THE USE OF FRUIT TREES IN AGROFORESTRY - A CONTRIBUTION TO IMPROVING THE DIVERSITY OF AGRICULTURAL LANDSCAPE AND ITS CULTURAL SERVICES

Eva Pekárová
National Agricultural and Food Centre – Soil Science and Conservation Research Institute, Trenčianska 55, 821 09 Bratislava, Slovakia

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Abstract
The paper is focused on the use of fruit trees in agroforestry which falls into the category of alternative farming. In the first phase of the assessment, the possibilities of using fruit trees in agroforestry systems were specified with regard to the type of land, especially on arable land and permanent grasslands to which extensive orchards and gardens have also been assigned. While in arable land, linear planting is considered inside or on the edge of soil blocks, in permanent grassland it is mostly scattered planting within plots. In the case of extensive orchards and gardens, it is a combination of linear and scattered plantings. In the second phase, the categorization of soil-climatic conditions of Slovakia was performed from the point of view of the requirements of individual fruit trees. Adapting the choice of fruit trees to habitat conditions is a basic precondition for their planting on arable land or permanent grassland to be beneficial both for increasing the ecological stability of the agricultural land and for diversifying agricultural activities. It should be recalled that weather fluctuations, including the occurrence of longer periods of drought, especially in lowland areas, will significantly determine the real benefits of integrating fruit trees into agroforestry systems. Although habitat conditions allow for a more even distribution of productive cultivation of fruit trees in the form of agroforestry on agricultural land, to factors that also determine the expansion of fruit trees belong tradition, technological equipment, including post-harvest processing of fruit and, of course, supplier-customer relations. The application of agroforestry on agricultural land can also be perceived as a contribution to enhancement of cultural ecosystem services of agricultural land which creates the basic preconditions for agri-tourism development.

Key words: agroforestry systems, fruit trees, arable land, permanent grasslands, agri-tourism

Introduction

Climate change is accompanied by the occurrence of extreme weather fluctuations, which ultimately affect growing conditions throughout Europe. Individual countries and their agricultural and forestry organizations are thus responding to extreme droughts, floods and other consequences with various recommendations and measures. In terms of mitigation and adaptation measures, the FAO has identified agroforestry as one of the most powerful tools in the context of climate change (Buttoud, 2013).

Agroforestry systems are also coming to the forefront of interest Slovak farmers. These systems offer a wide range of alternative land management, which combines tree cultivation with one or more forms of agricultural production or animal husbandry. In particular, fast-growing woody plants intended for biomass production are used. On the contrary, fruit trees, which have a long tradition in our country, are used much less. Fruit tree crowns, which have been developing for decades, protect the soil from temperature and moisture fluctuations, and the deep root system can supply the tree with nutrients even during the dry season. While tree lines and fruit tree alleys reduce wind speed, the underground root system stabilizes the soil.

The most widespread explanation of the concept of agroforestry and the possibilities of applying this system was developed in the 80s of the last century (The International Centre for Research in Agroforestry - ICRAF). As stated by Dawkins (1997), agroforestry is the collective name for land management and use systems and technologies in which perennial trees are purposefully grown with agricultural crops or animals, in different spatial and temporal arrangements. In general, it is a matter of landscape and economic management, in which the ecological and economic components should be balanced (Sádlo et al., 2005, 2008). At the same time, it can be stated that agroforestry represents the management of agricultural or forest land in various configurations, using both agricultural and forestry technologies (Sutuma, 1996). Kotrba (2014) characterizes agroforestry as agroforestry systems, in which agricultural production and cultivation of woody plants are combined only on agricultural land. In other words, agroforestry is the integration of trees with agricultural crops and / or livestock, taking advantage of economic or ecological interactions (Sinclair, 1999, Ehrenberger, 2014).

It follows from the above that this is not a new concept, only the improvement of the original foundations of agricultural production in the field of soil, biological, microclimatic and economic disciplines. From an economic point of view, agroforestry is today considered a tool that expands the range of products with the maximum use of timber, which has a multipurpose use.

Material and methods

The starting material for this paper is the design of the national project "Economically efficient and environmentally acceptable agriculture", prepared in 2017 by the Central Coordinating Body of the Office of the Deputy Prime Minister for Investment and Informatization. The aim of that project is based on the need to significantly increase the economic efficiency of sustainable land management in relation to the production, environmental and socio-economic requirements of agricultural, food and forestry production. It also includes stage 1.8 "*Agroforestry (agroforestry) systems for combined production and efficient use of agricultural land*", which aims to develop models and methodologies for establishing agroforestry systems for the conditions of Slovakia and to prepare the proposals to amend national legislation for the application of agroforestry systems.

In the first part of this paper, the possibilities of using fruit trees in agroforestry systems were specified with regard to the type of land, especially on arable land and permanent grasslands (Table 1).

Tab. 1: Basic typology for the use of fruit trees in agroforestry on agricultural land

Fruit trees on arable land (AGRISILVICULTURAL)	**Fruit trees on permanent grasslands including extensive orchards and gardens (SILVOPASTORAL)**
Linear plantings of fruit trees inside soil blocks	Planting of fruit trees in meadows and pastures combined with livestock grazing
Linear plantings of fruit trees at the edge of soil blocks such as windbreaks, tree lines, alleys, hedges	Planting of fruits trees in permanent grasslands, gardens and use of extensive orchards in combination with grazing of livestock

In the second part, the soil-climatic conditions of Slovakia were categorized from the view of the requirements of individual fruit species, using the system of soil-ecological units - BPEJ (Džatko, Sobocká et al., 2009). The result of the evaluation was the creation of a four-level categorization of soil-climatic conditions in terms of the suitability of their cultivation.

Results and discussion

Based on the above approach, the suitability of conditions for growing fruit trees within the agricultural land of the Slovak Republic was defined, while the selection of site conditions was focused on those that create a basic precondition for achieving fruit yields in the required quality and achieving of cultivation profitability. The suitability categories of soil and climatic conditions for growing fruit trees are summarized in Table 2.

Although agricultural land in Slovakia allows profitable cultivation of the vast majority of varieties of fruit species, there are also localities where the cultivation of fruit species is not suitable (Zone 4). The assessment of Slovakia's soil and climatic conditions through the real possible production of fruit cultivation is based on the well-known fact that the highest yields and thus also the economic profitability can be expected in the lowlands as with increasing altitude the production potential of soils decreases.

Tab. 2: Categories of suitability of soil-climatic conditions for the use of fruit trees in agroforestry

Zone 1 very suitable	- the area of the very warm region (00, 01, 03-04) of the warm lowlands (Nt) - optimal conditions with respect to all soil-ecological parameters - growing the most demanding varieties of fruit trees
Zone 2 suitable	- Lowlands including warm to moderately warm climates (02, 04-05) lowlands (N) - one parameter of BPEJ is less suitable but regular and high-quality fruit yields can be achieved by suitable agrorechnics - cultivation of demanding varieties of fruit trees
Zone 3 less suitable	- hilly areas covering moderately warm to moderately cold climate (02,05, 06-08) hilly (P) - two or more parameters from BPEJ are less suitable - growing less demanding varieties of fruit trees
Zone 4 inappropriate	- areas of highlands in the climate zone slightly cold to cold, slightly humid and very cold humid climate (08, 09, 10) – highlands (V) in very rugged territory and highly sloping terrain - unsuitable for intensive cultivation - growing fruit trees only as an additional ingredient

Assumptions of the application of fruit trees in AFS on arable land

The perspective of the use of fruit trees on arable land lies mainly in linear plantings inside soil blocks in combination with cereals, root crops, vegetables or honey plants (medicinal, aromatic and spice plants). Linear plantings along the edges of soil blocks can be used to reduce wind and water erosion, or to separate soil blocks to enhance the biodiversity. Linear plantings can simultaneously provide fruit production.

In combination with the cultivation of fruit trees with agricultural crops in one area, the use of trendy growing shapes and more powerful varieties is required, which is stated in the "*Pomology of the second half of the 20th century and the first years of the 3rd millennium*" (Hričovský et al., 2008). The non-native tree hazel (Corylus colurna L.), almond (Amygdalus communis / Prunus dulcis Mill.), and alder flycatcher (Amelanchier alnifolia L.) also have good adaptability to drought.

Agroforestry systems on arable land, whose production potential has a higher production potential compared to permanent grasslands, allow the use of current, but also more demanding fruit trees, such as hybrids (Juglans regia L.), whose gene pool diversification can improve not only fruit yields but in particular to contribute to the wood biomass indicator. The royal hybrids Juglans nigra × Juglans hindsii have acquired drought resistance from Hinds' walnut and great growth from black walnut (Bakay, 2021).

In addition to walnut hybrids, hybrids of the chestnut (Castanea sativa Mill.), such as marons, "Belle Epine" and "Bouche Rouge" varieties, appear to be a promising tree for agroforestry, not only on arable land, due to their versatile use (Pekárová, 2021).

High ecological and economic potential is also offered by the planting of multi-purpose fruit trees which separate agricultural land from watercourses provided that herbaceous vegetation is also present, which increases the efficiency of nutrient capture when soil erosion occurs.

Integrated production under the rural development program is a promising platform within which agri-silvicultural systems on arable land using fruit trees could be supported.

Assumptions of the application of fruit trees in AFS on permanent grasslands

The use of fruit trees in meadows and pastures (the so-called AFS system) with the parallel breeding of livestock (e.g. grazing sheep, goats, cows) seems to be promising in the conditions of climate change.

Tradition fruit trees are suitable for extensive cultivation, as they have the ability to survive in often unfavourable soil and climatic conditions.

These are mainly local and regional varieties, in the case of apple and pear trees a branch in the shape of a half-trunk (approx. 1.6 m) and in the case of cherries partly also a high stem at a trunk height of 1.8 m with a two-year-old crown. In the extensive conditions, it is advisable to follow other principles as well. It is suitable to plant high-stem species on large areas, resp. solitary fruit tree species, such as black / white mulberry (Morus nigra / alba L.), domestic apple (Malus domestica), or forest apple (Malus sylvestris L. Mill.).

For smaller areas, it is advisable to plant, for example, black bass (Sambucus nigra L.), dogwood (Cornus mas L.), honeysuckle (Cydonia oblonga Mill.), blackthorn (Prunus spinosa L.), hawthorn (Crataegus laevigata) or hazel (Carylus avellana L.).

To use all benefits of agro-forestry system it is possible to plant hedges or tree lines, which can create a natural transition from the forest environment to agricultural land. Of the low-demanding and at the same time resistant fruit trees, it is possible to mention bird cherry (Cerasus avium L. Moench.), medlar (Mespilus germanica) or mirabelle.

The target number of fruit trees should be up to 100 trees per ha with scattered or regular distribution on the cultivated area and edges (Lojka et al., 2020). The creation of a group of fruit trees serves as a vegetation cover for animals in unfavourable weather. In order to ensure a balance between trees and grazing, it is necessary to keep the crown airy and at the same time allow enough solar energy to create grass and herbaceous biomass under the treetops. The greater distance between the trees reduces the occurrence of diseases and pests, while apple seedlings and planks are naturally more resistant to weather fluctuations.

One of the advantages of the silvopastoral system is the use of cut tree shoots as animal feed that prefers them. From a practical point of view, it is not necessary to prepare these plots before tree planting because grass cover remains. However, in the first years after tree planting is to secure trunk protectors against animals. Extensive uses of fruit trees, combined with the permanent grassing of agricultural land, have a positive effect on the biodiversity of plant and animal communities, while supporting soil quality. Organic farming under the rural development program is a promising platform within which silvopastoral systems using fruit trees could be supported.

The growing interest in natural resources (soil, water) is forcing us to participate more actively in land management. However, natural resource and landscape management require diversified management approaches. The implementation of strategic goals in the field of sustainable growth is not possible without sustainable regions. Sustainable regions are significantly linked to rural population retention, as the associated economic activities have a primary impact on the environment.
Given the many vital functions of land for society and man, suitable areas for agriculture, forests, recreation and tourism should be used efficiently. As state Bujnovský et al. (2009), the use of agricultural soil as space for recreational purposes and tourism has till now the limited importance because the development of agri-tourism is less dependent on soil parameters. For these activities are usually attractive pre-hilly and hilly areas. However, the application of agroforestry on agricultural land can also be perceived as a contribution to increasing the attractiveness of agricultural land in terms of agri-tourism development, because some cultural biotic ecosystem services related to "Phsical and experiential interactions with natural environment" and "Intelectual and representative interactions with natural environment" defined by the classification of ecosystem services CICES v. 5 (Haines-Young and Potschin, 2018), may be positively influenced by the development of agroforestry.

Conclusions

As in the case of sustainability, as well as in connection with the adaptability of the agroforestry system, clear criteria have not yet been set according to which the individual systems would be evaluated and compared with each other. The evaluation or setting of measurable indicators from the environmental point of view and the subsequent setting of subsidy schemes in the agricultural sector is also difficult.
As the use of large-scale mechanization is lower in agroforestry systems, it is assumed that this form of farming in Slovakia will appeal mainly to medium-sized farms and family farms, which can help not only maintain biodiversity but also contribute to diversification of agricultural products and elimination of possible risks associated with monoculture crop production. Agroforestry systems they can contribute to the development of beekeeping and also partially compensate for the current deficit in the food processing sector. Nevertheless, in this context, it is recalled that agroforestry systems are not an alternative to conventional agriculture.
The implementation of agroforestry through fruit trees in combination with other agricultural crops or the grazing of livestock on a single plot can contribute to restoring the natural ecological balance to the agricultural land and to gradually improving the business environment in agriculture. In the conditions of climate change and the occurrence of drought, the priority should be given to fruit species that will not only be able to survive, but also contribute to increasing production and non-production functions in the landscape. Optimal soil and climatic conditions within the agricultural land make it possible to include fruit trees in the agroforestry system. As stated by ŠARAPATKA (2008), the increase in the number of fruit trees within the production areas of agricultural land can be seen as a contribution to increasing the biodiversity of the agricultural environment.
Although site conditions allow a more even expansion of productive fruit growing in the form of agroforestry on agricultural land, factors that probably also determine their increase in cultivation include tradition, technological equipment, including post-harvest processing of fruit, as well as supplier-customer relations. As tree planting requires long-term land use, problems with land ownership or lease is another area that needs to be kept in mind when expanding agroforestry in Slovakia.

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Souhrn
Agrolesnictví jako specifická forma hospodaření se dostává v současnosti do popředí prostřednictvím liniových výsadeb dřevin nebo krajinných prvků. V našich půdně-klimatických podmínkách jsou největším potenciálem pro agrolesnické systémy extenzivní výsadby ovocných dřevin, přičemž je třeba zohledňovat jejich víceúčelové využití. Implementace agrolesnictví prostřednictvím ovocných dřevin může přispět k navrácení přirozené ekologické rovnováze do obhospodařované země. Posuzování specifických možností ovocných dřevin lze vnímat jako příspěvek ke zkvalitnění kulturních ekosystémových služeb, což vytváří základní předpoklady i pro rozvoj agroturistiky.

Contact
Ing. Eva Pekárová, MBA
E-mail: eva.pekarova@nppc.sk