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DIVERSITY OF FIELD WEEDS WITHIN NADNIDZIAŃSKI LADSCAPE PARK, ITS CONDITIONS AND PROTECTION. PART II – THE EFFECT OF TILLAGE SYSTEMS ON DIVERSITY OF WEEDS IN ROOT AND FODDER CROPS

ABSTRACT

Species diversity of living creatures is in the centre of attention of scientists of many fields, as well as people who are involved in environment protection. The reason for this is continuous extinction of many plant species, including weeds, which can be observed in recent years. There are many factors that have an impact on weed extinction. Chemicalisation of crops (mainly use of herbicides) is considered the predominant factor here that limits weeds' diversity. Abandoning of correct crop rotation and organic fertilisation are not without significance as well; all this happens to the benefit of monocultures and intense mineral fertilization. Both abundant segetal flora, including weed species threatened by extinction, and typically formed phytocenoses of most of the field weeds associations are still more common in Poland comparing to other European countries that are more advanced in terms of civilisation. The above can be found in areas of small-area agriculture with low or average level of agricultural technique. For more than a thousand years *Niecka Nidziańska*- the area of research- has been dominated by one-agricultural- method of land management where small farms prevail. The research on weed species diversity has been conducted among root crops and fodder cultivations. The species abundance of weeds depends mostly on edaphic conditions but also on the plant that is cultivated, as well as forecrop, herbicides that were used or even distance between the field and farm premises.

Key words: abundant species, diversity, method of farming, root and fodder crops, weeds

INTRODUCTION

According to the State strategy for protection and moderate use of biological diversity (Polish: *Krajowa strategia ochrony i umiarkowanego użytkowania różnorodności biologicznej*, 2003), Poland's biological diversity is one of the most opulent in Europe. It is a result of both advantageous natural conditions and different, comparing to the remaining European countries, influence of human economy (non-uniform industrialisation and urbanisation of the country, traditional and extensive agriculture preserved in considerable areas). According to Andrzejewski and Weigle (2003), Poland is not only a bastion of these living resources but may also become a source of their restitution.

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As a result of the undertaken initiatives many problems referring to a reasonable use of biological diversity have already been solved. However, also in Poland there have been threats to biological diversity that are typical of contemporary civilisations. These include: change of land cultivation methods with limitation or abandoning of traditional farming methods and succession phenomena resulting there from. It causes transformation of landscape structure and liquidation or fragmentation of habitats as well as ecosystems and both simplification and destruction of the habitat assortment. Traditional species and old varieties of crop flora get extinct together with accompanying species such as weeds. A specific evolution in contemporary opinions on the significance of cultivation-accompanying plants can be observed. This is evident in specific understanding and assessment of the role played by plants called 'conventional weeds' in agriculture. More frequently certain advantages are assigned to the occurrence of such plants in agrocenoses.

A need to get to know the foregoing issues based on a specific survey area constituted an inspiration to take up a study that would present a variety of field weeds within the Nadnidziański Landscape Park; this is a so-called „land of old farming" (Szafer, Zarzycki, 1972). One of the oldest farming lands in Poland are located within the above area. Arable crops prevail in this landscape also these days.

SURVEY AREA

The surveys covered the area of the Nadnidziański Landscape Park, one of the group of the Ponidzie Region Landscape Parks. Boundary points of the park (without the protective zone) are delimited by the coordinates from 50°18'–50°34' N and 20°29'–20°49' E. According to physicogeographical conditions (Zając, 1995) the Nadnidziański Landscape Park is situated in the central part of the Niecka Nidziańska macro region.). In relation to the limits of administration units of the new division of Poland the area is situated in the Świętokrzyskie Voivodship within the Pińczów and Busko districts. A detailed description of the region and vegetation occurring in the area is included in the first part of the paper (Dostatny, 2005).

The area subjected to research has been for many years used for cultivation purposes. According to Plit (1994), cartography resources prove that the area of *Niecka Nidziańska* has been under cultivation since the early Middle Ages. There has been a domination of arable fields over any other method of using the land; however, a considerable area of arable land has been abandoned recently, mainly in areas where cultivation conditions are severe (e.g. significant inclination of land, too thin, stony limestone soil). A more detail history of settlement in the area is included in the first part of the paper (Dostatny, 2005).

SURVEY METHODS

Inventory of root and fodder crops weeds communities was made by means of 149 phytosociological records by Braun-Blanquet method (Brau-Blanquet 1964; Szafer, Zarzycki 1972) in vegetation seasons 1997, 1998, and 1999. Each phytosociological record was made for an area of 100 square metres.

A detailed description of phytosociological records and other methods used in comparison of the communities occurring in the area is included in the first part of the paper (Dostatny, 2005).

In each phytosociological record diversity was calculated using the Shannon index according to the formula:

$$H' = -\sum p_i \times \ln p_i$$

where: p_i = percentage of coverage of a given species (n_i / N); ln = natural logarithm.

In order to compare percentage values of coverage of crop plants and weeds, all records of cereal crops were divided into 2 groups: A – group of records from the fields located more than 200 m away from buildings; B – group of records conducted within a distance less than 200 m from buildings. All groups were compared using various statistical calculations performed in the STATISTICA program. Single-factor and multifactor variance analyses were conducted

In order to determine nitrogen content in soil of the tested habitats the Ellenberg index (EiN) was employed (Ellenberg, 1992). For all phytosociological records, as well as for groups A and B were calculated average weighted values of indices based on levels of coverage of weed species according to the following formula (Person 1981; Braak and Looman 1986; Braak and Gremmen 1987; Maarell 1993):

$$WA_j = \frac{\sum_k^n R_{ij} \times I_j}{\sum_k^n R_{ij}}$$

where: *WA* = weighted average; *R* = level of species coverage i in record *j*; I = value of the Ellenberg index; *n* = number of species in record *j*.

Coverage levels were obtained following transformation of the Braun-Blanquet scale into a 1–9 scale, respectively: r = 1; + = 2; 1 = 3; 2 = 5; 3 = 7; 4 = 8; 5 = 9 (Maarel 1979). Average values were calculated for the nitrogen abundance index – N.

RESULTS

1. Influence of the method of farming on formation of weed communities in root crops

The phytosociological records in root and fodder crops were divided into 2 groups:

A – a group of records taken in the fields located more than 200 m away from buildings;

B – a group of records made in the fields located within 200m from buildings.

Such division allowed comparison of coverage level percentage of the crop plant, the percentage of coverage level of the weeds and the number of weed species in these 2 groups of phytosociological records.

From among the 149 of phytosociological records made, 84 belong to the group A, and 65 to the group B. Group B is florally poor, whereas group A is richer. All the records made in the fields of A group were classified to an association. Fig. 1 shows average values of percentage coverage of a crop plant and of percentage coverage of weeds, as well as a number of weed species in groups A and B. Diversity between the foregoing variables is discussed later.

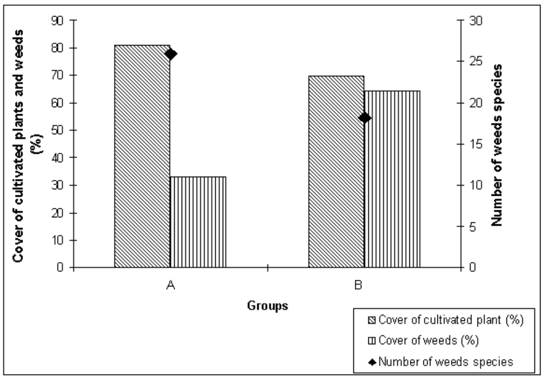

Fig. 1. Influence of farming method on diversity of field weeds in root and fodder crops

Table 1 shows the number of phytosociological records in individual communities classified to group A and B.

Table 1

Number of phytosociological records of particular root crop weeds associations depending on their location

Communities	Groups/ Number of records		No of records in communities
	A	B	
1. Ass.*Lamio-Veronicetum politae*	36	15	51
2. Ass.*Galinsogo-Setarietum*	5	28	33
3. Ass.*Echinochloo-Setarietum*	23	9	32
4. Ass.*Oxalido-Chenopodietum polyspermi*	8	1	9
5. Comm. with share of *S. media* and *T. officinale*	6	2	8
6. Community of the alliance *Eu-Polygono-Chenopodion*	6	10	16
Σ records in group A and B	84	65	149

A – a group of records taken in the fields located more than 200 m away from buildings;
B – a group of records made in the fields located within 200m from buildings.

In the records of the group A, i.e. the fields located further than 200m from buildings, the level of crop plant coverage is higher than in the previous group as it equals 81.13% (± 4.99); the level of weed coverage is quite low and equals 33.21 (± 9.90). In these fields the average number of species per 100m ^{2} was 26.37 (± 4.75) (Table 2; Fig. 2 – part A). So, it is obvious that there are more weed species in one record here and despite that fact the average weed coverage is lower than in records of the group B. The quantitativity of crop plants in these fields amounted to 5. In the communities of the discussed group no dominance of any of the weed species had been ever observed; they were usually quite evenly spread in the field. This makes qualifying of such group to a given association easier.

Table 2

Comparison of percentage coverage of a crop plant and weeds, as well as the number of weed species in groups A and B

Group	Variable	N	X	Mi	Ma	S2	S	SE
A	cultivation [%]	84	81.13	73	90	24.91	4.99	0.54
	weeds [%]	84	33.21	20	70	97.98	9.90	1.08
	weeds [n]	84	26.37	16	42	22.55	4.75	0.52
B	cultivation [%]	65	70.31	55	85	67.87	8.24	1.02
	weeds [%]	65	64.31	50	80	45.22	6.72	0.83
	weeds [n]	65	18.20	24	25	5.22	2.29	0.28

A – a group of records taken in the fields located more than 200 m away from buildings;
B – a group of records made in the fields located within 200m from buildings.
cultivation [%]: percentage coverage of a crop plant; weeds [%]: percentage of weed coverage; weeds [n]: number of weed species; weeds (N): number of phytosociological surveys; X: average; Mi: minimum value; Ma: maximum value; S^2: variance; S: standard deviation; SE: standard error; ($p< 0.000$)

In the records from crop fields of group B located near buildings the average coverage of the cultivated plant was 70.31% (±8.24), and the average weed coverage 64.31% (±6.72). The quantitativity of arable plants on these fields was 5, 4, and sometimes even 3. This denotes a high level of weeds coverage in comparison with the crop plant coverage. The average number of species was low – 18.20 species per 100 m^2 (± 2.29). The species that prevailed most often was *Galinsoga parviflora*; and in the fields where it occurred it usually had a high level of coverage: 4 or even 5. It was similar in the case of *Chenopodium album*, and sometimes also *Convolvulus arvensis*. Species such as: *Amaranthus retroflexus, Capsella bursa-pastoris, Echinochloa crus-galli*, *Galium aparine*, *Polygonum persicaria* and *Stellaria media* also proved high level of coverage in the fields located in the vicinity of houses. Mostly they were ruderal species; as it is known, their occurrence is connected with strong fertilization that is related with the closest vicinity of houses (and household animals). These fields are poor in species and look very monotonous as usually one species of weed prevails.

In the case of dominance of one weed species other species that are rare and characteristic for a given community do not occur; this leads to impoverishment of the floral composition of field weeds communities and very often makes defining an association or even alliance to which the weed community in a given cultivation shall be qualified impossible.

The Elleberg index (EiN) relating to soil abundance in nitrogen in patches located near buildings (group B) was always higher than in patches away from buildings. These are habitats very abundant in nitrogen. This is related to a high dose of organic fertilizers – animal manures – on these habitats (Table 3).

The soil's abundance in nitrogen on fields with root crops communities was higher in the patches of the association *Lamio-Veronicetum politae* with the dominance of *Galinsoga parviflora*: EiN= 8.78, as well as in the patches of the typical sub-association *Galinsogo-Setarietum*: EiN=8.06 and *Galinsogo-Setarietum* with the dominance of *Echinochloa crus-galli*: EiN= 8.17 (Table 3).

Table 3

Nitrogen abundance in plant communities and in two different groups relatively

Communities	No. of records	I Nitrogen	Group	No. of records	II Nitrogen
Lamium-Veronicetum politae typicum	28	4.98	A	28	4.98
Lamium-V. politae with dominance of *G. parviflora*	11	8.78	B	11	8.78
Lamium-Veronicetum politae with dominance of *Chenopodium album*	12	5.63	A	8	4.87
			B	4	7.14
Galinsogo-Setarietum typicum (*G-S*)	25	7.53	A	5	5.42
			B	20	8.06
(G-S) with the constant contribution of *E.a crus-galli*	8	8.17	B	8	8.17
Oxalido-Chenopodietum polyspermi	9	5.00	A	8	4.56
			B	1	8.53
Community with participation of *Stellaria media* and *Taraxacum officinale*	8	6.53	A	6	6.12
			B	2	7.75
Community of the alliance *Eu-Polygono-Chenopodion*	16	6.88	A	6	4.98
			B	20	8.02
Echinochloo-Setarietum typicum	18	4.52	A	18	4.52
Echinochloo-Setarietum depleted	14	6.52	A	5	4.20
			B	9	6.17
Total	149	-	-	149	-

A — records performed in the fields located more than 200 m away from farms;
B — records performed in the vicinity of farms (within 200 m)

Abundance in nitrogen was the highest in the turcated patches or where dominance of a species was present – these usually were florally poor patches with the supremacy of common and ruderal species over other characteristic species of a given association.

2. Diversity of field weeds species and its conditions

In order to verify the diversity of field weeds of the Nadnidziański LP “measuring steps” were taken up. There are different measures of species diversity. The most classic index is the number of species: the more species in the patch and in the phytosociological record, the bigger diversity. However the species with low and high quantitativity are treated the same then. In order to obtain the true picture of multiplicity of weeds on the tested area was calculated which is hereinafter referred to as the Shannon index.

To compare the Shannon index among root crop weeds the two groups: group A – a group of records of the fields that were located more than 200 m from buildings and group B – a group of records located within 200 m from buildings were taken into account. Here the situation is very similar to the group with root crop weeds. In the patches located in the vicinity of buildings there are 1 or 2 dominant species that are present next to the few other species with a lower coverage level. Fig. 2 shows that the Shannon index in relation to the number of species in all the record years in group B was lower, $R^2= 0.3048$, and in group A, higher, $R^2= 0.6924$.

The correlation index in all records in group A was also close to 1, i.e. r= 0.8321, which also means that the bigger the number of species, the higher the Shannon index (Fig.3). In group B the correlation coefficient was definitely lower r= 0.552

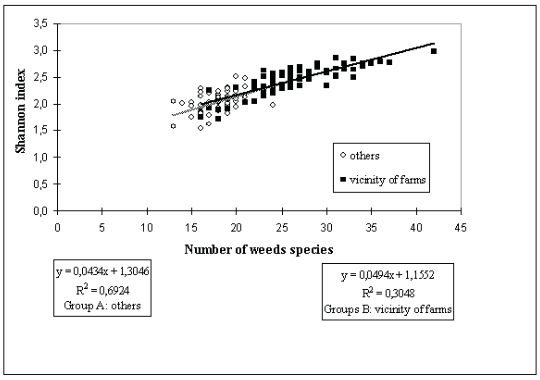

Fig. 2. Shannon index versus number of weeds species in root and fodder crops in years 1997 to 1999

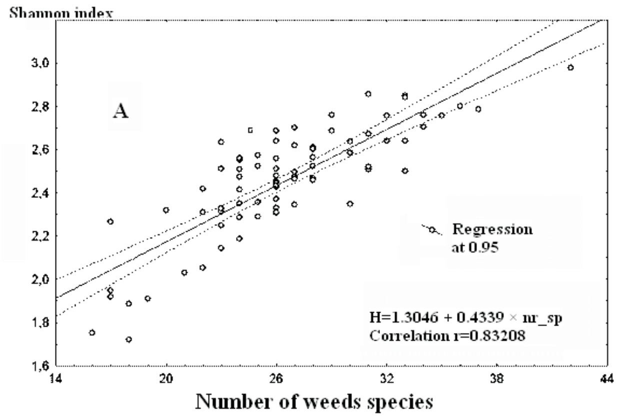

Fig. 3. Shannon index versus number of weeds species in root and fodder crops in the group A, in all years of research (records performed in the fields located more than 200 m away from farms)

(Fig.4), which may be explained with the fact that predominance of one species reduces the diversity coefficient H", which depends not only on the number of species, but also on their even quantitativity of occurrence (= coefficient J).

In group A mainly patches of the association *Lamio-Veronicetum politae*, were present whose characteristic species are very sensitive and though they have a high constancy in patches of root crop plants in the area of the Nadnidziański LP; they are present with a low coverage.

After calculating diversity H' in patches of weed communities, we may state that beta-diversity, i.e. the diversity between the communities is high, which is proved by high diversification between values (1.54 – 3.18) of the diversity index H'. However, alpha-diversity, i.e. diversity of the species inside individual patches is sometimes very low, although the general number of species in a given community is high.

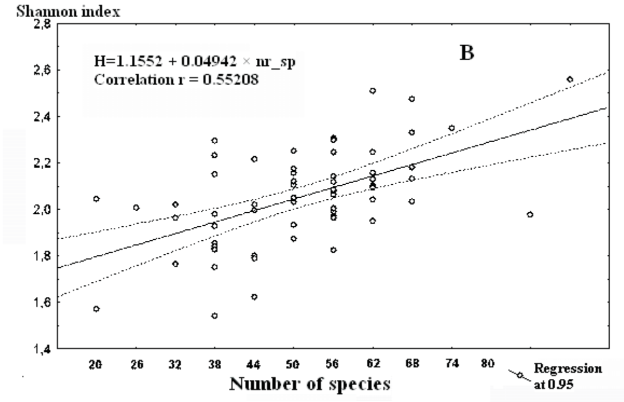

Fig. 4. Shannon index versus number of weeds species in root and fodder crops in the group B, in all research years (records performed in the vicinity of farms (within 200 m)

DISCUSSION

Flora of arable fields which is one of the main elements of Polish landscapes has been recently subject to violent and often irreversible changes due to intense intervention of man in the field environment, which results not only from the change of method of land and plants cultivation but also from the increasing use of farming machinery and devastation of the natural environment. This process is accompanied, apart from the phenomenon of expansion, by the effect of recession of many species of segetal plants (Warcholińska, 1986).

Chenopodium album, *Echinochloa crus-galli, Amaranthus retroflexus, Galinsoga parviflora* are species that occur with rather high stability and quantity in the researched area, particularly around households were abundant fertilisation is performed. These are expansive species that might have already formed resistant biotypes. Many authors describe that intensification of fertilisation and liming as well as chemical control lead to formation of resistant weed species, among others: Sobisz, Ratuszniak (2002); Kapeluszny, Haliniarz (2002); Wnuk, Ziaja (2002). Occurrence of this phenomenon is related to these species' becoming resistant through a multi-annual application on the same field of agents including the same biologically active substance (Rola, Rola, 2002). The above-mentioned weed species are thermophilous, which settle mainly on fields rich in nitrogen (Kutyna, Leśnik, 2002).

The segetal vegetation of the Nadnidziański LP is rich, a total of 101 species were noted in the root and fodder fields. Total richness, as well as relative share of individual species within a given area is determined by biological diversity (Wilson 1988). The following can be distinguished in classic depiction:

1. alpha-diversity (α), which refers to differences inside the community and is most frequently determined by means of the number of species within one ecosystem. In the case of the present surveys, within the agro-ecosystem (field phytocenosis);

2. beta-diversity (β), which refers to differences between communities.
3. gamma-diversity (γ), which covers both of the above and corresponds to so-called local floras (Richling, Solon 1998, Falińska 1996). In the case of the present surveys, we may analyze only the first two types.

In the case of the present surveys, we may analyze only the first two types. Within the Nadnidziański LP, the general alpha-diversity is high, although within individual patches it is sometimes very low. While beta-diversity is high and changes depending on the habitat. The most abundant communities of root crop weeds were present on fertile soils, mostly limestone soils, and para-rendzina type, where pH is higher than 6.5 (Dostatny, 2005), which is proved in the research of Trzcińska-Tacik (Trzcińska-Tacik, 2003). However, these were communities remote at least 200 m from premises. Weed species communities that accompany cultivation near premises are impoverished; dominance of one or two weed species that compete for light and other nutrients, as well limit growth of more sensitive weed species, can be observed. This phenomenon is connected with „the intensity of human activity with heavy maturing of these fields and with the introduction of plant diaspores by domesticated animals and on farmer's tools" (Dostatny, 1999; Trzcińska-Tacik, 1994). This is proved by the research of Wójcik and Kmosek (1988), who write that the span of ruderal plants on arable fields is limited to several hundred metres from premises.

Diversity may be expressed by means of various measures and indices. For measuring alpha-diversity the following is most frequently used: the number of species or the Shannon index or the Simpson index (Richling, Solon 1998). The Simpson index is a measure of the species diversity, which is based on the theory of probability of drawing two specimens belonging to the same species running. The foregoing index attaches less importance to rare species (Krebs 1997) and therefore in the present paper the Shannon index was selected for calculating diversity of field weeds. The Shannon index (H') contains two diversity components: relating to the number of species and uniformity or equality of distribution of specimens between individual species, i.e. evenness of species in sample (Krebs 1997), hence it takes into account percentage of occurrence of each species. After counting the diversity coefficient H', the values obtained ranged from 1.5 – 3.0 in the root crops weed communities. Value of this range is confirmed by Magurran (1988). The above author writes that value of coefficient H' usually ranges from 1.5 to 3.5.

Presence of different weed species' agro-ecosystems may be positive, as their actual harmfulness shows only in specific conditions and depends, among others, on weed species and its biology, as well as the size of population, type of cultivation, and its competitive properties; moreover, on soil, weather and, of course, on agro-technical factors. According to Hochół (2003), many weeds may play a positive role in an agro-ecosystem, even taking into consideration that they are a part of biodiversity, which increases landscape values of agricultural areas. Pursuant to the Convention on Biological Diversity there is no notion of 'a pest' or 'a weed', which means that most probably everything tends toward changing the notion of 'weeds' to 'cultivation-accompanying plants', at least in our understanding, in order to initiate protection of the dying out species of field weeds of the association *Lamio-Veronicetum politae.*

CONCLUSIONS

In fields where density (= quantitativity) of a given weed species was high, the percentage of crop plant's coverage was small, whereas in fields where none of the weed species reaches high levels of quantitativity, despite a bigger number of weed species, the percentage of crop plant's coverage was higher.

In fields located near premises most frequently one or two weed species such as: *Galinsoga parviflora*, *Chenopodium album*, *Echinochloa crus-galli* dominate. This is connected with intense fertilisation of such fields by animals, as well as with weed seeds distribution by members of the household and tools which they use in the fieldwork. In these fields also was observed the highest index of nitrogen. However the highest diversity was observed in fields that were remote from premises and only in such fields was founded the typical form of *Lamio-Veronicetum politae.*

Field weeds' communities are presently subjected to wide-ranging transformations. Decrease of occurrence frequency including total extinction of certain species, spreading or difficult to control domination of other species result from changes in agro-techniques. Presence of different weeds species' agro-ecosystems may be positive, as their actual harmfulness shows only in specific conditions and depends, among others, on weed species and its biology, as well as the size of population, type of cultivation and its competitive properties; moreover, on soil and weather. According to Hochół (2003), many weeds may play a positive role in an agro-ecosystem, even taking into consideration that they are a part of biodiversity, which increases landscape values of agricultural areas. Pursuant to the Convention on Biological Diversity there is no notion of "a pest" or "weed", which means that the most probably everything tends towards changing the notion of "weeds" to "cultivation-accompanying species", at least in our understanding, in order to initiate protection of the some threatened weed species of the association *Lamio-Veronicetum politae*.

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