THE ROLE OF SMALL FARMS IN MAINTAINING A BALANCE IN AGROECOSYSTEMS

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Abstract

Rural areas in Poland which offer biological and landscape diversity are of the most abundant in Europe. Small ecological farms, especially in southern and south-eastern Poland, still host rare weed species named in red lists of many European states. The diversity of animal and plant species in these areas is significantly higher than in the remaining parts of Poland. Consequently, the balance of agroecosystems is far more stable. The presence of rare weed species in the fields does not equal lower crop but contributes to maintaining of the considerable diversity of insects or birds. Preserving the mosaic structure of crop fields and traditional rural landscape is only possible on small farms and hence the importance of their further existence.

Keywords: weeds, preservation, small farms, agroecosystems, diversity

1. Introduction

Throughout ages the pressure of a man onto the environment has grown enormously. Shifting from hunting and gathering to farming caused replacement of the mosaic system of habitats by a growing number of single species cultivations. By simplifying the complex ecosystems and eliminating the 'unwanted' species, the man made his diet poorer and changed the habitats of wild flora and fauna completely. At the end of the 20th century there were 4.5 billion people and as little as 180 species of plants consumed of which 6 species provided more/less 90% of food of plant origin (FAO, 1996). In Polish registers there are 140 varieties of cultivated plants of several dozens of species (details of 2011, Research Centre for Cultivar Testing – COBORU).

Modern agriculture should put considerable emphasis on maintaining biological diversity. The purpose of original and modern agriculture is to produce food. The difference is that primitive farming uses mainly the work of men and animals and simple tools while modern farming is based on advanced technology of cultivation, which is characterised by very intense nature, and the entire production is meant for sale. There is no place to maintain diversity in agricultural ecosystems. Large scale monocultures, excessive chemisation and heavy machinery destroyed the balance of agroecosystems. Genetic erosion of crop plants is observed; also accompanying plants species as well as microorganisms and animals directly related to them die. Surviving of small farms agriculture is the only method of maintaining diversity and balance in agricultural agroecosystems.

2. Materials and methods

The research area is situated in the Nadnidziański natural landscape park and partly within the 'Natura 2000' network (Ponidzie area). This area has been settled for a very long time. The oldest traces of settlement date back to the neolith times. The Ponidzie was examined in detail, among others thanks to funding by the State Committee for Scientific Research of a supervisor research grant 'Diversity of field weeds of the Nadnidziański Natural Landscape Park, its determinants

and preservation' (Dostatny, 2000) and by a grant of the Ekofundusz Foundation as well as the **Plant Breeding and Acclimatization Institute** (2007-2009). A detailed survey of weed species was performed that enables comparison of changes occurring in segetal communities and further monitoring thereof. Places of occurrence of vanishing weed species, in particular among cereal crops cultivated on small farms of the region were identified. Research was carried out in close cooperation with local farmers that were very helpful with providing information on traditional cultivations in of the area. Favourable inclination towards the idea of maintaining of biodiversity and relevant activities was observed.

Occurrence of weed species in cultivations of 15 farmers was monitored. The number of weed species in the material harvested directly from the farmer was defined. Marking of weed seeds was made according to Kulpa (1988). For that purpose 0.5 kg of material was taken directly from the harvester on the aforesaid fields between 2008 and 2012. A list of weed species in the entire material was prepared based on the indexes of frequency and abundance of occurrence (Kulpa & Tabisz, 1963). It must be mentioned that farmers who took part in the research have small farms (usually up to 10 ha) and despite crop rotation the fields were more or less in the same area. Thus, the material could be compared.

3. Results and discussion

Extremely interesting weeds of crop fields occur in Niecka Nidziańska, on rendzina soils, which make 1% of Polish soils. Most of them are very rare plants in Poland (Dostatny, 2004). An example could be *Adonis flammea* which is endangered due to intensified farming systems. There are several factors causing the extinction of the species as well as other of the *Caucalido-Scandicetum* complex. The main include intensification and modernisation of contemporary agriculture: introduction of prolific cereal varieties, improved cleaning of seeding material, long-term usage of herbicides. Equally significant are changes of habitat conditions, particularly strong and continuing acidification of limestone soils (Aniol-Kwiatkowska, Popiela, 2011). Also urbanisation and changing arable land into non-arable as well as abandoning of farming on difficult land (e.g. high slopes) are of great importance. These factors had a strong influence on extinction of *Adonis flammea* and other species of the complex (calciphile archaeophytes related to traditional methods of cultivation, of Mediterranean reach).

In the analysed material, after harvest in the initial years of monitoring in Niecka Nidziańska area, a small number of weed species was observed (from 65 to 67 species, between 2008 - 2010) with high number of more common species such as: *Agropyron repens, Avena fatua, Convolvulus arvensis, Galium aparine, Polygonum convolvulus*, that were present in almost each of the 15 samples, with a high abundance index. In the consecutive years, the number of weeds in the material collected from farmers was increasing gradually. In the last 2 years (2011 – 2012) the differences in abundance between common and rare weeds were not so evident (from 71 to 91 species in 0,5 kg of collected material, in all of 15 samples) (graph 1). Abundance of common species dropped which was caused by occurrence of other, less common, species, such as: *Adonis aestivalis, Aethusa cynapium, Agrosthemma githago, Bupleurum rotundifolium, Camelina microcarpa, Lithospermum arvense, Neslia paniculata, Valerianella dentata*, between others. Specimens of these species probably came from the soil seed resources. What is important, single specimens of rare species have occurred in the fields, such as: *Anagallis foemina, Bupleurum rotundifolium* (It's increasing its coverage in the fields), *Caucalis platycarpos*. However, to date their seeds have not been identified in the collected material. After years of cultivation without the use of herbicides one may expect that vanishing weed species still present in soil seed resources will sprout and create a full composition of different vanishing weed complexes. A higher number of

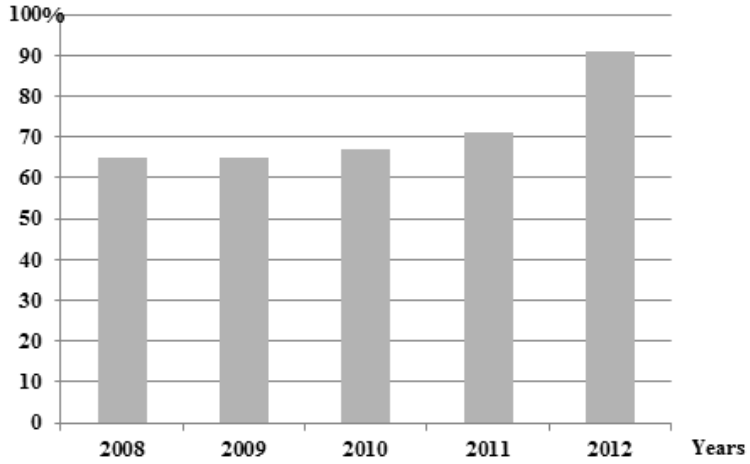

Figure 1. Frequency of occurrence of weeds in the seed material of 15 farms in Poland

segetal plants in crop fields equals increased abundance of other species such as: microorganisms, insects, birds, etc., that are necessary to keep agroecosystems in balance.

During the collection missions organised by National Centre for Plant Genetic Resources in the last 10 years, we observed that the South and Southeastern part of Poland is still abundant in local, old varieties of annual vegetable plants, leguminous plants, medicinal plants and rare species of weeds, as well as old varieties of fruit trees. Rare species of weeds are only present in the fields in small farms in the single villages in Poland, where the mosaic structure of crop fields is preserved, like in the researched area. Unfortunately such kind of place are becoming rare in Poland.

Further existence of populations of rare, annual weed species is connected with turning of soils surface during field works. This agrotechnical treatment prevents from occupation of biotopes of different grasses or perennials with higher competitive potential. We may hereby state that the seed resources in soil are of crucial significance for the preservation and dynamics of populations of segetal flora (Czarnecka, Czarnecka, 2006).

Species that accompany cultivations have the ability to adapt to the life cycles of crop plants (Kornaś, 1977). A given complex of weeds with a whole spectrum of species reflects a specific type of cultivation. If the cultivation is abandoned, then the accompanying species slowly yield. The same happens with bird and insect species that were directly connected with these plants. For example for the last 300 years approximately 150 species of mammals (another 240 are endangered) and 100 bird species have became extinct; of which around 70% species died due to elimination of their habitats. In the second half of the 20th century world agricultural production became 2.6 times higher and mineral fertilisation 8 times more intense. At the same time 6 million hectares of arable land per year changes into a desert owing to excessively extensive agricultural use. The national strategy of preservation and moderate use of biological diversity (2003) emphasises that all that has not been appreciated or even intentionally destroyed to date, e.g. 'pests and weeds' should be preserved. Therefore, from the point of view of the convention and nature there is no 'pest' or 'weed'. The strategy has been prepared upon request of the Polish Ministry of Environment and drawn up in accordance with the 'Convention on Biological Diversity' announced during the Earth Summit in Rio de Janeiro held in 1992. To maintain balance and increase diversity in agricultural ecosystems, a 'model refuge of agrobiodiversity' has been

formed in Niecka Nidziańska, southern Poland. The model refuge has been created thanks to the funds of Ekofundusz Foundation and the Plant Breeding and Acclimatization Institute. Its aims is to preserve and maintain biodiversity in farming ecosystems and to protect field weed species that are threaten by extinction by maintaining typical weed species of the region in the fields.

Weeds prove many positive impacts in agroecosystems. They protect the surface of soil from crusting, drying and erosion. Furthermore, after ploughing weeds decay in soil replacing composting and organic fertilisation. They also stimulate growth of crop plants through its allelopathic activity - the so called positive allelopathy consists in improved growth of a given species in the vicinity of others, by emitting complexes of different chemical compounds. They are used as 'biological weapon'. Weeds may indicate actual habitat conditions and therefore they are used as bioindicators. They make food or an ingredient of fodder mixtures for animals. They are also widely used in phytotherapy and cosmetic industry.

Very often segetal plants compete with one another, not only the crop plant, which means that a bigger number of weeds, with low coverage, only slightly decrease the harvest of a crop plant. The phenomenon may be explained by the fact that the more species (partners) to share the resources of an ecological niche, which is a field, the more often growth of one of them limits the growth and development of other which results in absence of dominance. A reverse case occurs when one or several weed species predominate in fields treated with herbicides. Some of the species became resistant to herbicides which causes growing number thereof in the field (the so-called compensation), consequently resulting in a drop of crop plant harvest.

The layer in cornfield decides about getting of the weed seeds to the collected material (crop). Research made in Kurpie confirms the phenomenon (Dostatny, Małuszyńska, 2007). Most of the seeds came from the medium layer, some from the higher, and few from lower. Therefore, we do not have to be afraid of weeds from the lowest layer of cornfield getting to the harvested crop. Their presence is recommended as they protect soils from crusting (Dostatny, Małuszyńska, 2007).

As it has already been mentioned, weeds prove many positive impacts in agricultural systems and therefore they should be covered by protecting or preserving schemes (reserves and refuges are not sufficient). The base of an efficient plan of weed management is ecological knowledge of this plant group and relations thereof with other organisms. Research carried out in Great Britain (Marshall and others, 2003) show that many segetal plant species influence maintaining of high diversity of insects. A drop in the number of feeding plants, i.e. weeds, may have an impact on the reduction of insect population as well as other animal species, such as birds. Weeds play an important ecological role by giving shelter to spiders and insects on which birds feed (e.g. larks). Poland has 26% percent of the entire bird population depending on arable land (BirdLife International, 2004). In order to keep this abundance of bird species, current diversity of agricultural landscape must be preserved (Wuczyński i in., 2011), this refers among others to buffer zones planted with grass and papilionaceous plants (Dajdok, Wuczyński, 2008).

Transformation of natural environment and production of food including chemicals that have a negative impact of human life. A reaction to the situation was, among others, Directive 2078/92 of 1992 of the UE Parliament introducing the term of agri-environmental plans, i.e. such types of agricultural production that guarantee preservation of the natural environment values being the base of agricultural production and enable obtaining satisfactory economic results. Farmers joining the agri-environmental plans produce food and maintain diversity in agroecosystems. These activities are subsidised. In Poland, the national agri-environmental plan was established within the Rural Areas Development Plan aiming at satisfaction of objections, priorities and principles based on which

activities towards a sustainable development are supported. The plan was drawn up the Ministry of Agriculture and Rural Development and approved by the European Commission. The Sixth Package (second stage: 2007-2013) – Preservation of endangered genetic plant resources in agriculture is directly connected with improvement of diversity in rural areas. Option 6.3 of the package – Seed production requested by gene bank, is addressed to small farms. Sub-option C provides for preservation of rare flora accompanying cultivations. Participation in this option allows farmers from Niecka Nidziańska (also from the rest of the country) to continue activities undertaken as part of the aforesaid project and enables other interested farmers from the entire country to join the plan which, with no doubt, contributes to improvement of diversity and maintaining the balance of agroecosystems.

4. Summary

Constant presence of rare weed species in crop fields does not mean "worse crop", as a significant part of these species belong to the lowest layer of cornfield that will never be collected by a harvester. Additionally, after a longer period of ecological or extensive farming the ecosystems gains balance. Different species coexist, supplement and compete with one another, which does not end in expansion of any of them. This is, with no doubt, more favourable to nature than uniform landscapes with immense areas of one crop plant, where only few species of the most common weeds, resistant to herbicides, prevail, creating a simple system of agricultural ecosystems. The mosaic structure of crop fields of small farms ensures living conditions for many animals and plants already rare across Europe and may help us save some species that may have a crucial meaning for the generations to come.

5. References

Anioł-Kwiatkowska J., Popiela A., 2011. *Adonis flammea* (*Ranunculaceae*) – wymarły archeofit Dolnego Śląska. w „Zagrożony archeofity Dolnego Śląska" (red. Anioł-Kwiatkowka, Szcześniak E.), Acta Bot. Siles. Supl.1: 32-34.

BirdLife International, 2004. Birds in Europe: Population Estimates, trends and Conservation Status. BirdLife International. Cambridge.

Centralny Ośrodek Badań Odmian Roślin Uprawnych – COBORU, 2011.

Czarnecka J., Czarnecka B., 2006. Glebowy bank nasion rzadkich gatunków murawowych i segetalnych: solidne zabezpieczenia czy zawiedzione nadzieje? Ogólnopolska konferencja i warsztaty „Rzadkie, ginące i reliktowe gatunki roślin i grzybów. Problemy zagrożenia i ochrony różnorodności flory. Kraków.

Dajdok Z., Wuczyński A., 2008. Alien plants in field margins and fields of southwestern Poland. Biodiv. Res. Conserv. 9-10: 19-33.

Dostatny D., 1998-2000. Różnorodność gatunkowa chwastów polnych Nadnidziańskiego Parku Krajobrazowego, jej uwarunkowania i ochrona. Grant promotorski nr. 6 P04F 029 15.

Dostatny D.F., 2004. Preservation of weeds diversity in protected areas. Bulletin of Botanical Gardens, 13: 79-83.

Dostatny D.F., Małuszyńska E., 2007. Skład gatunkowy chwastów podczas wegetacji i w materiale ze zbioru w uprawach ekologicznych i konwencjonalnych. Pam.Puł. 145: 1-17.

FAO, 1996. The state of food and agriculture. Roma

Kornaś J., 1977. Zespoły synantropijne. (w:) Szata roślinna Polski (red. W. Szafer i K. Zarzycki), wyd. III Warszawa. s. 442- 462.

Kulpa W., Tabisz H., 1963. Zanieczyszczenie nasion koniczyny czerwonej w województwie lubelskim. Biul. IHAR 52 (1): 149-156.

Kulpa W., 1974. Nasionoznawstwo chwastów. Wyd. II, PWRiL, Warszawa.

Marshall E.J.P., Brown V.K., Boatman N.D., Lutman P.J.W., Squire G.R., Ward L.K., 2003. The role of weeds in supporting biological diversity within crop fields. Weed Res. 43: 77-89.

Wuczyński A., Kujawa K., Dajdok Z., Grzesiak W, 2011. Species richness and composition of bird communities in various filed margins of Poland. Agric. Ecos. Env. 141: 202-209.