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PROTECTIVE AGROFORESTRY BELTS AND THEIR ENVIRONMENTAL IMPORTANCE FOR SUSTAINABLE AGRICULTURE DEVELOPMENT IN TRANSYLVANIA

Dana Malschi[1, 2], Nicolae Tritean[2], Romeo Şerbănescu[3]

[1] Babeş-Bolyai University, Environmental Science Faculty, Fântânele str., no. 30, Cluj-Napoca, Cluj County, Romania
E-mail: danamalschi@yahoo.com

[2] Agricultural Research and Development Station, Agriculturii str., no.27. Turda, Cluj County, Romania

[3] Territorial Inspectorate of Forest and Hunting Cluj-Napoca, Cluj County, Romania

ABSTRACT

In Romania, new directions towards conservative agriculture are taking shape within the systems of sustainable agricultural development by implementing the results of the research regarding planting forestry belts with many protective effects on crops, biodiversity, stability, insecticides application limiting, soil erosion control etc. The paper is related to plant-pest-entomophagous interactions in cereal agroecosystem of Agricultural Research-Development Station Turda, in Cean-Bolduț farm with protective antierosional forestry belts and in Turda cereal crops in open field areas. Under the conditions of present agro-ecological changes, yielded by climatic warming and dryness and by new technological and economic conditions of agricultural exploitations in the region, the research points out the risk of increased cereal pests attack, affecting the crops yields and the importance of the elaboration of agro-ecological integrated control strategy. Therefore, application of insecticide treatments was necessary on the cereal agro ecosystem in open field areas, because the development of pest population exceeded the adjusting capacity of entomophagous arthropod fauna. In comparison, on the farm with protective forestry belts and with field marginal herbs shelters, favorable for the development of entomophagous arthropod fauna, real natural entomocenotic equilibrium and natural biological control of pests were observed. The abundance and the activity of entomophagous populations were higher in the system of crops with protective forestry belts, existing since 1952, in Cean-Bolduț farm.

Key words: protective agro-forestry belts, entomophagous arthropod fauna, natural biological pests control, sustainable development of cereal agro-ecosystem.

INTRODUCTION

Sustainable development of agriculture, based on long-term research on crop yield factors, on biodiversity, environmental protection and use of natural resources, has been an important objective for the research institutes in Romania. New directions towards conservative agriculture are taking shape in the context of present climate changes, by implementing the results of the research regarding: the planting of antierosion agro forestry belts; the non-polluting ecological agriculture; the farming and soil tillage by antierosional terracing; the minimum and conservative soil tillage, in order to avoid the damaging effects of drought; the soils ecological reconstruction etc. The studies of integrated management, in accordance with European legislation and integration requirements, will be used in environment activities, contributing to long-term agricultural improvement and regional community progress (Malschi, 2007, 2008, 2009).

The integrated management system of agricultural crops and pest control (Malschi, 2003, 2004, 2005) includes - as an important link – the complex measures of conservation, use and reconstruction of biodiversity (plant diversity in the agrosystems, diversity of useful arthropod fauna – mainly entomophagous) through biological methods, in central Transylvania. These biotechnologies regard several aspects of sustainable use of bioresources: - protection and increase of using the activity of pest natural entomophagous reserve; - enriching the cultivated field edges with auxiliary entomophagous-attracting

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plants; - conservation of plant diversity belonging to marginal grass shelters, meadows and pastures with several flower plants, important to entomophagous growth; - afforestation of protective tree and shrub belts and antierosional terraces borders also favorable to entomophagous growth in the ecoton field areas and to their migration into the crops; - plantation of agroforestry belts comprising tree and shrub species (Lupe and Spîrchez, 1955; Malschi and Mustea, 1995; Malschi, 2003, 2005, 2007, 2008, 2009; Popescu, 1993).

In Romania this method of soil and agricultural crop protection with forestry belts was started in 1861 and was developed in the years of devastating calamities, excessive drought, sand storms (1890, 1935, 1946), and then over 6000 hectares of forestry belts were created until 1961; during 1970-1975 some 1700 ha more were planted in Southern Oltenia (Popescu, 1993). The efficiency of the forestry belts have been proved in the fight against drought and other adversities related to climate and relief: storms, torrents, snow-storms, landslides, in preventing and controlling of massive soil degradation processes. By protecting agricultural crops, the forestry belts play a decisive role because of their direct effect on the microclimate, the blocking of landslides and local torrents, increase and conservation of soil fertility. All these effects induced by the presence of protective forestry belts have also contributed to the protection and development of flora and fauna diversity. The role played by the forestry belts in the conservation of useful entomophagous arthropod fauna has had a special impact on the dynamic development of the agroecosystem with effects on stabilizing the entomocenotic balance.

The multiannual observations have recorded the presence of all significant groups of predatory entomophagous arthropods: *Aranea; Dermaptera (Forficulidae); Heteroptera (Nabidae* etc.); *Thysanoptera (Aeolothripidae); Coleoptera (Sylphidae, Coccinellidae, Carabidae, Staphylinidae, Cantharidae, Malachiidae*, and others); *Diptera (Syrphidae, Scatophagidae, Empididae* and others*); Hymenoptera (Formicidae)*; *Neuroptera (Chrysopidae*), (Malschi and Mustea, 1992, 1995; Malschi, 2007, 2008, 2009), the data being similar to other reports (Baicu and Săvescu, 1978; Chambon et al., 1985; Cîndea, 1986; Ciochia et al., 1992; Hassan, 1985; Sunderland et al., 1985; Stark, 1987; Basedow, 1990; Holz and Wetzel, 1989; Perju et al., 1988, 1989; Voicu et al., 1993; Welling, 1990; Wetzel, 1995).

This paper summarizes the research during 2006-2008, at Agricultural Research-Development Station Turda, with the aim to show the agroecological importance of protective forestry belts. Aspects regarding the abundance and structure of pests and entomophagous arthropod fauna, population dynamics and attack evolutions of cereal pests, are analyzed in a comparative study of the crop systems in open field area, in Turda and with antierosional agroforestry belts, in Cean-Bolduț.

MATERIAL AND METHODS

Data collection was performed by complex soundings in crops and in the bordering plant belts made of grasses, trees and shrubs of the forest belts. Ground soil traps (Barber) and 100 gatherings with the entomological sweep net were used, in three testing sites located 30 m away from the border and 30 m spacing between them in the middle of each plot (Figure 1).

Alive entomophags and pests were collected for laboratory trials. In individual insulator of growth, the prey composition and individual daily feeding ration, for the main predatory species of the families: *Chrysopidae* (*Neuroptera*), *Nabidae (Heteroptera); Coccinellidae, Carabidae, Staphylinidae, Sylphidae, Cantharidae, Malachiidae (Coleoptera); Syrphidae (Diptera)* were studied, in repeated tests, using phytophagous insects as food.

Study area on the antierosional forestry belts agrosystem of Cean-Bolduț

Laying in the South-Western part of the Transylvanian Plain, The Agricultural Research and Development Station in Turda is the beneficiary of a field crop farm arranged as an antierosional system with protective forestry belts at Cean-Bolduț, planted since 1952. The farm comprises 342 hectares of arable land and pastures, surrounded by the 14 hectares of forestry belts made of 36 tree and shrub species (Table 1), maintaining almost completely the initial planting plan (Lupe and Spîrchez, 1955) and thus being the only one of this type in Romania (Figure 1). With an obvious equilibrium of the cereal agroecosystem, the farm is the symbol of research and agricultural practice concerns focusing on crop protection and soil erosion control (Popescu, 1993; Lupe and Spîrchez, 1955), and also on the conservation of useful arthropod fauna (Malschi and Mustea, 1992, 1995; Malschi, 1996, 2003, 2004, 2005, 2007, 2008, 2009).

The network of antierosional forestry belts of Cean-Bolduț lies in a typical low-hilled area of the Transylvanian Plain having natural, geomorphological, climate, edaphic and phytocenotic characteristics. The geographical coordinates of this region in the Cluj county for this particular place Cean-Bolduț, the agroforestry-belted farm are: Latitude 46°36′00″ /Longitude 23°56′30″; while the coordinates by the Universal Transverse Mercator Coordinate System is GS 27 (Malschi, 2007). The landforms are not high, having altitudes varying from 280 to 460m and moderate slopes from north-east to south-east. Some areas are more abrupt and even show vertical fractures and slidings between the belts 1, 3, 8 and in the western pastures, on the upper third of the slopes (Figure 1).

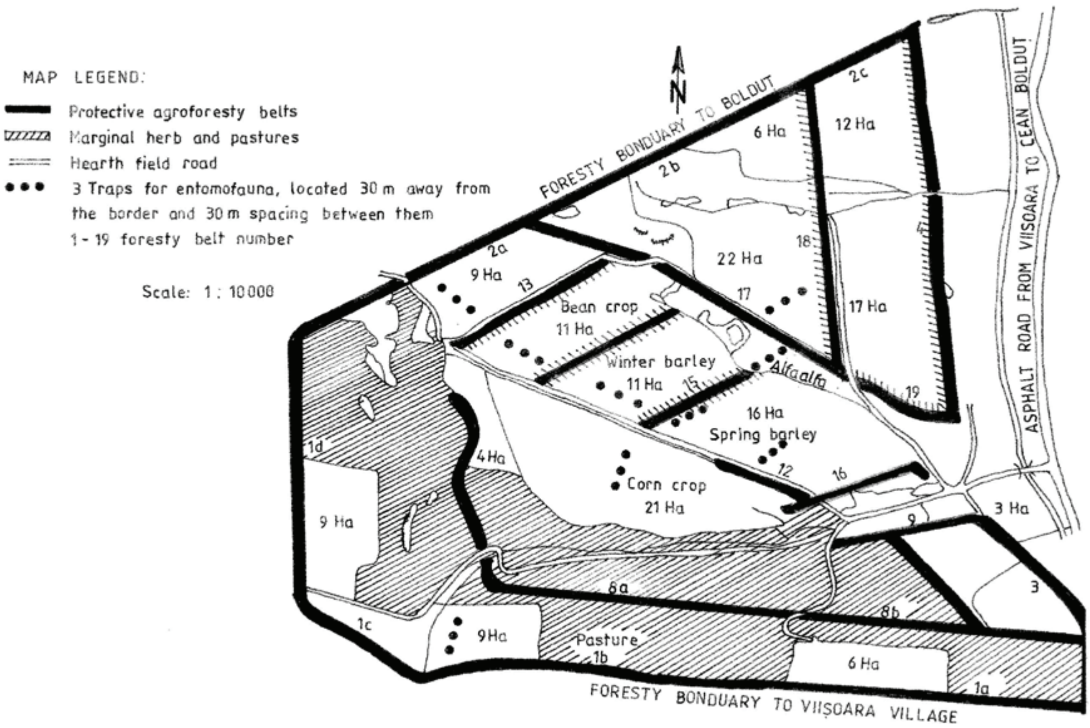

Figure 1. The map of agroforest belts network in Cean-Bolduț farm of A.R.D.S. Turda

Multiannual values regarding the mean temperature and annual rainfall average 8.6 °C and 509.2 mm, respectively. The prevailing soils are the chernozems and show different degradation processes: erosions, landslidings, alluvial deposits (Popescu, 1993). The arable land protected by forestry belts shows good soil conservation.

The antierosional curtains are made of mixtures of over 36 species of trees and shrubs. The side rows comprise fruit tree species and fruit bearing shrubs: the cherry tree (*Cerasus avium*), apple tree (*Malus silvestris*), pear tree (*Pirus piraster*), black thorn (*Prunus spinosa*), hawthorn (*Crataegus monogyna*), wildrose (*Rosa canina*), gooseberry (*Ribes sp.*), hazel (*Corylus avellana*), wild privet (*Ligustrum vulgare*), bladdernut (*Staphylaea pinnata*), elderberry (*Sambucus nigra*) and others. The inner rows of the curtains comprise forestry species especially oak *(Quercus robur*), Turchestan elm tree (*Ulmus* sp.), black locust (*Robinia pseudacacia*), Norway maple (*Acer platanoides*), sycamore maple (*Acer pseudoplatanus*), common ash (*Fraxinus excelsior*), small-leaved lime (*Tillis cordata*) and willow (*Salix caprea*), (Table 1), (Lupe and Spîrchez, 1955; Popescu, 1993).

Side pastures and grass belts shelters comprise species which characterize the area. Field crops are those of cereal rotation, usually a three year rotation with winter wheat, spring barley, maize, soybean, clover, alfalfa, cultivated in crop rotation fields of 9-16 maximum 22 hectares. These ecological conditions and especially the diversified flora structure in the forestry belt-based agroecosystem represent an extremely favorable environment for the growth of useful arthropod fauna.

RESULTS AND DISCUSSION

Pest control-related strategies of sustainable development. In the last three decades the results of applied entomological scientific research has led to the conclusion that in Transylvania pest control has been required as an important technological sequence of crop integrated system (Malschi, 2005). Climate warming, extremely hot periods, drought and heat during spring and summer months have been severe ecological factors which induced changes in species structure, facilitating the growth of populations belonging to a narrower spectrum of problem-arising species, which have become dominant and dangerous due to population increases and to local invasions and powerful attacks.

The following pests have been recorded as significant within the complex of regional phytophagous insect fauna: cereal flies: *Opomyza*, *Delia*, *Phorbia*, *Oscinella* and others); aphids (*Sitobion*, *Schizaphis*, *Metopolophium*, *Rhopalosiphum)* and cicads (*Psammotettix*, *Macrosteles*, *Javesella*); thrips (*Haplothrips tritici*); wheat flea-beetles (*Chaetocnema aridula*), cereal leafbeetles (*Oulema melanopus*), cereal bugs (*Eurygaster, Aelia*); ground pests (*Agriotes*, *Opatrum*, *Zabrus, Anisoplia*) etc. Increased pest abundance and aggressiveness in attack three to four weeks earlier than normal, which required control treatments applied as prevention, have been recorded especially in the case of cereal flies with their species complex, and wheat flea-beetles, both groups being important for the larvae attack inside the stems in April - May. They require preventive seed treatments and systemic insecticides application in spring. Wheat thrips represent some of the most significant pests nowadays, due to adults' attack on the ears (at the spike appearance – 45-59 DC stage) in May, and the attack on the flowers and emerging grains at the end of May and the beginning of June (Malschi, 2005, 2007, 2008, 2009).

Agroforestry belts and sustainable agricultural development. In the forestry belts-based agricultural system, the conservative effects of biodiversity, flora diversity and the fauna of auxiliary entomophagous arthropods have been shown. The agroforestry belts made of trees and shrubs (Table 1) and also the marginal shelters of herbs are extremely rich in entomophagous species (Malschi and Mustea, 1995; Malschi, 2007). The abundance, activity and conservation of entomophagous arthropods are supported by the presence of diversified flora, which is the main factor of species richness, survival, abundance increase and seasonal migration from one field to another of useful entomophagous arthropods (Welling, 1990; Rupert and Molthan, 1991; Malschi and Mustea, 1992; Malschi, 1996). In the protective forestry belts-based farms, a real entomocenotic balance has been established, and a natural biological control has been performed in the case of the important regional pests, which have been kept under the economic damage threshold, with no demand for insecticides control application (Figure 2). Therefore, 57 years after their initiation, antierosional protective forestry belts-based farm of Cean-Bolduț may constitute a model of ecological agriculture, of conservation and sustainable use of biodiversity, and a strategy of sustainable agricultural development in Transylvania.

The reason for this thorough research has been depicted from the interesting ascertainment that there is an entomocenotic equilibrium in the field crops with antierosional forestry belts 57 years after planting; thus, no critical pest attack situations have been recorded, and no insecticide treatment application has been required. In comparison, under the conditions of climate warming during 2000-2008, in the open field agricultural system, real risk or calamity situations were recorded. This proves the protective importance of consolidated agroforestry belts-based agricultural system. The investigations have been intensified by recording some extremely powerful preypredator interactions (Table 2).

Table 1. The different types of belts compositions in Cean-Bolduț farm with antierosional agroforesty belts (Lupe and Spirchez, 1955)

The belt number and features	The species composition in the planted rows of forest belt
The belt number 1 (on border, of 11 m width):	in the rows 1 and 7: *Prunus cerasifera*, shrub; in the rows 2 and 6: *Quercus* spp., with shrubs and accompanying species.
The belt number 2 (on border, of 16 m width):	in the rows 1 and 15: *Prunus sylvestris* and *Malus sylvestris*; in the par rows 2 – 1: *Staphylea pinnata*; in the rows 3 and 13: *Ulmus minor, Ulmus pumilla*; in the rows 5, 7, 9 and 11: *Quercus robur*, *Acer pseudoplatanus*.
The belt number 3 (on border from road, of 11 m width):	in the rows 1 şi 7: *Cerasus avium (1)*, *Corylus avellana (4)*; in the rows 2, 4, 6: *Quercus robur*; in the rows 3 and 5: *Acer pseudoplatanus*, *Staphylea pinnata.*
The belt number 4 (on border from road, of 16 m width):	in the row 1 (to fields): Ulmus minor and shrabs; in the par rows 2-14: *Staphylea pinnata* ; in the inpar rows 3-13: *Quercus rubra*, *Fraxinus excelsior*; in the row 15 (to road): *Crataegus monogyna*.
The belt number 7 (antierosional and protective belt of 11 m width):	like the belt number 3 but with other *Acer* species on 100 m lenght variants in the rows 3 and 5.
The belt number 8 (antierosional belt, of 17 m width):	in the rows 1 and 11: *Prunus cerasifera (3)*; in the par rows 2-10: *Quercus robur*, in variants with and without shrsbs; in the rows 3, 5, 7, 9: *Acer* pur, or Acer with shrabs, on variants.
The belt number 9 (antierosional belt, of 11 m width):	in the row 1: *Pirus piraster*, *Corylus avellana*; in the rows 2, 4 and 6: *Fraxinus excelsior, Cornus sanguinea*; in the rows 3 and 5: *Ulmus minor*, *Cornus sanguinea*; in the row 7 (to fields): *Prunus cerasifera*, *Crataegus monogyna*.
The belt number 13 (antierosional belt, of 12 m width):	in the rows 1 and 11: *Cerasus avium*, *Ribes spp*; in the rows 2 and 10: *Quercus robur*, *Acer pseudoplatanus*; in the rows 4, 6 and 8: *Quercus robur*, *Acer pseudoplatanus*; in the rows 3, 5, 7, 9: *Ligustrum vulgare.*
The belt number 14 (antierosinal belt, of 16 m width):	in the rows 1 and 15: *Cerasus avium*, *Ribes grossularia*; 2, 8 si 14: *Quercus robur, Fraxinus excelsior*; in the inpar rows 3-13: *Ligustrum vulgare*. in the rows 4, 6, 10 and 12: *Quercus robur*, *Acer pseudoplatanus*;
The belt number 15 (antierosional belt, 22 m width):	in the rows 1 si 21: *Cerasus avium*, *Ribes grossularia*; in the rows 2, 8, 10, 12, 16, 18: *Quercus robur*, *Acer pseudoplatanus*; in the inpar rows 3-19: *Ligustrum vulgare*.
The belt number 17 (wetting belt, on the crest hill, of 22 m width):	in the rows 1 and 21: *Rosa canina*; in the rows 2 and 20: *Malus sylvestris*; in the inpar rows 3-19: *Ligustrum vulgare*; in the rows 4 and 18: *Ulmus pumilla*; 6 and 16: *Acer platanoides*; in the rows 8, 10, 12, 14: *Quercus robur*, *Padus mahaleb*.
The belt number 18 (antierosional belt, of 16 m width):	in the rows 1 and 15: *Cerasus avium* and shrub; in the rows 2, 6, 10, 14: *Quercus robur, Acer platanoides* and *Acer pseudoplatanus*; in the rows 3-5, 7-9, 11-13: *Staphylea pinnata*.

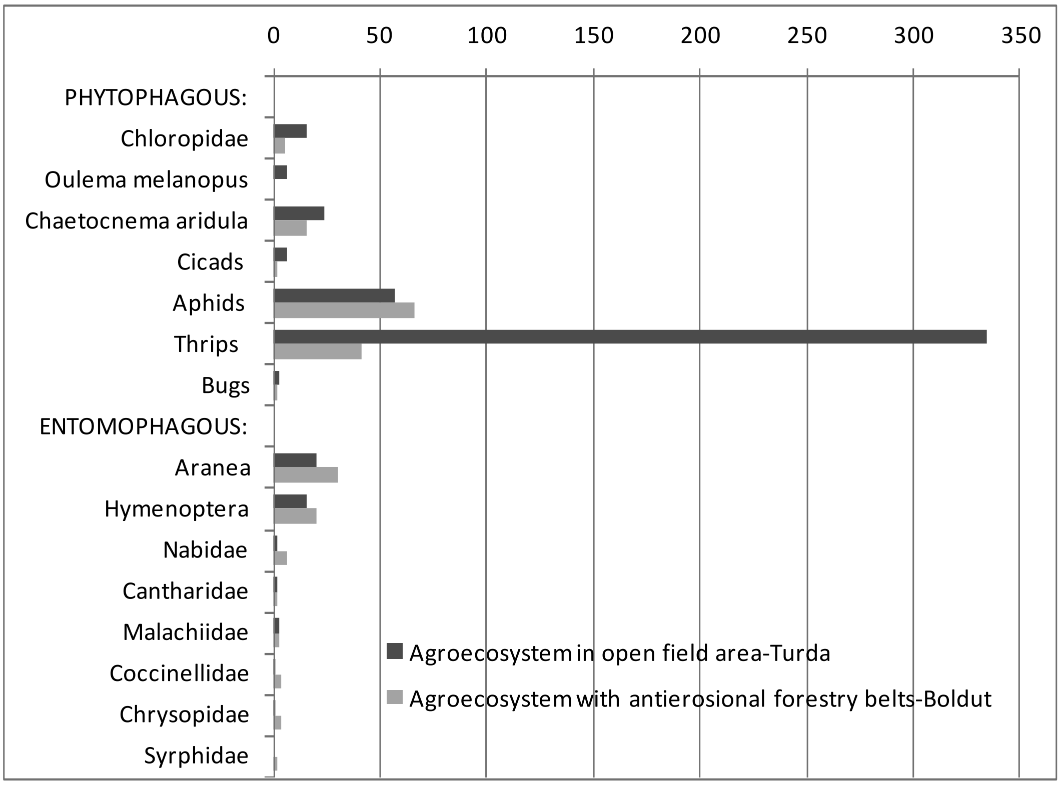

Figure 2. Comparative abundance of wheat pests and entomophagous in two agricultural systems: in open field area with conservative minimum tillage technology and in agroecosystem with antierosional forestry belts, ARDS Turda (May, 2007, in entomological sweepnet catches samples)

Table 2. Prey composition and feeding rate of main predators with cereal pests in laboratory trials (Malschi, 2007, 2008, 2009)

Entomophagous predators	Cereal pests species										
	1	2	3	4	5	6	7	8	9	10	11
Consumed phytophagous individuals number / day / individual predator											
Chrysopa carnea (larva)	10	5	10	40	30	50	10	3	1	2	-
Nabis ferus (adult)	8	5	-	42	60	25	-	3	4	3	4
Nabis ferus (larva)	-	-	-	30	25	17	-	-	-	-	-
Coccinella 7-punctata	10	3	-	35	50	25	16	5	7	5	7
Propylaea 14-punctata	7	3	-	20	40	25	-	-	2	-	-
Malachius bipustulatus	-	10	15	30	40	-	-	-	-	3	-
Cantharis fusca	6	-	15	-	40	-	-	2	-	4	-
Staphylinus spp.	10	-	-	-	30	15	-	1	-	4	4
Tachyporus hypnorum	8	-	-	-	-	25	-	1	-	1	-
Poecilus cupreus	9	6	-	-	60	50	10	5	10	5	7
Pseudophonus pubescens	8	9	-	-	60	50	10	1	-	2	1
Harpalus distinguendus	8	3	-	-	-	50	-	-	-	2	2
Harpalus aeneus	5	4	-	-	-	50	-	-	2	4	2
Amara aenea	9	5	-	-	-	50	10	-	-	8	-
Brachinus explodens	-	5	-	-	25	30	-	-	-	-	-
Sylpha obscura	14	3	-	-	-	-	10	1	4	2	4
Episyrphus balteatus	-	-	10	-	25	-	-	-	-	-	-
1 - Oulema melanopus (eggs 2 - larvae), 3 - Haplothrips tritici (adults, 4 - larvae), 5 - Sitobion avenae, 6 - Rhopalosiphum padi, 7 - Eurygaster maura (eggs), 8 - Opomyza florum (larvae, 9 - pupae), 10 - Phorbia securis (larvae, 11 - pupae).											

Many of the collected arthropods comprised entomophagous groups, recording 33% in the open field agroecosystem, where the useful species averaged 41% in winter wheat, 19% in spring cereal crops, 52% in soybean. The forestry belt-protected field crops agroecosystem has shown a higher percentage of the entomophagous groups, reaching 78%. Under these conditions the auxiliary species represented 82% in winter wheat, 73% in spring cereals, 79% in soybean and 75% in grasses marginal to crops (Table 3).

Table 3. Structure and interactions of pests and entomophagous arthropod fauna in cereal agroecosystems in Transylvania (2000-2002).

Crops	Winter wheat		Spring cereals		Soybean		Marginal herbs		Summarized fields	
Annual abundance	No.	%	No.	%	No.	%	No.	%	No.	%
In open field area cereal agroecosystem, at Turda										
Pests	1787	59	1928	81	205	48	-	-	3920	67
Beneficials	1230	41	462	19	219	52	-	-	1911	33
Total	3017		2390		424		-	-	5831	40
In the cereal agroecosystem with protective forestry belts, at Cean-Bolduț										
Pests	715	18	485	27	115	21	609	25	1924	21
Beneficials	3357	82	1307	73	438	79	1846	75	6948	78
Total	4072		1792		553		2455		8872	60
Total	7089		4182		977		2455		14703	

In the protective forestry belt-based farm under the conditions of the present climate warming and aridization, complete natural biological control of cereal leaf beetle populations *(Oulema melanopus* L.*)* and limitation of some other cereal pest populations: aphides (*Sitobion avena* Fabr. and others.) and thrips (*Haplothrips tritici* Kurdj.), at levels under the damaging economic threshold has been recorded (Table 4).

Table 4. The average attack of cereal pests (2000-2008), in cereal agroecosystems in open area in Turda and with forestry belts in Bolduț

Oulema melanopus		*Haplothrips tritici*		*Aphids*		*Diptera larvae*		*Eurygaster, Aelia*	
Turda	Bolduț	Turda	Bolduț	Turda	Bolduț	Turda	Bolduț	Turda	Bolduț
350 larvae/ m^2	9 larvae/ m^2	22 larvae/ ear; 80% ears; 30% spikelets.	4 larvae /ear	17 aphids/ ear; 11 aphids/ leaf.	2 aphids/ ear; 5 aphids/ leaf.	40% attacked tillers	9% attacked tillers	1-3/m^2 3 attacked ears/m^2	0.5/m^2 0.5 attacked ears/m^2

Regarding the conservation and use of biological diversity for the natural biological pest limitation, the protective and quality importance of forestry belts-based agricultural system as a model of sustainable and non-polluting technology is obvious in comparison with open field agriculture. In the open field agriculture, during 2000-2008 climate conditions, pest attacks represented real risk situations (Tables 5 and 6), and the application of insecticide treatment has been required. Therefore, the integrated pest control management should include regional entomophagous biodiversity conservation and use, in order to restrain pest populations and to get better results of control with positive results accumulated in the agroecosystem and extended in the following years.

Techniques for enriching the natural entomophagous reserve, by attracting and preserving auxiliary species in the crops, are recommended.

Table 5. The long term evolution of wheat pests structure in classic and minimum tillage conservative technology, at A.R.D.S. Turda

Pests	Classic technology, 1980-2005 (%)			Conservative no tillage technology, 2006-2008 (%)		
	1980-1989	1990-1999	2000-2005	2006	2007	2008
Wheat leafhoppers	10.5	9.4	9.0	8.0	1.1	1.0
Cereal aphids	32.5	40.4	6.0	13.0	4.0	11.0
Wheat thrips	30.0	23.3	27.0	36.0	88.0	79.2
Cereal bugs	0.2	2.3	6.0	1.0	1.0	4.0
Cereal leaf beetle	1.0	4.0	14.0	5.5	0.3	0.5
Chaetocnema aridula	5.0	3.0	19.6	5.0	0.5	3.0
Phillotreta vitula	4.0	1.1	6.5	0.5	0.2	0.5
Cephus pygmaeus	0.3	0.7	1.2	1.0	1.0	0.4
Cereal flies	16.5	16.0	10.7	30.0	4.0	1.4

Table 6. Pests attack during 2000-2005 in wheat classical technology and during 2006-2008 in no tillage technology

Technological system		Classic technology	No tillage technology		
Pests	The attack	2000-2005	2006	2007	2008
Cereal flies	% deadheart tillers	46	41	21	64
Wheat thrips	Adults/ear	11	8	8	15
Wheat thrips	Larvae/ear	14	12	22	21
Cereal bugs	Sun bugs/m^2	5	1	2	3
Cereal aphids	Aphids/ear	21	2.5	2.5	5

Entomocenotic characteristics of forestry belt-based agroecosystem

The observations performed in the cereal agroecosystems have shown that the field crops have been colonized by entomophagous populations over the entire vegetation period, following their species biology-related dynamic cycle. Most of the entomophagous species migrate towards crops from the appropriate hibernation and refuge places, represented by belts with the forestry curtains and bordering grasses (Welling, 1990; Stork Weyhermüller and Welling, 1991; Basedow, 1990; Sustek, 1994; Wetzel, 1995; Malschi, 1996). The role of polyphagous entomophagous predators flying as adults, from one crop to another, over the entire vegetation period is extremely important in pest limitation.

Another important group is made of ground level active predators. *Sylpha obscura (Sylphidae)* feeding with *Oulema* larvae and eggs, diptera larvae and pupa (*Phorbia*); *Tachyporus hypnorum* L., *Staphylinus* sp. (*Staphylinidae*) and Carabidae (*Poecilus cupreus* L., *Harpalus rufipes* De Geer, *Brachinus explodens* Duft., *Amara aenea* De Geer), feeding with aphids, *Ostrinia, Eurygaster* eggs and *Oulema* larvae, diptera larvae and pupa, and others, colonizing different crops. Some carabid beetles (*Poecilus, Pterostichus, Amara, Agonum*) get 100-150 m into the crop in two weeks (Welling, 1990), being very dynamic and passing through grass, trees and shrubs corridors at the field border in their seasonal route from one crop to another (Derron and Goy, 1996; Sustek, 1994). In cereal crops, these species are extremely active and rich, species dominance changing from one period to another, due to species migration dynamism. In spring, the following species have been dominant: *Harpalus aeneus* F., *H. distiguendus* Duft., *Amara aenea* De Geer, in April; *Poecilus cupreus* L., *Brachinus explodens* Duft. and less abundant, *Pterostichus* sp., *Agonum* sp. and *Dolichus chalensis* Schall., in May, June; while *Pterostichus niger* Schall., *P. cylindricus*

Hrbst. and especially *Harpalus (Pseudophonus) rufipes* De Geer in July, August and September.

Before the initiation of entomophagous activity in crops, many entomophagous species head towards some maximum concentration sites represented by some favorite food sources or refuge sites. Thus, great attractiveness areas and banks are: the grass belts for *Aranee, Carabide, Staphylinide, Formicide*; *Urtica dioica* for *Coccinella* and *Chrysopa*; blossoming oak (*Quercus robur*) for *Coccinella septempunctata*; blossom cherry tree (*Cerasus avium*) for *Cantharis fusca*; *Sambucus nigra* and other blossoming shrubs for *Cocinellidae*; moreover, other flowering plants such as: *Pastinaca sativa, Daucus carota, Achillea millefolium, Hypericum perforatum, Tanacetum vulgare, Cichorium inthybus, Sinapis arvensis, Papaver rhoeas, Sonchus arvensis, Veronica persica* etc. (Malschi, 1996; Rupert and Molthan, 1991; Welling, 1990) display special attractiveness for *Syrphidae* and *Hymenoptera;* the flower plant species in the field border or in crops such as: *Matricaria chamomilla, Myosotis arvensis, Viola arvensis, Lolium perene, Plantago major* (Stark, 1987; Welling, 1990), show attractiveness for the *Empididae* diptera.

The main species of entomophagous predators from the families *Chrysopidae, Coccinellidae, Cicindelidae, Carabidae, Staphylinidae, Cantharidae, Malachiidae, Syrphidae, Formicidae* and *Aranea* use profitably the plants in the spontaneous flora, in grass and pastures belts, as well as the shrubs and trees in the forestry belts; these represent concentration and feeding banks of the individuals prior to entering the crops, and passing and spreading corridors into the agroecosystem, towards the field crops.

Crop colonization by the entomophagous predators is achieved a lot faster in the case of cultivated lands surrounded by forestry belts than the agroecosystems in open fields. The diversification of cereal crop rotation structure and the network of the existing forestry curtains and marginal grasses, allow entomophags migration from one crop to another, in accordance with the requirements of the biological cycle, the ecology of each species and in accordance with phytophagous insect population development, which represents their prey in the crop. The diversified vegetation offers refuge places and favorable niches of microclimate and extra feeding in preparing diapause and hibernation, thus ensuring the conservation of entomophagous species.

By comparison, the level of pests in the open field cereal farms exceeds the possibilities of natural self regulation through entomophags, insecticide treatments being required. During 2000-2008, pest aggression has shown increased values. Especially the climate warming, drought and aridization during the decisive periods of the crops, between 2006 and 2008, have favored increases in abundance and aggressiveness of some pest groups, which require special attention for plant protection.

The incorrect crop technologies, the demarcation of the arable land into small area crop strips and the lack of phytosanitary measures have lead to a more severe increase of pest biological reserve. The modern, conservative soil technologies involving minimal tillage or no tillage, recommended for dry and arid conditions, create favorable development conditions for some pest species (Tables 5 and 6), requiring complex phytosanitary hygiene systems for the integrated pest control.

The use of auxiliary natural reserve in the control of cereal crop pests represents a great advantage for the agriculture in the area. In the case of cereal-based agroecosystems in central Transylvania the positive role of predating entomophags is a certainty (Malschi, 2007, 2008, 2009). The natural entomophagous reserve in the regional cereal agroecosystems represents an extremely important defense system against the growth of biological and attack potential of cereal pests, and for prevention of quarantine species invasions. In central Transylvania it is necessary to promote the protection of auxiliary entomophagous diversity in field crops.

Useful arthropod fauna is favored by flora and entomophauna diversity, the presence of vegetation-rich crop borders, grass shelters, pastures, shrubs, trees, forestry plantations.

The auxiliary efficiency is favored by the rational and selective application of pesticide treatment, only at warning; by the diversified structure of the crops, by including in rotation small grain cereals, maize, soybean, beans, forage crops (alfalfa, clover and others) which provides the continuity of the feeding and refuge sites for entomophags (Malschi, 2007, 2008, 2009).

CONCLUSIONS

Biodiversity, species composition and natural control of cereal pests were studied in comparative research performed in Transylvanian cereal agroecosystems, at Agricultural Research and Development Station Turda, in two different farms: a farm in open field area, at Turda and a farm with protective forest belts at Cean-Bolduț. The results proved the important role of biodiversity on farming model of agroecosystem with protective agro-forest belts, as an ecological technology for the conservation and use of biological diversity, for soil erosion control and for limiting the land degradation.

The biodiversity is involved in natural efficient biological pests control, in the reduction of insecticides pollutants and in sustainable development of cereal crops.

Multiannual observations have recorded the presence of all significant groups of predatory entomophagous arthropods: *Aranea; Dermaptera (Forficulidae); Heteroptera (Nabidae* etc.); *Thysanoptera (Aeolothripidae); Coleoptera (Sylphidae, Coccinellidae, Carabidae, Staphylinidae, Cantharidae, Malachiidae*, and others); *Diptera (Syrphidae, Scatophagidae, Empididae* and others*); Hymenoptera (Formicidae)* and *Neuroptera (Chrysopidae*). Entomological research has shown the increased role of entomophagous predators and their efficiency in the cereal pest limitation, in the protective forestry belts-based agroeco-system. These biotechnologies include several aspects of sustainable use of bioresources: plantation of agroforestry belts comprising tree and shrub species: *Cerasus avium, Malus silvestris, Pirus piraster, Prunus spinosa, Crataegus monogyna, Rosa canina, Corylus avellana, Ligustrum vulgare, Staphylea pinnata,* etc., on the outer sides and *Quercus robur, Ulmus* spp, *Robinia pseudacacia, Acer platanoides, Acer pseudoplatanus, Fraxinus excelsior, Tillia cordata, Salix caprea* etc. on the inner sides (model of Cean-Bolduț farm); enriching and conservation of plant diversity belonging to marginal shelters, important to entomophags growth *(Pastinaca sativa, Daucus carota, Achillea millefolium, Hypericum perforatum, Tanacetum vulgare, Cichorium inthybus, Sinapis arvensis, Papaver rhoeas, Sonchus arvensis, Veronica persica, Matricaria chamomilla, Myosotis arvensis, Viola arvensis, Lolium perene, Plantago major* etc.*).*

A natural entomocenotic equilibrium and a natural biological control of pests that are important for the region, like *Oulema* spp., cereal flies, aphids, cicads, thrips, bugs etc. are achieved. No insecticide application was needed, as a result of the activity of entomophagous natural reservoir. In compa-rison, on the cereal agroecosystem in open field area insecticide treatments were necessary, because the development of pest population exceeded the adjusting capacity of entomophagous fauna.

During 2000-2008, pest attacks in the open field cereal biocenoses represented real risk situations, requiring a complexity of repeated insecticide treatments. The protective and qualitative importance of the agroforestry belts agricultural system has been proven to be extremely favorable to the conservation of the natural reserve of auxiliary entomophags in the Cean-Bolduț farm founded in 1952. On the agro-ecosystem with protective agro-forest belts favorable results on the erosion control and land degradation limitation, under the last years conditions, characterized by arid microclimate - excessive dryness and high temperatures, or excessive rainfall, storms, torrents and landfalls were achieved. Therefore, the antierosional agroforestry belts system has a real environmental importance for sustainable agriculture development in Transylvania.

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