# Importance of Underutilized Field Crops for Increasing Functional Biodiversity

Franc Bavec, Urška Lisec and Martina Bavec

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.70472

**Abstract**

Despite the suggestions to include two or three crops into crop rotation that is widely considered to support the richer biodiversity on fields, industrial field crop production systems are still based mainly on monoculture, where the farmers produce permanently mainly one crop. Review and analyses of different possibilities showed that more diverse functional (also important for diverse nutritional and health products of food) biodiversity of underutilized field crops needs to be established, especially if beneficial social and economic effects of introducing underutilized crops into small-scale farms are taken into account. We can conclude that functional biodiversity based on rich crop rotations associated with underutilized crops increases biodiversity in the soil and has an effect on richer and sustainable behavior of cultural plants with good balance of pests and plant diseases.

**Keywords:** underutilized crops, alternative crops, biodiversity, functional biodiversity, crop rotation

## 1. Introduction

Industrial-supported production systems with monocultures production of one crop during the years at one place are known to unbalance complete biodiversity of the fields. The main reasons for decreasing soil, plant, and landscape biodiversity are bad agricultural practices such as: (i) reduction of organic inputs in the soil, (ii) use of synthetic compounds including heavy metals as a part of fertilizers, (iii) use of high inputs of herbicides, pesticides and fungicides, and (iv) "scientific" supported GMO organisms adaptable to high inputs of herbicides. Especially, GMO plants in field crop production represent a compensation for the mentioned bad agricultural practices.

Few basic documents on agroecosystems biodiversity [1–3] gave extensive descriptions and figures about relationships of forming sustainable biodiversity. It is now clear that monoculture gives rise to decreased natural enemies of species diversity and habitat diversification, whereas rotations and cover crops can improve biodiversity [2]. An extensive overview from different aspects contains terms such as (i) prevention of culture and ethno science, (ii) knowledge about potential uses of plants, and (iii) uses of local resources for pest control, etc., but on other hand, the whole approach is done in the context of industrial-supported agriculture by synthetic pesticides and fertilizers [3]. Assessment of potential indicators for sustainability (especially biodiversity) of food production on the field level looks like built a house without strong fundament [4]. Indicators of soil quality and food quality (influenced by different crops in crop rotation) are essential for the indicator frameworks; they are strongly correlated with each other.

The main problem of dominant monoculture production (based on five main crops such as maize, wheat, soybean, rice and cassava, and potato, rye, etc., depending on specific regional circumstances) is genetic erosion of plant diversity and associated biodiversity of life cycles in the soil and behavior of the plants (pests, diseases, new components of GMO sequences in the plants, etc.). It is true and important that agricultural and biodiversity conservation sectors must work in partnership [5]. However, kind of theoretical basis is not enough for protecting biodiversity from landscape to the soil level. Especially, it needs to be in the scope of natural processes of known good agricultural practices.

In spite of discussions with different officers (Brussels, Ministry) and presented chapter [6], where we focused on agricultural measures for increasing biodiversity on the field level with supporting remarks for policy makers, "green measures" is nothing new. EU green measures (also the USA and other parts of world are not exception) in many cases smell more like "green washing" than real base for increasing rich biodiversity on the field level and produce niche products of health and nutritional foods [7].

The aim of the chapter is to analyze potential underutilized species of field crops and their benefits for introducing them into broader crop rotation instead of monoculture or two crops rotation. It is also important to show the data and idea to environmental, agronomical advisers, and policy makers for better understanding and support of rich biodiversity of crop plants in the fields.

## 2. Methodology

The chapter is based on extensive review of latest results and rare scientific papers (from databases Web Sci., Sci. Direct, keywords like functional biodiversity, crop rotation, and underutilized crops) particularly focusing on basic part of agricultural biodiversity with real change of crop rotation based on underutilized crops as a part of functional biodiversity. SWOT analyses of underutilized crops vs. biodiversity were also employed. As a special part of this basic change on the field instead of monoculture or two crops rotation, a special focus will be an interdisciplinary approach of underutilized crops vs. biodiversity and other environmental, social, and economic benefits.

http://dx.doi.org/10.5772/intechopen.70472

## 3. Results and discussion

### 3.1. Review of scientific and professional bibliographies in field underutilized crops as part of functional biodiversity

According to numerous projects' (e.g., by Agrobiodiversity international, different environmental agencies like PBL Netherlands Environmental Assessment Agency [8], and others) designs and explanations of agricultural biodiversity [2, 3] from agronomic point of view, underutilized crops are the main point for real sustainable biodiversity on the fields. Considering the basic part of agricultural biodiversity, especially underutilized crops growing in organic (biological, ecological) production system without synthetic chemistry and transgenic plants are the best support for rich agricultural biodiversity. In this way, rich functional biodiversity of underutilized crop supports all parts of natural biodiversity in the soil and on the field (**Figure 1**).

Potential of underutilized crops for rich biodiversity is extensively described by different authors [9] through global and regional assessments from wild to cultivated plants. In different literatures, about 100,000 used plants, 80,000 explored plants by humans since down civilization and about 118,000 edible plants are listed. In addition, 9500 plants as a source of economics, etc., are reported at the world level. Regional types of species are diverse according to climatic conditions, but in every region, a lot of minor, underutilized, and even neglected crops also exist. It is also based on the fact that in one region, one species can be neglected, but it may be a main crop (like a chick pea).

In case of small country Slovenia, we can describe a relatively long list of potential edible and economical valuable field crops (**Table 1**). However, just a few of main crops are economically acceptable for the farmers. Because of this, agricultural biodiversity has reduced mainly to one or two crops per field. In recent years, biodiversity structure on the fields has been increasing especially on organic farms. The list in **Table 1** can be longer if herbal and vegetable crops or even their intercrops with fruit plants are included in crop rotation. In this case, in every region over the world, the increase of functional plants is nonlimited due to usable plants. Only question is whether political decision-makers support it. In case of Slovenia, we numbered more than 200 plant species in these combinations. However, many of this kind of combinations were not examples of research and specific development. In case of more traditional plants, we can represent some possibilities from more conventional intercrops to the intercrops and sole crops of underutilized plants.

Underutilized crops are better adapted to marginal soil, complex and difficult environments conditions (climate change, which will have impact on biotic and abiotic stress), and they can contribute significantly to diversification and resilience of agroecosystems [10, 11]. Underutilized crops, which are known for their drought tolerance, are the minor millets, sorghum, and amaranth [12–14]. We have to know that we need to grow population of crops, which would have the ability to maintain the satisfactory yield under changing climates. Excellent drought resistance combined with good tolerance of heat, low fertility, and a range of soils make cowpeas viable throughout the temperate climate. It makes an excellent N source and attracts many beneficial insects. Cowpeas also can be used on poor land [15].

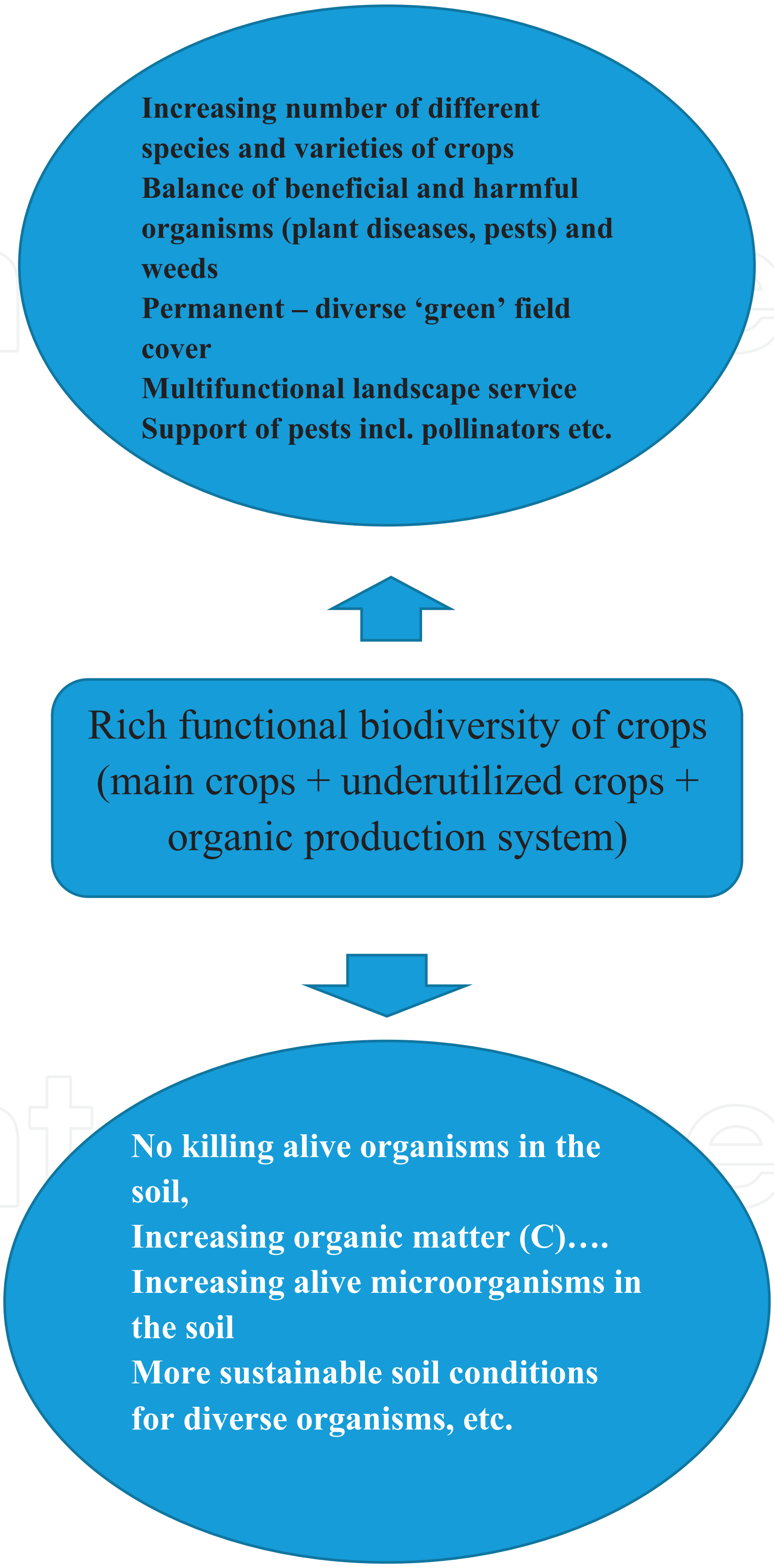


**Figure 1.** Some effects of underutilized crops like functional biodiversity on soil and field diversification.

| Crops | Intercrops |
|---|---|
| **Main crops** | |
| Maize (*Zea mays*) | Maize × climbing bean |
| Cereals: wheat (*Triticum* sp.), barley (*Hordeum vulgare*), rye (*Secale cereale*) | Cereals × pea |
| Potatoes (*Solanum tuberosum*) | Hops × under sown cover crops |
| Hops (*Humulus lupulus*)—monoculture | (Clover, buckwheat, white mustard,…) |
| **Less produced crops** | |
| Soybean (*Glycine hispida*) | Pea × cereals, clover × maize, soybean × maize (strip sowing) |
| Pea (*Pisum sativum*) | |
| Oil (seed) pumpkins *Cucurbita pepo* group | |
| Oil rapeseed (*Brassica napus* var. *napus)* | |
| Clovers, alfalfa,… | Clover × under sown cereals |
| **Underutilized (minor, neglected, alternative) crops** | |
| Horse bean (*Faba bean*) | |
| Beans (*Phaseolus* sp.) | Maize × climbing bean |
| White lupine (*Lupinus albus*) | |
| Buckwheat (*Fagopyrum esculentum*) | |
| Proso millet (*Panicum miliaceum*) | |
| Spelt (*Triticum aestivum* ssp. *spelta*) | |
| Einkorn (*Triticum monococcum*) | |
| Emmer (*Triticum diccocum*) | |
| Khorosan (*Triticum turgidum* ssp. *turanicum*) | |
| Camelina (*Camelina sativa*) | Camelina × barley |
| Hemp (*Cannabis sativa*) | |
| Flax (*Linum usitatissium*) | |
| Garden poppy (*Papaver somniferum* ssp. *somniferum*) | |
| Safflower (*Carthamus tinctorius*) | |
| Quinoa (*Chenopodium quinoa*) | |
| Grain amaranths (*Amaranthus* sp.) | |

**Table 1.** The list of usable (practically introduced and researched in Slovenia) and economical valuable crops including their intercrops for increasing functional biodiversity in crop rotation.

As mentioned, underutilized species are generally deployed in multicropping system [12]. If more diverse production is required, we can use different intercropping. These cropping systems are more stable and resilient than monocultures [12]. Abiotic stress can be ameliorated by intercropping, which reduces the accumulation of nitrate in the soil, permitting lower application rates of N and reducing down streams effects [16]. Altieri [2] states that in the areas where intercropping system was used, 52% less arthropods were observed compared to monoculture. There was also an increase in density of all living organisms up to 15.3%.

It is a known fact that the most effective suppression of weeds in organic and more sustainable agriculture systems is intercropping. It can provide benefits in nutrient availability and pest control, finally higher yield too [16]. The most common combination is between cereals with legumes. This enables more stable yields, greater use of land, and effectively controls the growth of weeds and soil mainly to improve the hock (fixation of nitrogen of the roots of legumes), the quantity of organic material, and the quality of the soil by the addition of atmospheric carbon.

In Serbia [17], an experiment was performed in which impact of monocultures of corn and soya compared with the intercropping of both was investigated. They examined coverage, abundance, and biomass of weeds. In the monocultures, the number of weeds was statistically different compared with other production system. The intercropping system was proved to be more effective than the estimate parameters of monoculture. Earthworm population is more affected by species-rich if more legumes are included [16]. Cropping systems increase biological diversity and prevent the onset of nematode problems as it balances a dynamic soil ecological and improves healthier soil structure with higher organic matter [15].

For soya production, temperate climates in northern part of the Alps are too low to ensure yield potential and stability. This is the reason why soya can be neglected in this region, although on the global scale, it is in the fifth place in the list of the most important main crops [14]. Amaranth is a very notorious leaf vegetable; it can be comparable to spinach. With regard to resistance to cold weather condition, quinoa is similar to peas and faba beans. However, they are not adapted to modern production techniques. Switzerland has made adjustments to test if soya can be adapted to cold climate. Hemp is known as a robust plant for producing fibers, but has some other problems such as too short fibers for the construction industries and too long fibers for textile [24]. Buckwheat has short vegetation, so it can be suitable for regions that enable stubble crop. With global warming, there will be a longer growing season. In addition, the role of underutilized crops as a buffer for climate change should be promoted [10, 14].

Different species (like millets from different genera) are important in fragile ecosystems such as those of arid and semiarid lands, mountains, steppes, and tropical forests. Crops do not require high imputes, so they can be grown in degraded and wastelands. They can increase agricultural production and enhance crop diversification. At the same time, they can contribute useful genes to breed better varieties [10].

A lot of sole or mixed populations of underutilized crops can be used as cover crops. These can cover the soil during the summer and winter, thus improving soil diversity and also prevent leaching of nutrients. They can reduce the intake of various fertilizers for the next crops and minimize the use of nonrenewable resources [18].

### 3.2. Underutilized crops performance of SWOT analyses

There are an extensive number of crops at the world level, continent, region, or country (see **Table 1** for Slovenia). From agronomic (**Table 2**) point, crop rotations with different underutilized crops have some opportunities and weaknesses, with more promising structure for increasing functional biodiversity (**Table 3**). In case of including underutilized crops and intercrops into crop rotation, we can increase important benefits of agronomic factors such as soil organic matter, soil structure, phosphorus mobilization, and reduction of diseases or weeds, etc. (**Figure 1**).

Strengths, opportunities, weaknesses, and threats of including underutilized crops into crop rotation have been frequently criticized over the world from supporting industrial thinking agronomists. It is partly included in the lists of presented weaknesses and threats (**Tables 2** and **3**).

Due to SWOT analyses, including comments from literature, we need to underline that underutilized crops have a good impact on preservation of the ecosystem. Grasses, sacrum, and buckwheat are good ground cover, and they effectively prevent erosion with their dense root system. They produce a lot of biomass, which ensures the subsequent increase in the organic matter with increasing soil microbiology. With their intense growth of crops, they also prevent the growth of weeds. Hardy rye, sorghum, sudangrass, and the sacrum with their excreta prevent the germination and development of weeds due to allopathy. Particularly, rye is an effective crop for weed control as it can reduce the germination of weeds by preventing access of light to the ground; consequently, the soil is colder [19].

The role of grain legumes in cropping system is nitrogen effect caused by N provision from bacterial symbiotic fixation and N sparing process that provides a long-term supply to other

| | |
|---|---|
| **Strengths** | **Weaknesses** |
| Rich crop rotation | Loss of genetic materials |
| Less plant diseases, pests and weed populations | Not well organized breeding |
| No synthetic chemistry in process | In some cases bad adaptation to environment |
| No transgenic plants | Lack of whole chain knowledge |
| More niche product | Lack of knowledge about nutritional and health value of products |
| Nutritional and healthy food | Less specialized mechanization than in conventional production |
| Higher prices of products than conventional | |
| **Opportunities** | **Threats** |
| Les risks with sell prices | Low yields |
| Increasing employment | Unknown products as a food |
| Organize production whole chain (from seed to sell the product) | Opposition from intensive sector and multinational corporations |
| Increasing production of diverse food | |
| Development of new tastes by consumers | |
| New trading possibilities | |

**Table 2.** SWOT analyses of crop rotations with more underutilized crops on main agronomic, social and economic parameters.

| Strengths | Weaknesses |
|---|---|
| Increasing usable crops in the fields<br>Natural populations of predators and pests, natural regulation of plant diseases and weed populations<br>Increasing pollinator plants<br>Green covered field during longer period<br>More plant rests with different effects on the soil cycles<br>More microorganisms in the soil | Bad organized breeding and gene banks exploitation<br>Bad genetic adaptation to growing conditions |
| **Opportunities** | **Threats** |
| Preservation of honey bees<br>Increasing soil organic matter and available nutrients<br>Symbiotic N fixation with legumes in crop rotation | Misunderstanding of policy makers about biodiversity benefits for support<br>Use underutilized crops just for genetic modification of plants |

**Table 3.** SWOT analyses of functional biodiversity of underutilized crops in total agricultural biodiversity.

crops [20]. Peas, legume, has ability to fix nitrogen from the air with the help of bacteria (*Rhizobium* sp.), living on their roots. It contributes on the formation of organic substances and positive influence on the structure of the soil, as its roots exudate sugar bind soil particles to larger structures. Consequently, it retains moisture.

It is worth to mention that lupines included into crop rotation has the ability to accumulate heavy metals such as Cu, Cd, Ni, and Zn [21]. In the same time, it has a positive influence on the increase of N (it has the biggest content and uptake), the organic matter, the number of microorganisms (bacteria), and plant accessible metal "bioavailability metals" [22, 23]. According to our experience, hemp is a promising bioremediation crop as a part of crop rotation because of high production of biomass and their accumulation of heavy metals [22].

Cover crops can reduce the number of nematodes, pests, and diseases. Sudan grass is one of the good inhibitors of nematodes as it effectively reduces the formation of nematode eggs. This was evidenced in experiments on lettuce and its previous crops [25, 26].

Preissel et al. [22] compared different precrops without fertilizers application and reported that yields of cereals following grain legumes increased yield by 11–41%, and compared to oats or precrops, the benefits increase by 27–110%. Grain legumes, plants with multiple impacts on the environment can provide a stable yield and the possibility of reduce inputs (spraying, fertilization, and multiple treatments). They also indicated that grain legume intercropped with cereals is the most important in rotation system as they are the most effective natural way to prevent diseases of cereals. In the grains of cereals, the content of proteins also increased. Cropping system with legumes reduced nitrous oxide emission and caused lower nitrate-N leaching. In the same time, it had positive phytosanitary effects [23]. Alteri [2] argues the same emphasize that the polyculture (maize-beans and squash) can produce up to 4 t $ha^{-1}$ of dry matter compared with 2 t $ha^{-1}$ from monoculture of maize. This reflects that the presence of different crops can be efficient of using natural resources.

Diversified crop rotations may be one of the prospective methods of reducing the expansion of pests beside soil improvement. Phatak [15] proved that, by using crimson clover and vetch as cover crops, it is possible to reduce the amount of fertilizers and insecticides to 30–100%. As it is known that some crops like lupines and oilseed rape have big impact on the crop of cereals, especially on wheat. Both reduce the presence of root diseases and grass weeds. These combinations influence the effect on the final harvest index.

Pollination is an essential ecosystem service in which bumble and solitary bees play an important role. If we used crop rotations without using pesticides, we can improve production. If habitats islands were isolated from agricultural field, species richness of flower-visiting bees decreases. The same is valid for seed production. This is a proof how important is the relation between crop and pollinator diversity. It is a good example of importance of interactions among different components of biodiversity [16].

Intercropping can also have a negative effect on crops, particularly if it is not selected by the correct combinations within the intra- and interspecific varieties; consequently, there will be competition between crop plants. This is a reason why the next plant should be selected according to the characteristic of competition of the precrop.

Several vetches, clovers, and certain cruciferous crops increase high density of populations of beneficial insects such as insidious flower bugs (*Orius insidiosus*), bigeyed bugs (*Geocoris* spp.), and various lady beetles (*Coleoptera: Coccinellidae*). These predators are reproduced on nectar, pollen, thrips and aphids and are established before key pests arrived. When pests attack crops, they send chemical signals that attract beneficial insects. Lady beetles in rotation crops systems can control aphids attacking many crops [27].

Minimally tilled crimson clover or cahaba vetch before cotton planting have been successful in reducing fertilizer N down to 50% and insecticide inputs by 30–100%. A system of transplanting tomatoes, peppers, and eggplants into a killed hairy vetch or vetch/rye cover crop can influence benefits of weed, insect, and disease suppression, improved fruit quality, and overall lower production cost. Rye has the ability to reduce soil-borne diseases, nematodes, and weeds. It produces significant biomass that smothers weeds when it is left on the surface provides habitat for beneficial insects and controls weeds allelopathically through natural weed-suppressing compounds. Rye is not suitable cover where those worms are a problem (crops like corn, sweet corn, sorghum, or pearl millet) [15].

Crimson clover suppresses weeds effectively by forming a thick mulch and supports high densities of beneficial insects by providing food and habitat [15]. Buckwheat is very effective in suppressing weeds and supports high densities of beneficial insects. It is very attractive to honeybees and also sunflowers [15, 16].

After tests with oats, broccoli, white lupine, and field peas, researchers cautioned that it might take 3–5 years to effectively reduce stem lesion losses on potatoes. Cover crops with documented nematocidal properties against at least one nematode species include sorghum-sudangrass, marigold, hairy indigo, showy crotalaria, hemp, velvet bean, rapeseed, mustards, and radish. Sorghum-sudangrass and buckwheat are warm-season crops that suppress weeds by allelopathy. Cereal rye is an overwintering crop that suppresses weeds both physically and chemically. Rye residue, which is left on the soil surface, can release allelo chemicals [15].

## 4. Conclusions

We agreed with the statement of Frison et al. (2011) that "Diversity will be essential to improve productivity, to enhance ecosystem functions, and to provide adaptability." In addition to environmental services, underutilized crops produced in different regions are urgent for preserving food security and food quality [28, 29], especially if grown under organic farming system [30].

We conclude that only real increasing of functional biodiversity is based on underutilized crops managed in multiple crop rotation and intercrops in organic farming production system. Conservation of many underutilized crops needs to be based on practical production on small-scale farms. This kind of supporting usable functional biodiversity would be a chance for increasing positive social and economic impacts by the farmers with an extensive protection of nature. Worldwide and EU policy makers need to find better ways to develop this kind of practical and beneficial environmental development.

## Author details

Franc Bavec*, Urška Lisec and Martina Bavec

*Address all correspondence to: franci.bavec@um.si

University of Maribor, Maribor, Slovenia

## References

[1] Altieri MA. Biodiversity and Pest Management in Agroecosystems. New York: Haworth Press; 1994. 185 pp

[2] Altieri MA. The ecological role of biodiversity in agroecosystems. Agriculture, Ecosystems & Environment. 1999;**74**:19-31

[3] Altieri MA. Agroecology: The science of natural resources management for poor farmers in marginal environments. Agriculture, Ecosystems & Environment. 2002;**93**:1-24

[4] Štraus S. Potential Indicators for Sustainability Assessment of Food Production on the Field Level. PhD Thesis: Univ. Maribor; 2012. 195 pp

[5] Heywood V. 1999. Trends in agricultural biodiversity. Second Meeting, Montreal 2-6 September 1996

[6] Bavec F, Bavec M. Underutilized crops and intercrops in crop rotation as factors for increasing biodiversity on fields. University of Maribor, Maribor. In: Lo Y-H, Blanco JA, editors. Biodiversity in Ecosystems–Linking Structure and Function. Intech; 2015. p. 583-595

[7] Bavec F, Bavec M. Organic Production and Use of Alternative Crops. Boca Raton, New York, London. Taylor and Francis; 2006. 241 pp

[8] PBL Netherlands Environmental Agency. How sectors can contribute to sustainable use and conservation of biodiversity. CBD Technical series. 2014;**79**:17-86

[9] Padulosi S, Hodgkin T, Williams JT, Haq N. Underutilized crops: Trends, challenges and opportunities in the 21st century. In: Engels JMM et al., editors. Plant Genetic Diversity; 2002. p. 323-338

[10] Staphit B, Padulosi S, Mal B. Role of on-farm/in situ conservation and underutilized crops in the wake of climate change. Indian Journal of Plant Genetic Resources. 2010;**23**:145-156

[11] Powell B, Thilsted SH, Ickowitz A, Termote C, Sunderland T, Herforth A. Improving diets with wild and cultivated biodiversity from across the landscape. Food Security. 2015;**7**: 535-554

[12] Padulosi S, Heywood V, Hunter D, Jarvis A. Underutilized Species and Climate Change: Current Status and Outlook. Crop Adaptation to Climate Change. New York; 2011. p. 507-521

[13] Ebert AW. Potential of underutilized traditional vegetables and legumes crops to contribute to food and nutritional security income and more sustainable production system. Sustainability. 2014;**6**:319-335

[14] Stamp P, Messmer R, Wlater A. Competitive underutilized crops will depend on the state funding of breeding programmes: An opinion on the example of Europe. Plant Breeding. 2012;**131**:461-464

[15] Phatak S.C., 2016. Managing Pests. http://www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition/Text-Version/Managing-Pests (12 November 2016)

[16] Frison EA, Cherfas J, Hodgkin T. Agricultural biodiversity is essential for a sustainable improvement in food and nutrition security. Sustainability. 2001;**3**:238-253

[17] Dolijanović Ž, Oljača S, Kovačević D, Simić M, Dragičević V, Popović V. Weediness of a maize and soybean intercropping system. Herbologia. 2015;**15**:2-10

[18] Robačer M, Canali S, Lakenborg Kristensen H, Bavec F, Grobelnik Mlakar S, Jakop M, Bavec M. Cover crops in organic field vegetable production. Scientia Horticulturae. 2015;**208**:104-110

[19] Laub CA, Luna JM. Winter cover crop suppression practices and natural enemies of armyworm (*Lepidoptera Nuctoidae*) in no till corn. Environmental Entomology. 1992;**21**:21-49

[20] Peoples MB, Brockwell J, Herridge DF, et al. The contributions of nitrogen-fixing crop legumes to the productivity of agricultural systems. Symbiosis. 2009;**48**:1-17

[21] Fumagalli P, Comolli R, Ferre C, Ghiani A, Gentili R, Citterio S. The rotation of white lupine (*Lupinus albus* L.) with metal–accumulation plant crops: A strategy to increase the benefits of soil phytoremediation. Journal of Environmental Management. 2014;**145**:35-42

[22] Preissel S, Reckling M, Schlafke N, Zander P. Magnitude and farm economic value of grain legume pre-crop benefits in Europe: A review. Field Crops Research. 2015;**175**:64-79

[23] Reckling M, Hecker J-M, Bergkvist G, Watson CA, Zender P, Sclhlafke N, Stoddard FL, Eory V, Topp CFE, Maire J, Bachinger J. A cropping system assessment framework-evaluating effect of introducing legumes into crop rotations. European Journal of Agronomy. 2016;**76**:186-197

[24] Klavž D. Growing and phytoremediation potential of hemp (*Cannabis sativa* L.). Diploma work. University of Maribor, Maribor. 2016. 68 p

[25] Wang KH, Mc Sorley ČR, Kokalis-Burrele ČN. Effects of cover cropping, solarisation, and soil fumigation on nematode communities. Plant and Soil. 2006;**286**:229-243

[26] Bonanomi G, Filippis F, Cesarano G, Storia A, Ercolini D, Scala F. Organic farming induces changes in soil microbiota that affect agroecosystem functions. Soil Biology and Biochemistry. 2016;**103**:327-336

[27] Sharad C. Phatak and Juan Carlos Diaz-Perez. Managing Pests With Cover Crops. http://www.sare.org/Learning-Center/Books/Managing-CoverCrops-Profitably-3rd-Edition/Text-Version/Managing-Pests (Accessed 10.2.2017)

[28] Dansi A, Vodouhe R, Azokpota P, Yedomonhan H, Assogba P, Adjatin A, Loko YL, Dossou-Aminon I, Akpagana K. Diversity of the neglected and underutilized crops species of importance in Benin. The Scientific World Journal. 2012; 19 p

[29] Brussaard L, Caron P, Campbell B, Libber L, Mainka S, Rabbinge R, Babin D, Pulleman M. Reconciling biodiversity conservation and food security: Scientific challenges for a new agriculture. Environmental Sustainability. 2010;**2**:34-42

[30] Das A, Patel DP, Kumar M, Ramkrushna GI, Mukherjee A, Layek J, Nagachan SV, Buragohhhain J. Impact of seven years of organic farming on soil and produce quality and crops yields in eastern Himalayas, India. Agriculture, Ecosystems & Environment. 2017;**236**:142-153