PROBLEMY EKOROZWOJU – PROBLEMS OF SUSTAINABLE DEVELOPMENT
2016, vol. 12, no 1, 135-141

Agricultural Biodiversity for Sustainable Development

Bioróżnorodność rolna dla zrównoważonego rozwoju

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Abstract

Agricultural biodiversity should be considered as a key resource and the most important human heritage. Biodiversity of farm animals and plants gives the foundation to food production that ensures the existence and future of contemporary civilizations. Rapid economic development, unfortunately, does not facilitate the preservation of biodiversity and organisms characterised by many desirable properties and features are perishing. Economic progress forces humans to abandon traditional, safe and more varied species, and to switch to monocultures and those non-native to specific habitats, but which are more productive. In this way mankind had lost forever a large part of this *living deposit of the past times*, and this process continues. Probably, in some cases, this results simply from the pure ignorance of local keepers concerning traditional varieties and breeds. Therefore, it is worth promoting and encouraging the efforts of both individuals and institutions in terms of a better understanding of this subject, and to seek support in the interests of present and future mankind.

Key words: agricultural biodiversity, genetic erosion, ecological agriculture

Streszczenie

Bioróżnorodność rolną należy traktować jako podstawowy zasób i najważniejsze dziedzictwo ludzkości. Na zróżnicowaniu biologicznym hodowanych zwierząt i roślin opiera się produkcja żywności zapewniająca byt i przyszłość współczesnym cywilizacjom. Gwałtowny rozwój gospodarczy niestety nie sprzyja utrzymywaniu bogactwa form. Znikają zatem organizmy kryjące w sobie wiele pożądanych właściwości i cech. Progres ekonomiczny zmusza do porzucania tradycyjnych, bezpiecznych i bardziej zróżnicowanych gatunków na rzecz ujednoliconych i obcych danemu miejscu, ale bardziej wydajnych. W ten sposób bezpowrotnie ludzkość utraciła już sporą część tego *żywego depozytu przeszłości* i wyzbywa się go nadal. Prawdopodobnie, w niektórych wypadkach, wynika to po prostu ze zwykłej niewiedzy depozytariuszy lokalnych i tradycyjnych odmian czy ras. Warto zatem propagować i promować wysiłki zarówno ludzi jak i instytucji zmierzające do pogłębienia wiedzy na ten temat oraz szukania wsparcia w interesie dzisiejszego i przyszłego człowieka.

Słowa kluczowe: bioróżnorodność rolna, erozja genetyczna, rolnictwo ekologiczne

Introduction

Biodiversity is a term commonly known and used today to define the diversity of the living world[1]. Typically, it is used with reference to the abundance of different forms of animate nature. Its scope includes the diversity of ecosystems, species and genes. A full understanding of the importance of biodiversity and its assessment is not easy – if at all possible. The term biodiversity became popular in science, politics and society in the 1990s. This coincided with the documented, alarmingly rapid extinction of species. However, from the epistemological point of view, biodiversity is a new paradigm, because it combines various areas of knowledge, both of the human sciences and natural sciences.

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[1] The biodiversity of agricultural ecosystems includes agrobiodiversity, and hence the diversity of crop plant species and varieties, along with the multitude of farm animal species and breeds, and the biodiversity of wild fauna and flora accompanying domesticated plants and animals on land used for agricultural purposes.

The value of biodiversity is particularly appreciated in agriculture (Tyburski, Kostrzewska, 2013, p. 11). For centuries, to achieve stable access to diverse food, people have learned to breed many animal species and to grow even more plant varieties. Contemporary agriculture is focused on the same goal, but additionally seeks to develop new production systems with the lowest possible environmental impact. The increase in the global human population forces us to look again at species that were once domesticated but over time have been forgotten and are now almost extinct. One of the aims of this paper is to support the justification to develop conservation measures and to restore economically marginalised and/or declining traditional and local varieties and breeds (Badora et al., 2014), which, being better adapted to the place of their origin, may provide food where more popular but feeble alien species are no longer able to do so. Besides, many wild species contain genes that can improve the resistance of crops to diseases and pests without resorting to chemical plant protection, or to provide active ingredients to treat numerous human diseases.

The decline of biodiversity, and anthropogenic pressure

Genetic diversity within the population is the basis of evolutionary processes resulting from environmental interaction with the biological mechanisms at the molecular level. Organisms that, due to their genetic potential, are able to make better use of adaptive traits survive, reproduce and pass on a part of their genetic material to offspring, contributing in this way to the evolutionary improvement of the species. The more diversified the populations and individuals of the species, the greater the genetic diversity of the species. Thus, the diversity largely depends on environmental pressure, and in the case of crops or livestock, also on human activity. On the other hand, genetic erosion, i.e. the loss of valuable and painstakingly achieved genetic diversity, progressing at the same time due as human activity, is a serious signal of a hazard which, when left without an adequate response, may bring grave consequences. The diversity within and between species is therefore a specific guarantee for the functioning of adaptation mechanisms, the continued existence of the species, and life in general.

Living organisms forming ecosystems are closely dependent on each other, and are in dynamic equilibrium oriented at evolution and differentiation. Therefore, if one species disappears or enters into a new relationship with another, the established balance is upset, the ecosystem looks for new solutions. However, when more than one species disappears (or, for example, the dominant one), the formed ecosystem may collapse, and even perish. But ecosystems do not exist as separate units; they always interact with each other through constant energy flow, circulation of matter, or the migration of individuals and species. Gradual exploration of these relationships between biotic and abiotic components has led to the creation of the concept of ecology at the macro level. For this reason, since the 1970s the Earth has been considered as a single large ecosystem. Therefore, it is logical to make conclusions about the global consequences of the extinction of even local species.

The most pernicious factors, besides natural ones, responsible for the decline of species generally include habitat destruction, fragmentation of ecosystems, invasions of alien species, deforestation and land drainage, urbanization and industrialization, which are all a part of multidirectional destructive economic and non-economic unsustainable human activity. Another factor is global climate change (considered, however, as both the cause and effect), the intensity of which depends, to varying degrees, on all of these causes[2].

Thus, we can say without much error that humans, through more or less intensified transformations, introduce the most undesirable changes in their environment, exposing in this way themselves and their environment to additional hazards. Through science and technology humankind, convinced of its emancipation from being biologically dependent on its environment, is in fact working to its own disadvantage. Agriculture is considered the last redoubt of the former relatively harmonious cooperation with nature, as it still perceives human dependency on *the friendly attitude* of the environment (Sobczyk, 2014). Nevertheless, centuries of agricultural activity brought both remarkable damages and successes. Paradoxically, agriculture itself, and more precisely the need for increased food and feed production, contributed to the loss of biodiversity in breeds and varieties that once had been purposefully created. It can be said that at some point the focus on economic profitability replaced common sense. The current situation can also be justified by the lack of relevant studies before the problem emerged. Over the years only selective species conservation has been promoted, while the direct relationship of the conserved species and its habitat and their mutual influence has been ignored. Spatial forms of conservation for rural areas have not been taken into account at all, while in fact they, by gathering valuable wild and domesticated species (unless the use of means increasing productivity led to advanced degradation), are characterized by a unique richness of life forms not found elsewhere. Fallow lands, field margins, wastelands, brushwoods and woodlots among fields, microhabitats, ponds, ditches, etc. are real incubators of biodiversity (Tyburski 2013, 279-291). The same can be

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[2] Too rapidly progressing (again due to human activity) climate change and succession of plant species may, for example, contribute to increase or decrease of biodiversity up to certain limits.

applied to, e.g. traditionally used grasslands. Regular mowing of meadows and grazing pastures prevents natural but harmful succession from the point of view of protecting biodiversity.

Varying degrees of complexity and constant changes in the species composition of individual environments significantly complicate research on the actual status and nature-related and non-nature values of agricultural ecosystems, which additionally strongly rely on sophisticated technologies and chemicals. Hence, the direct and indirect causes of biodiversity loss are usually attributed to human activity. Biodiversity indices play an important role in understanding the dynamics of this process. Two other factors are also considered, although they do not always, and not directly, lead to the right conclusions. These are genetic erosion, namely the decline in biodiversity within species, and the decline in the number of species characteristic for a given ecosystem. The use of appropriate bioindicators makes it easy to monitor multiple environmental parameters indirectly, demonstrating the state of the environment and the level of biodiversity on the world[3].

The situation in Europe, as well as all over the world, is not optimistic. According to the report of the European Environment Agency (EEA), the number of endangered species is continuously rising. In many countries, particularly in the north-western and the central part of the continent, over 70% of habitats have been destroyed or seriously damaged and approximately 60% of the species living there (including 50% vertebrates) have been in danger of extinction. This situation is mainly caused by changes in exploitation of ecosystems mostly for agricultural purposes, expansion of transport and industrial infrastructure, water use and water pollution, steppe formation and desertification. However, population growth is noticed in species connected with the presence of humans and their activities, chiefly plants which tolerate acidification and increased level of nutrients. It also refers to some birds, terrestrial and aquatic invasive species.

The Southern Europe is particularly affected by the loss of waterlogged areas. Similar process occurs to a minor extent in the western and central part of the continent. Attempts of bringing back the previous state of some rivers, lakes, swamps, peat-bogs, small field and forest reservoirs do not compensate for the losses suffered as a consequence of urbanization and intensification of agricultural production. Paradoxically also afforestation conducted with a view to increasing production of wood leads to impoverishing of biotopes and disappearing of extensively harnessed agricultural half-natural ecosystems distinguished by great biodiversity.

In the Eastern Europe agricultural use of land has been decreased since 1990s. An area of sowing is also reduced. Land use pattern of cross-border areas has been changing and there have appeared set-aside, abandoned, shrubby vegetation and forest areas. Many anthropophilic species have increased their amount. There has been a drastic decrease of the number of wild plants and animals which are concomitant of extensive agricultural economy or simplified use of meadows, pastures, sometimes strictly dependent on the presence of field wasteland and balks. Stopping erosion and sustaining existing in this region natural and agricultural biological diversity seems to be possible, although it requires serious financial, organizational and legal investments.

In the Western Europe tendency towards developing intensive and specialised agriculture has not been decreased. In spite of serious subventions – based on the need of stopping the process of genetic erosion and human habitat degradation – the cases of reafforestation or reintroduction of wild species or even restoring the degraded place into the primeval state are incidental and they are regarded as a considerable success. They have rather media than ecologic dimension (Tyburski, 2013).

Agriculture, agricultural biodiversity and food production

The beginnings of agriculture can be traced back to 10,000 years ago. Presumably, this practice was neither a discovery nor an invention, but a simple consequence of the need to supplement food deficits by people involved on a daily basis in hunting and gathering. It spontaneously appeared in many regions of the world and developed with various pace depending on the local biotic and abiotic conditions.

Thus, the will and need to secure a steady source of food was the first reason that pushed humans towards innovative solutions for cyclic storage and the use of some seeds for replanting, the selection of preferred plants and improving growth conditions in order to obtain the greatest possible benefits. This process, repeated again and again, with time led to the enhancement of quantitative and qualitative traits in species, preferred from the point of view of human needs.

However, regardless of its later successes, the origins of agriculture were associated with the domestication of preferred or randomly chosen species. Phenotypes and genotypes of species were selected

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[3] Some plants, for example, accumulate heavy metals or sulfur compounds in their tissues, thereby signalling, in advance, processes and changes that lead to the decline of more sensitive species. Hence, the search for plants that are able to serve this purpose is very urgent. Indicators of biodiversity are all those species whose changes in occurrence and abundance are correlated with similar changes in other species, for example, economically important ones. Advanced technologies that use molecular indicators make it possible to spot the *shrinkage* of the species within the population, even before changes are revealed on the phenotypic level.

more or less consciously, with the main focus on their suitability for consumption, often at the expense of weaker adaptive traits. Plants altered in this process moved from place to place, and have spread along with human populations. Through selective pressure, human interference in the natural evolution of plants was so effective that in a relatively short period of time it led to a loss of genetic diversity obvious in the populations of wild ancestors. The exceptional productivity of species with impoverished genetic diversity replaced effective mechanisms of adaptation stemming from this diversity.

The situation in the agricultural sector, of course, has not always looked the same. A significant development took place along with great inventions and increased economic activity. The popularisation and spread of new species was stimulated by human curiosity, increased demand for previously unknown commodities, and the development of maritime trade. The opening of new markets coincided with an increase in food productivity and changes in land use. This fact, in the 18th and 19th centuries, enabled the shifting of surplus labour from the countryside to the cities, and its use in transforming small-scale craftsmanship into large-scale industrial production. The second agricultural revolution took place in the 19th century. This time, traditional agriculture gained the characteristics of agricultural production by using modern machinery and fertilizers. The scale of the revolution, however, was limited, as it mostly affected western countries, where agriculture was supported by the developed machine and chemical industries.

The second half of the 20th century brought more changes. Advances in biological sciences with the development of the industrial sector have led to the Green Revolution. The production of basic cereals doubled, and new and high-yielding varieties of rice, wheat, corn and other crops were created. But these spectacular successes had their price. Negative transformations of agricultural environments stimulated the need for a closer look at innovations in this sector of production. A belief emerged that changes need to be continued, but this time with a focus on sustainable agriculture.

Today, the commercial attractiveness of crops mainly depends on their productivity and morphological characteristics, while nutritional and organoleptic values only began to gain importance. For this reason, the use of some almost forgotten and/or abandoned species, grown only occasionally or on a small-scale, despite their outstanding nutritional parameters, is still limited to local communities and markets. However, these plants have great potential. First and foremost, they are characterized by significant genetic diversity, and if grown on a large scale could diversify product range, increase food security, and improve the economic status of producers and the health of people suffering from nutritional deficiencies. Some of these plants also have medicinal properties. They do not require large inputs (fertilizers, plant protection measures), and are generally well adapted even to extreme local climatic conditions, so they perfectly fit into the modern trends of sustainable agriculture. And because science has never before given them proper attention, information from people cherishing knowledge about their properties and methods of cultivation is now proving to be very valuable, and is part of cultural diversity. Modern agriculture relies primarily on modern biotechnology focused on the genetic improvement of utility organisms, the selection of individuals resistant to adverse environmental factors, cross-breeding varieties and genetic engineering. To reduce the negative impact on the environment, and to improve the water-air relations and soil physicochemical parameters, farmers are trying to use catch crops and innovative *ecocompatible* farming practices (they are usually associated with proecological or integrated agriculture), and to establish seed banks or landscape parks.

Since agricultural activity is based on the skilful exploitation of the potential of the natural environment, emphasis should be put on thoughtful interference, and changes that are integrated with, or at least minimally colliding with, the environmental changes resulting from the need to improve food and feed production. By expanding agricultural production humankind has already very seriously transformed natural ecosystems into agroecosystems, with varying degrees of impact on them. Negative consequences of this process – beyond those regarding the natural environment – can be found in the strained social, political and economic situations in many countries. Agriculture can therefore be defined as general activity aimed at obtaining products of the land necessary to feed people and animals, and materials for further processing (e.g. fibre, medicines) or energy resources. Agriculture can be regarded as the primordial form of biotechnology – knowledge shaping the cultural decision-making models aimed at improving the quality and quantity of products obtained from plants and animals. This very feature distinguishes agriculture from a simple spontaneous gathering of fruit produced by land, which humans neither influence nor support. It must therefore take a very long period of accumulated experience, including organoleptic and aesthetic, to go beyond gathering and to take up new activities, this time related to domestication. In areas where land and climate conditions were favourable, satisfactory production yields were obtained by growing plants which for some reason drew the attention of their first-time breeders. The first ancient centres of biodiversity then developed in different geographic locations: The Fertile Crescent, China, Central America, and the Mediterranean Basin.

Biodiversity and sustainable agriculture

Agriculture, in addition to hunting, forestry, fishery, aquaculture, mining and quarrying, is today a part of the primary sector of the economy. It differs depending on the era and region, and even today, traditional, or even extensive, agriculture exists alongside very advanced, almost industrial production practices. Extensive agriculture is a term used to define low-productivity systems which require relatively little effort and resources. Conversely, agriculture aimed at maximum profit requires high workload and financial resources. It is characterized by the widespread use of high-performance machines, farming and breeding practices.

Conventional agriculture is a way of farming aimed at maximizing the profit obtained thanks to the high performance of plants and animals in specialized farms, using technologies based on the high consumption of means of production, mainly agrochemicals. As a result, there has been a considerable increase in the occurrence of weeds and diseases, and the use of pesticides led to an increase in expenditure. Disturbed crop structure and the need for supplementary feeding of high-yielding crop varieties forced the increasing use of fertilizers. Thus, a number of negative consequences for agriculture, the environment and consumers have been recorded, manifested by:

– reduced ability of self-regulation in ecosystem and reduced populations of some groups of organisms due to the use of pesticides This led to the selection of resistant pathogens and harmful organisms, and reduced the number of their natural enemies;
– decrease in soil fertility caused by the lack of organic fertilization increased erosion, the use of heavy machinery, and adverse changes in agricultural ecosystems;
– contamination of groundwater and eutrophication of surface water by the excess of unassimilated nitrogen and phosphorus;
– accumulation of harmful substances and their presence in food chains;
– reduced nutritional value of plant-derived food and feed due to the imbalance of minerals or pesticide residues.

Ecocompatible agriculture departs from the use of chemical plant protection and fertilization, and is aimed at producing healthy, low-processed food and environmental protection.

Intensified conservation activities in agriculture are mainly driven by progressive genetic erosion, i.e. the rapid loss of species, animal breeds and crop varieties. The most important reasons rightly pointed out include the disappearance and fragmentation of sustainable agricultural habitats and ecosystems caused by natural (e.g. climate change) and anthropogenic factors, popularization of monocultures and high-yielding crop varieties, environmental pollution and the extinction of the most vulnerable species, the expansion of alien species, and economic factors forcing maximized productivity[4]. Awareness of these facts obviously leads to remedial organizational and legislative initiatives. Centres of usable and natural biodiversity are created, collections of crop plants in their original places of occurrence (*in situ*) and banks of seeds and propagating material stored outside the place of their natural occurrence (i.e. *ex situ*) are being established. All this has a legal framework of international[5] conventions and national regulations aimed at the protection of the environment, but also the rights of the communities associated with them. Hence, besides clear environmental targets, i.e. creating sites to protect the ancestor and original species of those currently grown which are important for food and feed production, activities are carried out to maintain local cultural diversity, through the work of farmers using, preserving and keeping for the future generations plants they tend, and together with them the assets of practical knowledge and experience[6].

Biodiversity and sustainable development

Life on Earth forms a single self-sustaining ecosystem in dynamic equilibrium. Human life depends on its normal functioning. Accumulating difficulties with maintaining the status of the natural environment force the need for deeper insight into the essence of problems that threaten contemporary man. One of them is the conservation of existing resources, which includes everything that is obtained from the environment to meet human needs. Most of these resources, unfortunately, are not present everywhere in the same amount or enough to cover the demand, and only some of them are renewable. Sustainable development should support efforts to satisfy at least the basic needs of humankind. By definition, sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Biodiversity plays a key role in this strategy. The state of the human living environment depends

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[4] Modern highly productive agriculture rejects old varieties, mainly due to their low productivity and lack of adaptation to the new mechanized production technologies.

[5] Art. 8, 9 of the Convention on Biological Diversity; Art. 5, 15 of the International Treaty on Plant Genetic Resources for Food and Agriculture.

[6] Biodiversity is strongly linked with culture as a whole characteristic of a particular group or nation, knowledge, tradition, processes and technical procedures, practices systematically shared and used.

Food is one of the emanations of biodiversity and cultural diversity. Some dishes prepared according to specific recipes are linked with the celebration of holidays, religions, traditions and customs.

This link, of varying strength, is present in every civilisation and culture.

on the diversity of other living organisms. The destruction of this diversity leads to ecological, economic and cultural losses. Thus, for several decades, people have aimed at revising the established approach of humans to the nature surrounding them. An important achievement in this area is, for example, awareness of cross-border environmental interactions, also taking into account the ethical, cultural, political, scientific, technical and institutional interests of countries.

Huge progress in agricultural production, especially in the yield of the major crops in the second half of the 20th century, was achieved through genetic improvements in specific varieties, with the strong support of fertilizers and plant protection measures. Varieties were created that satisfied expectations, but only under optimum conditions for them; any changes – in water or nutrient supply, weather conditions, or the presence of pathogens against which the vast majority of farmers in the world are not able to protect crops (for financial constraints or other reasons), always result in decreased yield. Moreover, modern varieties are not adapted to biotic and abiotic stresses and local conditions, which are usually very varied. Despite that, they supplanted, often permanently, a substantial number of primary varieties grown locally and characterized by much lower productivity, but having better nutritive values. The latter features have re-awakened local markets, as the food security policy tends to prefer qualitative to quantitative issues. The chemicals and heavy machinery necessary for the production of high-yielding varieties disturb soil structure, water and air transport, contribute to soil erosion, increase salinity, impoverish flora and fauna in the soil, reduce natural fertility and resistance, and increase the risk of the spreading new diseases and pests. And since most land suitable for food production is already in use, all possible efforts should be made to sustain its long-term productivity. In this aspect plants used as food are still the main substrate. Because of that, their genetic improvement is important to maintain biodiversity, but also to obtain new varieties more suited to the expectations of producers and consumers. For this reason, all projects – either aimed at the conservation or utilization of genetic resources – are interdependent and important for future.

For sustainable agriculture, a specific *qualifying test* is the ecology of the land which is intended for the production of safer foods and feeds. And the purpose of this sustainability is – as far as possible – the transformation of industrial agriculture from destructing to supporting activity. It is therefore not only about the quantity but also the quality of products, and the place of its origin, because only sustainable production gives a chance to achieve the quality of life which we all expect. Agricultural production itself was somehow assigned a new strategic goal – to build a sense of long-lasting public safety by ensuring ecological and food security. The goal is both ambitious and complicated, and therefore must be implemented in many areas in parallel, according to the rules relevant to local conditions and needs. These include, for example, wider use of the natural processes of binding elements in order to reduce the use of fertilizers, reduction in the use of pesticides that interfere with biological cycles and replacing them with, for example, ecological methods of pest control; diversification of production systems through the use of the biological and genetic potential of native and local species; restoration of crop rotations to maintain soil fertility; increase in the absorption capacity of the soil and wetlands; preferential market mechanisms promoting small-scale farmers; development of biotechnology and genetic engineering to explore and create an effective system of protection and safe use of the survived potential of agricultural biodiversity.

Conclusions

The last of these goals seems to be the most important, because biodiversity opens a way to sustainable agriculture, can improve production without unnecessary damage to the environment, compensate for losses in the yields of high-performance but risky monocultures, stabilize fluctuations in yield volumes, respond in a positive way to climate change, and give greater guarantees of food security. These and other goals can be achieved only by maintaining the greatest possible level of biodiversity, which allows organisms to evolve and adapt to changing environmental conditions. Thanks to biodiversity, humans can everyday use various ecological products and services. It is therefore worth making an effort to rescue the prematurely lost crops and farm animals because, although only 20 species cover 90% of energy demand, there are tens of thousands of plants of economic importance (sometimes only very limited or local). However, all of them are of great importance in food production, shaping the local economy, and are usually closely connected with the local cuisine, culture and tradition. Following this direction, and with a consistent policy aimed at supporting, and where necessary restoring sustainable methods of food production, requires *biological facilities*. The major component of this is the diversity of organisms, plants and animals used in agriculture, whose pool is dangerously depleting. Various legal, financial and organizational measures undertaken for that purpose should certainly be considered as promising and necessary investments.

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