. Official gazette of the Republic of Serbia No. 30/2010, 93/2012, 89/2015 and 95/2018 – other low
- Law on Agricultural Land. Official gazette of the Republic of Serbia No. 62/2006, 65/2008-other low, 41/2009, 112/2015, 80/2017 and 95/2018- other low
- Law on reproductive material of forest trees. Official Gazette of the Republic of Serbia No. 135/04, 8/05 - correction, 41/09
- Strategy for the development of forestry in the Republic of Serbia. Official gazette of Republic of Serbia No. 59/2006
- Strategy of Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024. Official gazette of Republic of Serbia No. 85/2014

According to Forest law, a forest is an area overgrown with forest trees, with a minimum area of 500 m2, with a minimum land cover of 30% tree crowns. According to Law on Agricultural Land, local self-government units will ensure that anti-erosion biological measures are taken every year on at least 4% of new areas from the total areas attacked, susceptible or threatened by erosion.

With all the significant positive impacts of forests on agriculture, neither the Forestry Development Strategy of the Republic of Serbia (2006), nor the Agriculture and Rural Development Strategy of the Republic of Serbia for the period 2014-2024., do not recognize the meaning and role of shelterbelts and their enormous contribution to agriculture. Agricultural protection shelterbelts are not mentioned at all in the Forestry Development Strategy, while in the Agriculture and Rural Development Strategy of the Republic of Serbia for the period 2014-2024., mentioned only once (Marinković et al., 2020).

There is a lack of officially prescribed new agro-ecological measures and good practices in Serbia. Of primary importance is revision of the Rulebook on agro-ecological measures and good agricultural practice in order to establish economic models of permanent support for this method of sustainable production. In addition, in this way, the applied sustainable measures would be unambiguous and recognizable in the horizontal and vertical system of legislation, as well as their monitoring and reporting from all three mentioned crucial aspects.

As for subsidies to farmers, there are subsidies only for afforestation. These funds are allocated at the level of the Province of Vojvodina from the Forest fund.

According Regulations on the allocation of funds from the Annual Program for the use of funds from the Budget Fund for Forests of AP Vojvodina for the year 2022, according to the Competition for the allocation of funds:
1. Afforestation - planting of new forests in the total amount of up to 60,000,000.00 dinars at the following maximum unit prices:

- for afforestation with hard and noble hardwoods up to 220,000.00 dinars per hectare;
- for afforestation with soft hardwoods and conifers up to RSD 180,000.00 per hectare;
- for afforestation with acacia up to RSD 140,000.00 per hectare.

Funds are allocated for afforestation of virgin forest land, agricultural land in accordance with the Law on Agricultural Land and other land where afforestation is permitted. These funds are sufficient for establishing forests, but not for further care and management of planted seedlings.

The community's response to weak afforestation in Vojvodina Province

The movement "Pošumimo Vojvodinu" ("Let's Reforest Vojvodina")[1] NGOs network of 24 organizations, launched a petition asking the competent authorities to solve the problem of insufficient afforestation in this part of the country.

The demands of this movement are as follows:

- The Government of Vojvodina is requested to, as an authorized proposer, submit to the Parliament of Serbia proposals for amendments to the law on: forests, agricultural land and fees for the use of public goods.
- When it comes to the Law on Forests, it is required that municipalities and cities prepare multi-year afforestation plans in their territory, by a certain deadline.
- Also, with the amendments to the Law on Agricultural Land, municipalities and cities should set aside a certain percentage of state agricultural land for the construction of wind protection shelterbelts and for afforestation, in appropriate quality.
- The "Let's reforest Vojvodina" network points out that the amendment to the Law on fees for the use of public goods should abolish the fee for changing the use of agricultural land for afforestation.

1 https://posumimovojvodinu.rs/

- The network requests the Provincial Government to amend the Decision on the establishment of the Budget Fund for Forests in order to ensure the participation of citizens and the general public in deciding on the fund's program.
- As they state in the explanation, although a third of the municipalities and cities in Vojvodina have less than one percent forest coverage, only the one Municipality (Municipality of Srbobran) has a multi-year afforestation plan. That is why municipalities and cities should be obliged to prepare these plans by a certain deadline. Through the development of plans, it is necessary to distinguish which specific areas will be reforested and with which species, to resolve property relations, to determine who will take care of the forests after planting, and how much everything will cost. The development of these plans and their subsequent implementation can be partly paid for from the Provincial Forestry Fund.
- Municipalities and cities should be obliged to set aside a certain percentage of the state's owned agricultural land for afforestation and building windbreaks. If they do not fulfill this obligation, part of the income from the land lease would be additionally given to the provincial budget.
- From 2014 to 2020, the national budget received between 1.7 and 2.5 billion dinars per year from the lease and change of land use, of which 85 percent to 90 percent came from leases in AP Vojvodina. A small part of this money, between 10 percent and 20 percent, was spent on purpose, but only on the territory without provinces, and the largest part was not intended. Thus, the tenants from Vojvodina, in essence, paid for land development in central Serbia, as well as activities that have nothing to do with the land, the petition states.

Professional and Technical Capacities

Practical knowledge in the field of agroforestry is severely lacking in Serbia. The country has three specialized forestry faculties and institutes: The University of Belgrade, Faculty of Forestry[1]; Institute of Forestry, Belgrade[2] and Institute of Lowland Forestry and Environment (ILFE), Novi Sad[3]. While the literature on 'Forest Protection Belts' is available to students at the Faculty of Forestry in Belgrade (Lukić, 2019), there is a dearth of specialized literature on agroforestry in the Serbian language.

The ongoing implementation of the project titled "Agroforestry practices in West Balkan for sustainable development: weaknesses and strengths" - AGFORWEB, as part of the ERASMUS+ program, aims to improve education in this field. The project is coordinated by the Faculty of Forestry in Belgrade. However, basic knowledge about agroforestry is currently limited to agricultural students through their regular curriculum, and practical application of agroforestry is carried out individually with insufficient field practice.

Moreover, there is a notable absence of popular literature targeting farmers, such as handbooks with practical recommendations, specifically dedicated to agroforestry, within the Serbian language.

1 http://www.sfb.bg.ac.rs/en/faculty/about-faculty/
2 http://www.forest.org.rs/?about-the-institute
3 https://ilfe.org/en

IV Survey processing, prior knowledge and interest in agroforestry

To better understand the prior knowledge and interest of farmers in agroforestry, a direct survey was conducted with 27 respondents encompassing 10 questions. The main purpose of this survey was to assess the level of interest among farmers in adopting agroforestry practices. The survey provided valuable insights into various aspects related to agroforestry, including participants' knowledge, perceptions, and willingness to engage in this sustainable agricultural approach.

Eight questions were structured with predefined answer options (checkboxes), while two questions allowed for free-text responses. One of the questions aimed at gathering valuable insights and open-ended feedback was question number 10: „In your current opinion, what would be the most significant measure to scale up agroforestry practices in the Republic of Serbia?" This question sought to capture participants' valuable perspectives and suggestions, enabling us to collect highly valuable responses that aligned with the objectives of the survey.

Question number 2: "Occupation and position of the participants" also provided an opportunity for participants to provide free-text responses. This question allowed us to gather additional insights into the diverse professional backgrounds and roles of the participants, enriching the overall understanding of the survey findings.

According to the **ownership structure of the land**, the majority of respondents were from family-owned agricultural holdings, comprising approximately two-thirds of the total. Around one-fifth of the respondents represented agricultural enterprises, while 11% of the participants belonged to government institutions, predominantly in the higher education sector (Figure 3).

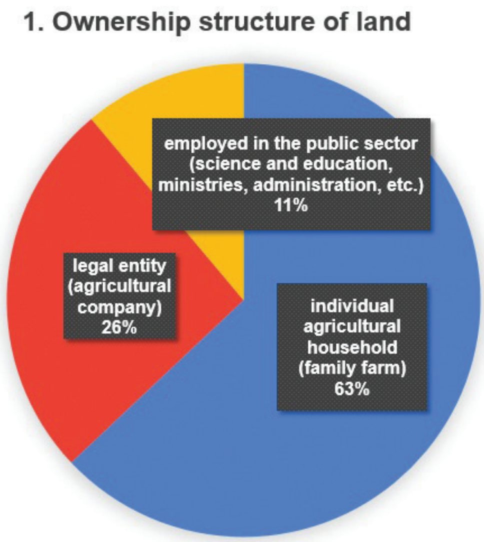
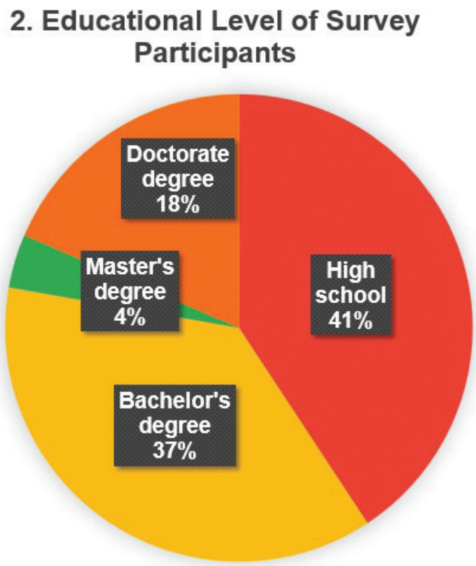


Figure 3. Ownership structure of respondents' land

In terms of education level, 41% of respondents have completed high school, while the remaining respondents hold a degree or higher. Among the respondents, 63% have an education in the field of agriculture and related sciences (Figure 4).



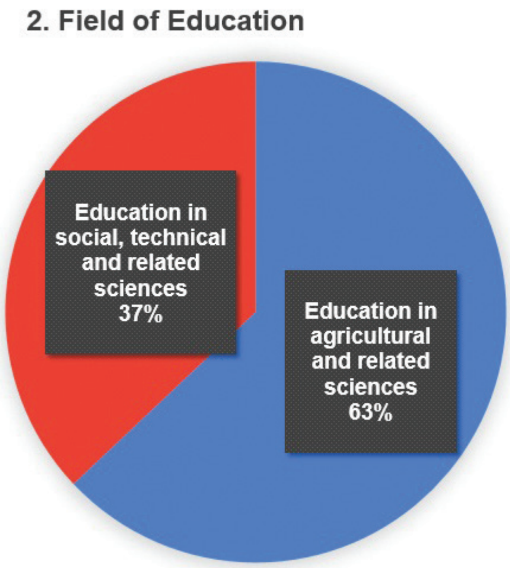


Figure 4: Education level and field of education of survey participants

Regarding the size of the land managed by the respondents, the majority fall into the 5-10 ha category (30%), followed by the 10-15 ha category (19%). 11% of respondents manage over 100 ha of land. The remaining categories of land size are equally represented at 7% each (Figure 5). Roughly estimated, the survey covered a minimum land area of approximately 800 hectares.

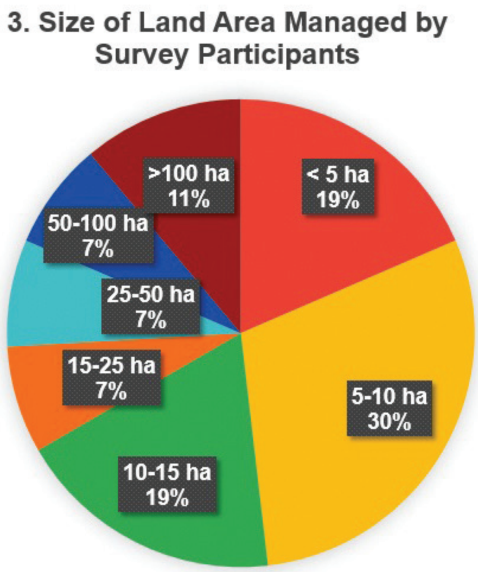


Figure 5. Size of land area managed by survey participants

According to the participants' perception, there were no responses indicating excellent afforestation of the land they manage, including windbreak belts. 30% of the participants rated the afforestation as extremely low, half of them rated it as insufficient, while a total of 18% of the ratings fell into the categories of moderate and very good (Figure 6).

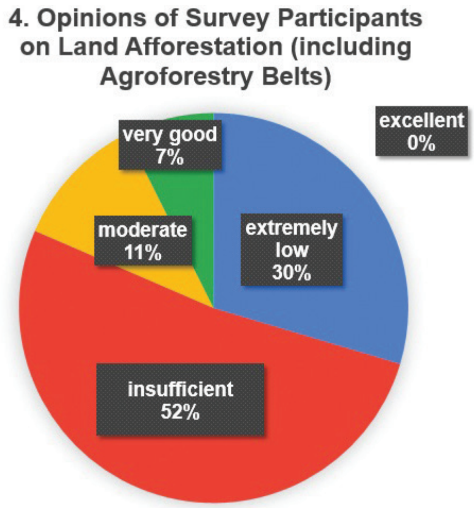


Figure 6. Opinions of survey participants on land afforestation (including agroforestry belts)

In response to the question regarding the perceived impact of climate change on agricultural production, a significant majority of participants (over 50%) expressed a high level of observation. They noted that the consequences of climate change are remarkably pronounced. Additionally, 37% of respondents acknowledged a moderate level of impact, while 11% reported no noticeable consequences resulting from climate change in their agricultural practices (Figure 7).

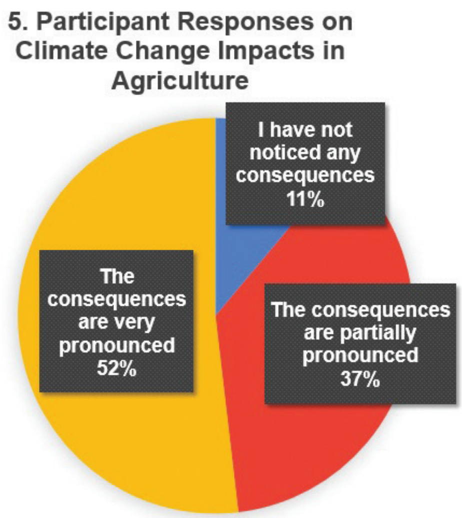


Figure 7. Opinions of survey participants on climate changes consequences in agriculture

Based on their self-assessment of prior knowledge in agroforestry, 67% of respondents indicated familiarity with basic concepts, 18% reported partial knowledge, and 15% claimed to have a good understanding of the topic. Regarding their interest in acquiring new knowledge in the field of agroforestry, 44% expressed a high level of interest, 45% indicated moderate interest, while 11% showed no interest (Figure 8). This section of the survey suggests a significant interest in education and learning opportunities related to agroforestry. It is also interesting to note that respondents who claimed to have a good understanding of the topic also expressed a high level of interest in acquiring further knowledge.

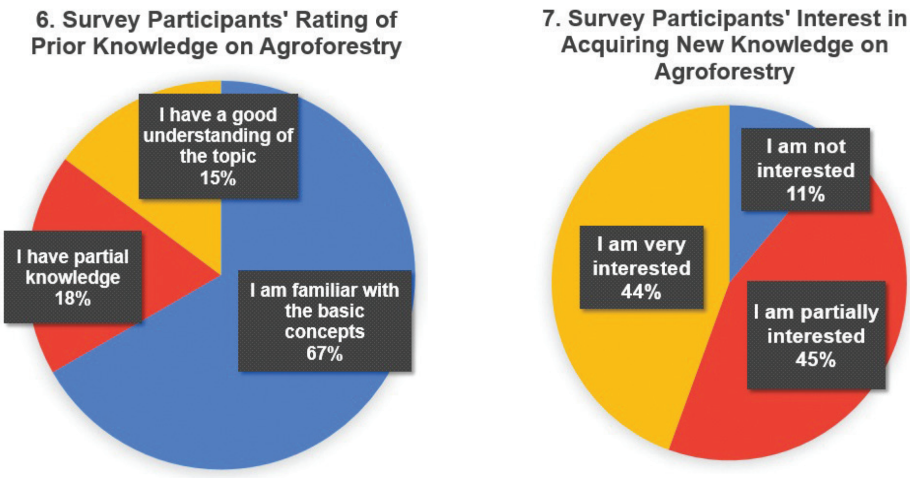
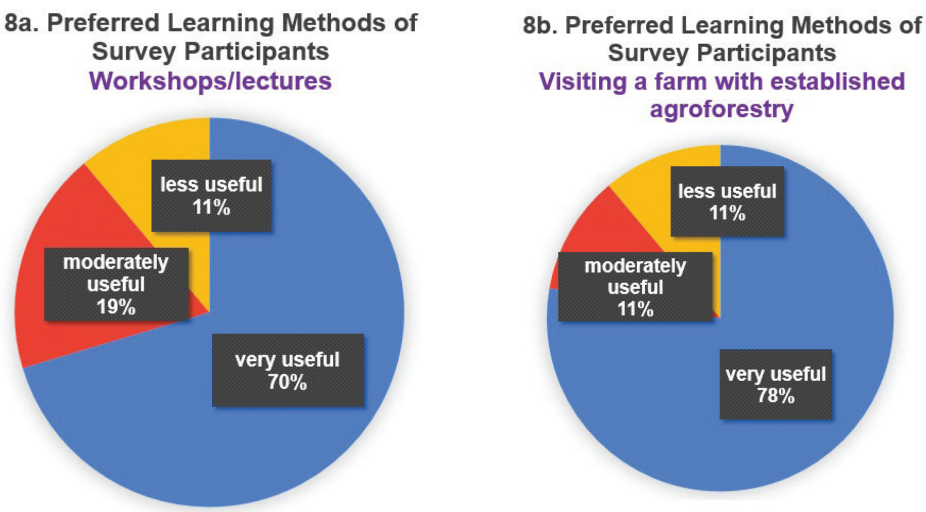


Figure 8. Evaluation of prior knowledge in agroforestry and interest in acquiring newknowledge among survey participants

According to survey respondents, the most significant methods for acquiring new knowledge in agroforestry were identified as farm visits to established agroforestry farms, followed by workshops and lectures. The opinions regarding the usefulness of printed materials and internet portals were diverse, while TV and radio shows were considered the least valuable sources of information (Figure 9).



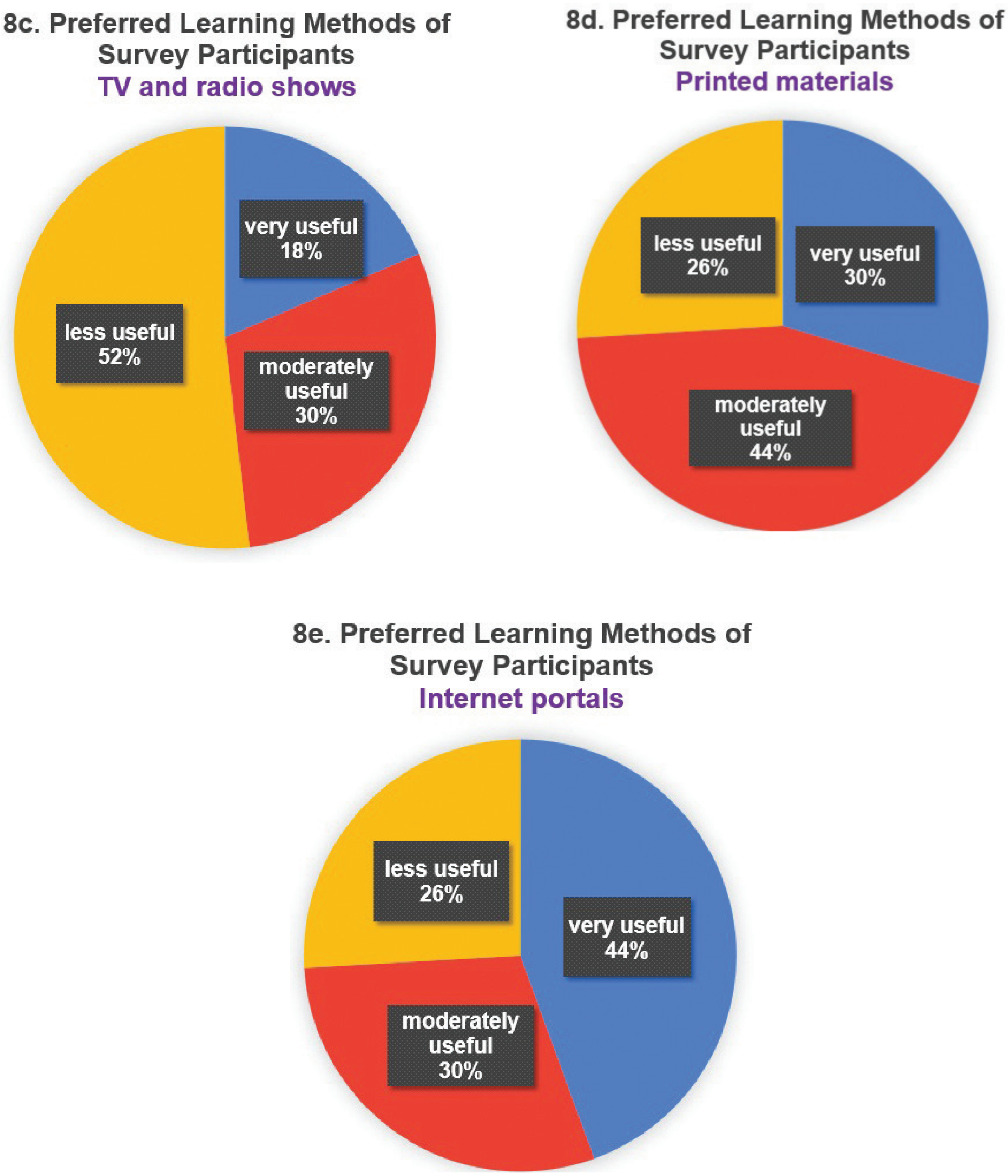


Figure 9. Preferred learning methods of survey participants

In response to the question regarding their interest in implementing agroforestry on their own land, 7% of the participants indicated no interest, 78% expressed potential interest contingent upon favorable conditions for such practices, and 15% showed significant enthusiasm and willingness to engage, even at the initial stages of development, such as pilot projects (Figure 10) .

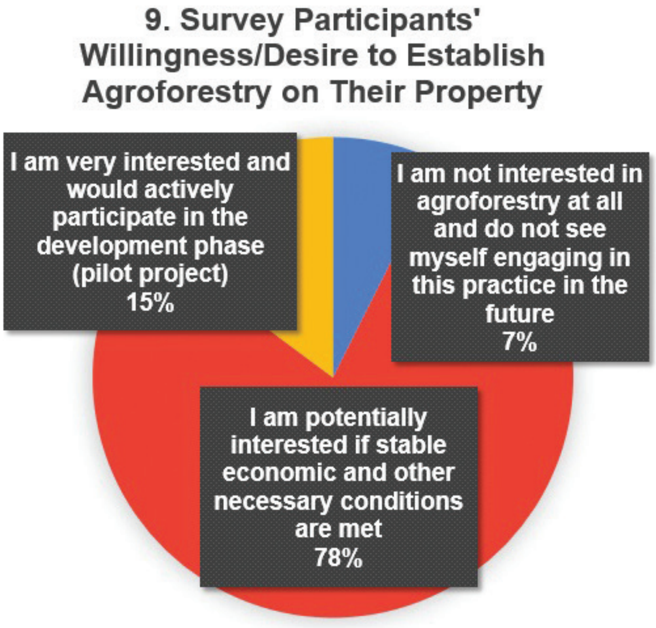


Figure 10. Survey participants' willingness/desire to establish agroforestry on their property

These findings suggest a notable level of interest and receptiveness among the surveyed individuals towards agroforestry. The majority of respondents demonstrated a willingness to explore agroforestry practices if certain conditions were met, indicating the potential for wider adoption and implementation. The fact that a significant portion of participants expressed both knowledge about agroforestry and a strong desire for further learning highlights the importance of education and knowledge dissemination in promoting and popularizing agroforestry in Serbia.

Overall, these results underscore the significance of creating favorable conditions, providing education and training opportunities, and facilitating pilot projects to drive the adoption of agroforestry practices among farmers and land managers.

The tenth question, "In your current opinion, what would be the **most significant measure to scale up agroforestry practices in the Republic of Serbia?**" elicited interesting and comprehensive perspectives on the possibilities of agroforestry in Serbia (Figure 11). The majority of respondents emphasized the importance of reliable and consistent state subsidies as the key measure. It was evident that all participants regarded it as the government's responsibility to provide support in this regard. This sentiment was reflected in the responses that highlighted the role of local authorities and Vojvodinašume (a state-owned company specializing in afforestation) in fulfilling their respective obligations.

Another noteworthy aspect is that all respondents tend to mix agroforestry practices with agro-protective belts and emphasize the need to expand afforestation alongside road networks. Additionally, education and raising awareness among farmers about the importance of agroforestry emerged as significant factors after subsidy measures. It is worth mentioning that participants who indicated limited knowledge about agroforestry also displayed less willingness to implement it on their own land, indicating a correlation between knowledge and willingness.

The need for regulatory changes was also emphasized by the respondents. Furthermore, they expressed the need for more nurseries and the restoration of responsibilities to the forestry sector, particularly the forest guardians. The suggestion to include agroforestry as an IPARD measure and provide support from this fund was also considered highly significant.

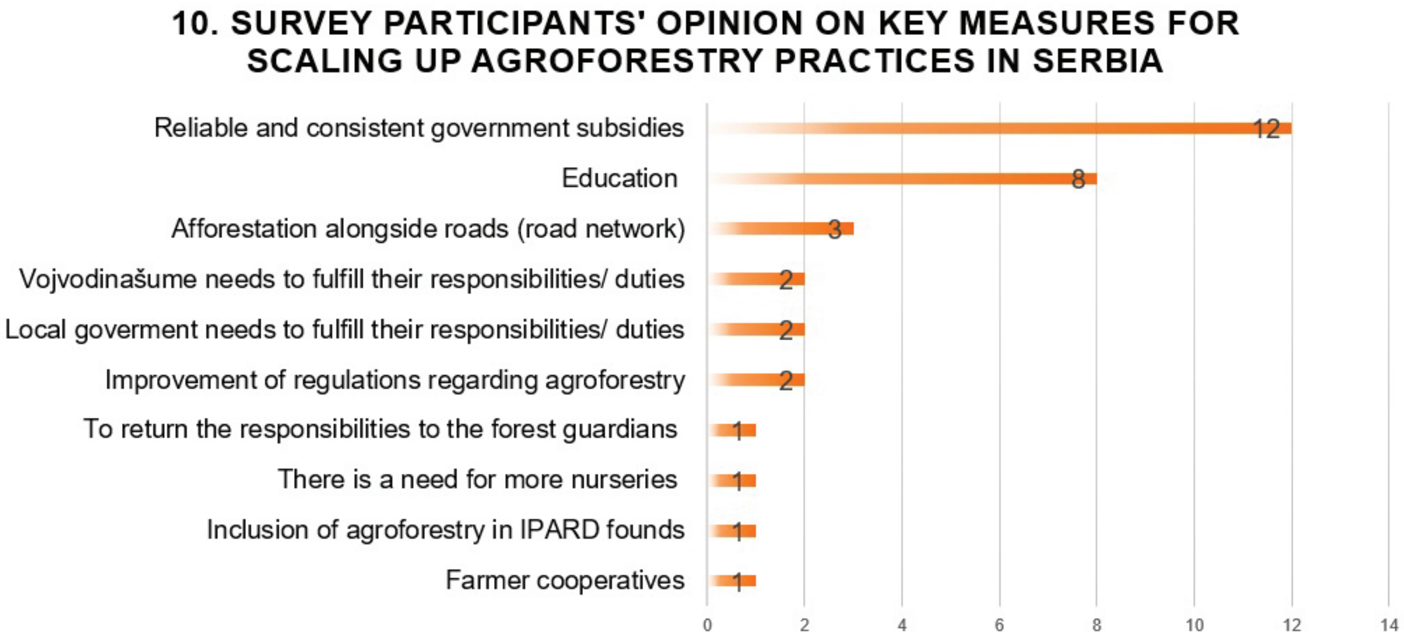


Figure 11. Survey participants' opinion on key measures for scaling up agroforestry practices in Serbia

Overall, the survey results highlight the importance of reliable state subsidies, education, regulatory adjustments, increased nursery capacity, the involvement of local communities, and the inclusion of agroforestry in funding programs such as IPARD to promote the widespread adoption of agroforestry practices in Serbia.

V Conclusion and key observations

- The Province of Vojvodina has natural resources and a long tradition in arable agricultural production, as well as great potential for organic farming, particularly within the system of group certification of producers.
- Considering the extremely weak forest cover of Vojvodina agricultural plains, the development and expansion of agroforestry practices seems to be the best measure for soil protection and sustainable agriculture, especially in context of climate change.
- The benefits of agroforestry are well known worldwide from scientific literature and practice for agricultural land protection, but the realization of them in praxes, in R. Serbia, are connected with a lot of obstacles.
- On the one hand, there is not enough professional and technical capacity, and on the other hand, there is no legal framework for financial support for producers. In addition, the practice of agroforestry gives results only in a longer future period, and the invested funds and results are not immediately noticeable.
- Based on the conducted survey on prior knowledge and interest in agroforestry, it can be concluded that there is significant potential and interest among respondents in this agricultural practice in the Republic of Serbia. In conclusion, the survey findings underscore the significance of creating favourable conditions, providing education and training opportunities, and implementing supportive measures such as reliable state subsidies and regulatory adjustments to drive the widespread adoption of agroforestry practices among farmers in Serbia. By addressing these factors, it is possible to enhance the knowledge, interest, and implementation of agroforestry, promoting sustainable and resilient agricultural practices in the country.
- In light of Vojvodina's limited forest coverage and the urgent need for implementing agro-protective measures, such as windbreak belts, under the jurisdiction of local authorities, it is crucial to explore the potential of wider and multi-tiered agroforestry belts. These belts should not only serve as effective crop protection measures but also encompass agroforestry practices, integrating both forestry and agricultural elements.
- Precisely because it takes a long time to obtain visible results from agroforestry, now it is of crucial importance to be established agroforestry demo experimental fields and to strengthen professional and technical capacities for the development and application of agroforestry.
- The introduction of agroforestry and organic farming practices in Vojvodina can contribute to the diversification of agricultural systems and the creation of more sustainable practices. Governmental and local authorities play a crucial role in promoting and supporting agroforestry through legislation, subsidy programs, and farmer education. It is important to ensure collaboration among various stakeholders, including farmers, the scientific community, local authorities, and other experts, to maximize the potential of agroforestry in Vojvodina.

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