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Agricultural and environmental importance of Cean-Bolduț antierosional forest belts in Transylvania

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Abstract. The paper is related to plant-pest-entomophag interactions in cereal agroecosystem of Agricultural Research-Development Station Turda, in Transylvania. Under the conditions of actual agro-ecological changes, yielded by climatic warming and dryness and new technological and economical conditions of zone agricultural exploitations, the research points out the extension risk of cereal pests attack with an increasing potential and the importance of the elaboration of integrated control strategy (ICS). The attack diminishing recommended methods of the ICS are agro-technical methods; pests, diseases, weeds integrated control; insecticides treatments; conservation and use of entomophagous limiters. The natural predators play an important role in decreasing the pest abundance in Transylvania. The well-known systematic groups of enthomophagous predators: Aranea; Dermaptera; Thysanoptera (Aeolothripidae); Heteroptera (Nabidae); Coleoptera (Carabidae, Cicindelidae, Staphylinidae, Sylphidae, Coccinellidae, Cantharidae, Malachiidae); Diptera (Syrphidae, Empididae); Hymenoptera (Formicidae); Neuroptera (Chrysopidae) were represented in the structure of arthropod fauna. The abundance and the activity quality of entomophagous populations were higher in the system of crops with protective forest belts, existing since 1952, in the Cean-Bolduţ farm of A.R.D.S. in Turda. Therefore, on the farm with protective forestry belts and with field marginal herbs shelters, favorable for the development of entomophagous arthropod fauna, a real natural entomocenotic equilibrium and a natural biological control of important pests were registered. By comparison it is necessary to apply the insecticide treatments on the cereal agroecosystem in open field areas, because the development of pest population exceeds the adjusting capacity of entomophagous arthropod fauna.
Key words: protective agro-forestry belts, entomophagous fauna, natural biological pests control, diminution of insecticides pollutants, soil erosion control, land degradation limitation, sustainable development of cereal agro-ecosystem.

Rezumat. Lucrarea evidențiază interacțiunile plante-dăunători-entomofagi din agroecosistemul cerealier, la Stațiunea de Cercetare-Dezvoltare Agricolă Turda, în Transilvania. Cercetările prezintă creșterea riscului și potențialului de atac al dăunătorilor cerealelor și importanța elaborării strategiei de combatere integrată (SCI), în condițiile schimbărilor agroecologice actuale, caracterizate prin încălzire climatică și secetă, dar și prin noile condiții tehnologice și economice ale exploatațiilor agricole zonale. Metodele SCI recomandate pentru reducerea atacului sunt metodele agrotehnice; combaterea integrată a dăunatorilor, bolilor, buruienilor; tratamentele cu insecticide; conservarea și utilizarea limitatorilor entomofagi. În Transilvania, prădătorii naturali au un rol important în reducerea abundenței dăunătorilor. În structura faunei de artropode au fost reprezentate toate grupele sistematice bine cunoscute de prădători entomofagi: Aranea; Dermaptera; Thysanoptera (Aeolothripidae); Heteroptera (Nabidae); Coleoptera (Carabidae, Cicindelidae, Staphylinidae, Sylphidae, Coccinellidae, Cantharidae, Malachiidae); Diptera (Syrphidae, Empididae); Hymenoptera (Formicidae); Neuroptera (Chrysopidae). Abundența și activitatea populațiilor de entomofagi au fost mai ridicate în culturile din sistemul cu perdele forestiere de protecție, existente din 1952, în ferma Cean-Bolduț a S.C.D.A. Turda. Astfel, în ferma cu perdele forestiere de protecție și cu ierburi de refugiu în marginile culturilor, favorabile pentru dezvoltarea faunei de artropode entomofage, s-a înregistrat un echilibru entomocenotic real și o combatere biologică naturală a principalilor dăunatori. Prin comparație, în agroecosistemul cerealier aflat în câmp deschis, a fost necesară aplicarea tratamentelor cu insecticide, deoarece dezvoltarea populațiilor de dăunători a depășit capacitatea de limitare a faunei de artropode entomofage.
Cuvinte cheie: perdele agroforestiere de protecție, fauna de entomofagi, combatere biologică naturală a dăunătorilor, limitarea poluării cu insecticide, combaterea eroziunii solului, limitarea degradării terenurilor, dezvoltarea durabilă a agroecosistemului cerealier.

Introduction. The applied preoccupations for a sustainable development of agriculture based on long-term fundamental researches on crop yield factors, on biodiversity, environmental protection and use of natural resources, have been important objectives for the research institutes, in Romania. New directions towards conservative agriculture are taking shape within the systems of sustainable agricultural development, in the context of present climate changes by implementing the results of the research regarding: the planting of antierosion agroforestry belts with many protective effects on cultures, biodiversity, stability and biocenotic equilibrium, avoiding insecticide pollution etc; the farming and soil tillage by antierosional terracing; the minimum and conservative soil tillage, in order to avoid the damaging effects of draught; the soils ecological reconstruction; the non-polluting ecological agriculture etc. The studies of integrated management, including the sustainable agricultural development management in accordance with European legislation and integration requirements, will be used in environment activities, contributing to agricultural improvement and regional community progress on long-term (Malschi 2007).

In order to have a sustainable development of agriculture in Central Transylvania, 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. 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 entomophag-attracting plants; - conservation of plant diversity belonging to marginal grass shelters, meadows and pastures with several flowers plants, important to entomophag growth; - afforestation of protective tree and shrub belts and antierosional terraces borders also favorable to entomophag growth in the ecoton field areas and to their migration into the crops; - plantation of agroforestry belts comprising tree and shrub species. The existence of diversified flora within the protective belts system represents the main factor to ensure richness of the species, survival, increase of abundance and seasonal migration of useful entomophagous arthropods (Malschi & Mustea 1992, 1995; Malschi 2007).

Material and Methods. The comparative study regarding the entomocenoses abundance and structure in the cereal crops of open field area and in the farm with protective agroforesty belts have shown certain aspects recorded in the researches on entomocenoses from the Agricultural Research-Development Station Turda. Data collection has been performed by complexe soundings tests in crops and in the bordering plant belts made of grasses, trees, shrubs of the foresty belts. Ground soil traps (Barber) and 100 gatherings with the entomological sweepnet have been used, three different times, in the three testing sites located 30 m away from the border and 30 m spacing between them in the middle of each lot (Figure 1).

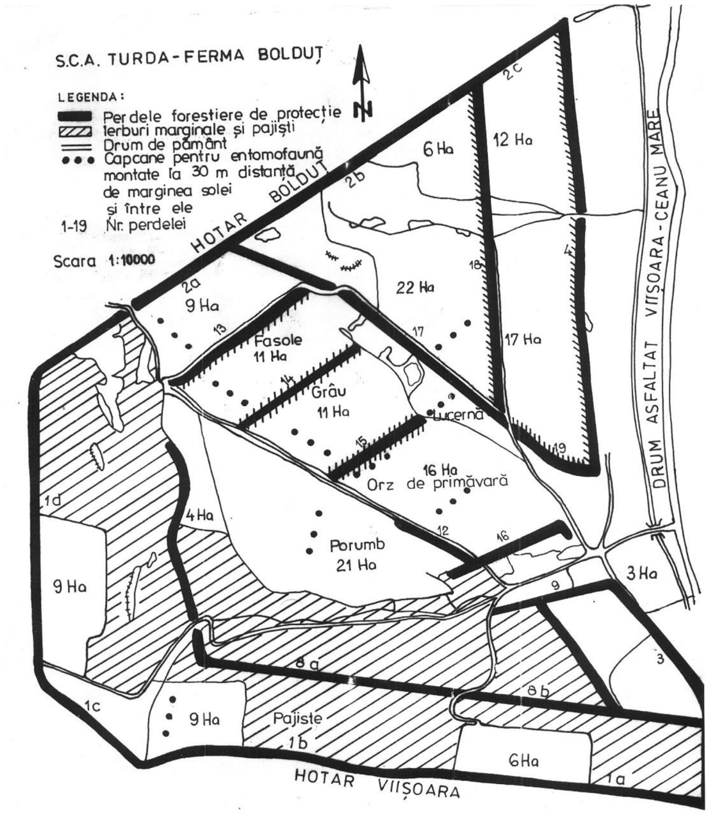

Figure 1. The map of agroforest belts network in Cean-Bolduţ farm of A.R.S. Turda.

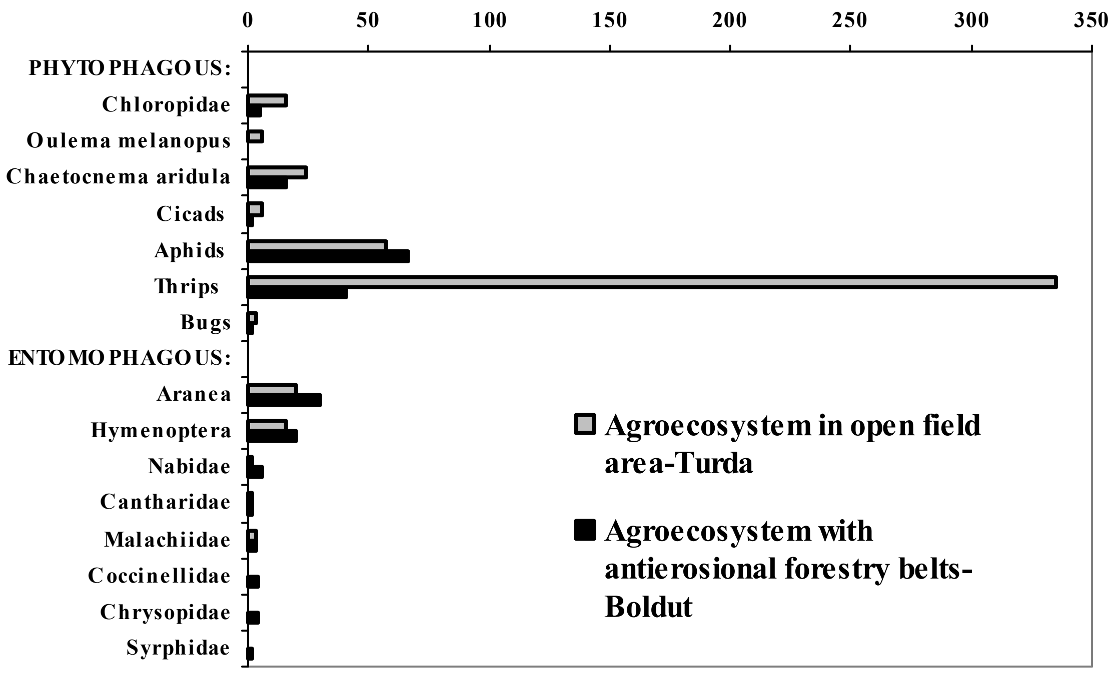

Figure 2. Comparative abundance of wheat pests and entomophagous in two agricultural systems: in open field area with conservative minimum tillege technology and in agroecosystem with antierosional forestry belts, ARDS Turda (May, 2007, in entomological sweepnet catches samples).

The study of interactional sequences between phytophagous species and entomophagous pests have been performed based on the natural model established in the cereal agrobiocenoses, in the two types of technological systems: open field area and antierosional foresty belts. Pest and alive entomophags have been collected for laboratory studying of pest activity. In individual isolation rooms for entomphagous predators, 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)* and others have been studied in repeated tests using phytophagous insects as food (Table 2).

Many of the collected arthropods comprised entomophags 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 entomophag groups, reaching 78%. Under these conditions the auxiliary species represented 82% in winter wheat, 73% in spring cereals, 79% in soybean and 75% in crop marginal grasses (Table 3).

Results and Discussions

Agroforestry Belts and Sustainable Agricultural Development. 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-Bolduţ, planted since 1952. The farm comprises 342 hectars of arable land and pastures, surrounded by the 14 hectars of forestry curtains made of 36 tree and shrub species (Table 1), maintaining almost completely the initial planting plan, and thus being the only one of this type in Romania (Figure 1 and 3). 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 & Spîrchez 1955), and also on the conservation of useful arthropod fauna (Malschi & Mustea 1992, 1995; Malschi 1996, 2003, 2004, 2005, 2007, 2009).

Table 1

The different types of belts compositions in Cean-Boldut farm
with antierosional agroforesty belts (Lupe & Spîrchez 1955)

The belt number 1 (on border, of 11 m width): *Prunus cerasifera*, shrub, in the rows 1 and 7; *Quercus spp.*, with shrubs and accompanying species in the rows 2 and 6.
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: *Prunus 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 (antierosinal and protective belt of 11 m width): like belt number 3 but with other *Acer* species on 100 m lenght variants in the rows 3 and 5.
The belt number 8 (antierosinal 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 shrubs; in the rows 3, 5, 7, 9: *Acer* pur, or Acer with shrabs, on variants.

The belt number 9 (antierosinal belt, of 11 m width): in the row 1: *Pirus piraster*, *Corylus avellana*; in the rows 2, 4 and 6: *Fraxinus excelsior, 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 (antierosinal belt, of 12 m width):
in the rows 1 and 11: *Prunus 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: *Prunus avium*, *Ribes grossularia*; 2, 8 si 14: *Quercus robur, Fraxinus excelsior*;
in the rows 4, 6, 10 and 12: *Quercus robur*, *Acer pseudoplatanus*; in the inpar rows 3-13: *Ligustrum vulgare*.

The belt number 15 (antierosinal belt, 22 m width): in the rows 1 si 21: *Prunus 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*; 8, 10, 12, 14: *Quercus robur*, *Padus mahaleb*.

The belt number 18 (antierosinal belt, of 16 m width): in the rows 1 and 15: *Prunus 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*.

Table 2

Prey composition and feeding rate of main predators
with cereal pests in laboratory trials

Entomophagous predators	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).

Table 3

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

Crops	*Winter wheat*		*Spring cereals*		*Soybean*		*Marginal herbs*		*Summarized fields*	
Annual abundance	Nr.	%	Nr.	%	Nr.	%	Nr.	%	Nr.	%
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-Bolduţ										
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 our country this method of soil and agricultural crop protection with forestry belts was started in 1861 and developed in the years of devastating calamities, excessive draught, sand storms (1890, 1935, 1946), and then over 6000 hectars of forestry belts have been created until 1961, during 1970-1975 some 1700 ha more have been planted in Southern Oltenia (Popescu 1993). The efficiency of the forestry belts have been proved in the fight against draught and other adversities related to climate and relief: storms, torrents, snow-storms, landslidings, in preventing and control of massive soil degradation processes, and also in the protection and growth of the natural entomophagous reserve. By protecting agricultural crops, the forestry belts play a decisive role because of their direct effect on the microclimate, the blocking of landslidings 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 arthropod fauna has had a special impact on the dynamic development of the agroecosystem with effects on stabilizing the entomocenotic balance.

The Antierosional Protective Forestry Belts-based Agrosystem of Cean-Bolduţ. The network of antierosional forestry belts of Cean-Bolduţ 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-Bolduţ, 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 460 m and a moderate slopes from north-est to south-est. 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).

Multiannual values regarding the mean temperature and annual precipitations average 8.6% and 509.2%, 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 (*Prunus avium*), apple tree (*Malus silvestris*), pear tree (*Pirus piraster*), black thorn (*Prunus spinosa*), hawthorn (*Crataegus monogyna*), wildrose (*Rosa canina*), gooseberry (*Vaccinium spp.*), 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*), sycameore maple (*Acer pseudoplatanus*), common ash (*Fraxinus excelsior*), small-leaved lime (*Tillia cordata*) and willow (*Salix caprea*) (see Table 1), (Lupe & Spîrchez 1955; Popescu 1993).

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

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 & Mustea 1992, 1995; Malschi 2007), the data being similar with the scientific literature (Chambon et al 1985; Sunderland et al 1985; Stark 1987; Basedow 1990; Welling 1990; Wetzel 1992, 1995).

Pest Control-related Strategies of Sustainable Development. In the last three decades the results of applied entomological scientific research has lead to the conclusion that in Transylvania pest control has been required as an important technological sequence of crop integrated system (Malschi 2005). Climate warming, the settlement of extremely hot periods, draught 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 more narrow spectrum of problem-arising species which have become dominant and dangerous due to the number 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).

Forestry Belts-based Agricultural System. In the forestry belts-based agricultural system the conservative effects of biodiversity, flora diversity and the fauna of auxiliary entomophagous arthropods have been shown together with antierosional effects (Table 1). The agroforestry belts made of trees and shrubs and also the marginal shelters of herbs are extremely rich in entomophagous species (Malschi & Mustea 1995; Malschi 2007). The abundance, activity and conservation of entomophagous arthropods are supported by the presence of diversified flora (Table 2) 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 & Molthan 1991; Malschi & 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, Table 3). 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 ascertainement that there is a real entomocenotic equilibrium in the field crops with antierosional forestry belts 57 years after network planting; thus, no critical pest attack situations have been recorded, and no insecticide treatment application has been required. Moreover, under the conditions of climate warming during 2000-2008, in the open field agricultural system, pest control has shown real risk or calamity situations which proved the protective and qualitative importance of consolidated agroforestry belts-based agricultural system. The investigations have been intensified by recording some extremely powerful prey-predator interactions.

It has been noticed that in the protective forestry belt-based farm under the conditions of the climate warming and aridization of the present, complete natural biological control of cereal leaf beetle populations *(Oulema melanopus L.)* and the 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 (Tables 4).

As 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 has been accentuated in comparison with open field agriculture. During 1990-2008 the climate conditions and pest attacks represented real risk situations, and the application of insecticide treatment has been required, in the open field agriculture (Tables 5-6).

Therefore, the integrated pest control management should include entomophagous regional 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. Enriching techniques of natural entomophag reserve are recommended by means of drawing and preserving auxiliary species in the crops.

Table 4

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

Oulema melanopus		*Haplothrips tritici*		Aphids		Diptera larvae		*Eurygaster, Aelia*	
Turda	Bolduţ	Turda	Bolduţ	Turda	Bolduţ	Turda	Bolduţ	Turda	Bolduţ
350 larvae/ m^2	9 larvae/ m^2	22 larvae/ ear 80% ears 30% spikles	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

Table 5

The long term evolution of wheat pests structure by comparison with the structure in minimum tillage conservative technology, in A.R.D.S. Turda

Wheat pests	*Classic technology, 1980-2005 (%)*			*Conservative 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 density, in 2000-2005 at wheat in classical technology and in 2006-2008 in soil 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 iver the entire vegentation period, following their species biology-related dynamic cycle. Most of the entomophagous species migrate towards crops from the appropriate hybernation and refuge places, represented by belts with the forestry curtains and bordering grasses (Welling 1990; Stork-Weyhermüller & 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 the 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 (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 entomophag species head towards some maximum concentration sites represented by some favourite food sources or refuge sites. Thus, great attractiveness areas and banks are: the grass belts for *Aranee*, *Carabide, Staphylinide, Formicide*; *Urtica dioica* for *Coccinella* şi *Chrysopa*; blossoming oak (*Quercus robur*) for *Coccinella septempunctata*; blossom cherry tree (*Prunus avium*) for *Cantharis fusca*; *Sambucus nigra* and other blossoming shrubs for *Cocinellide*; 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 & 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; they represent concentration and feeding banks of the individuals prior to entering the crops and passing corridors, and spreading into the agroecosystem, 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 rotation crop 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 presence of diversified vegetation in the forestry belt-based farm offers refuge places and favorable nices 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 exeeds the possibilities of natural self regulation through entomophags, insectidide treatments being required. During 2000-2008, pest aggression has shown value increases. Especially the climate warming, draught and aridization during the decisive periods of the crops, between 2006-2008, 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, the missing 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 have been regarded as favorable development conditions for some pest species, requiring complex phytosanitary hygiene systems for the integrated pest control (Table 5-6).

The use of auxiliary natural reserve in the control of cereal crop pests represents a great advantage for the area agriculture. The need for researches on agricultural entomocenoses results from the content, dynamics and intensity of structural prey-predator interactions in different ecological crop area. In the case of cereal-based agroecosystems in Central Transylvania the positive role of predating entomophags is a certainty. The natural entomophag reserve in the reagional cereal agroecosystems represents an extremely important defense system against the growth of biological and attack potential of cereal pests, and prevention of carantine species invasions. In Central Transylvania it is necessary to promote the protection of auxiliary damaging entomophag 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, foresty plantations. The auxiliary efficiency is favored by the rational and selective application of pesticide treatment, when warned; by the small sizes of the cultivated lands, by the diversified structure of the crops, in insertion lots of small grain cereal, corn, soybean, beans crops, forage crops (alfalfa, lucerne and others) which provides the continuity of the feeding and refuge sites for entomophags.

Conclusions. The data related to biodiversity, species composition and natural control of cereal pests were carried out in comparative research performed in Transylvanian cereal agroecosystems, at Agricultural Research Station Turda, in two different farms: in a farm in open field area, at Turda and in a farm with protective forest belts at Cean-Bolduț. The paper proved the important role of biodiversity on farming model of agro-ecosystem with protective agro-forest belts, as an ecological technology for soil erosion control and land degradation limitation, for the conservation and use of biological diversity. This biodiversity is involved on natural efficient biological pests control, on the diminution of insecticides pollutants and for 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)*; *Neuroptera (Chrysopidae*). Entomological researches have been shown the increasing role of entomophagous predators and their efficiency in the cereal pest limitation, on the protective forestry belts-based agroecosystem. The abundance of useful entomophagous species was superior in the farming system with protective forestry belts and marginal herbs shelters conservative for biodiversity. These biotechnologies regard several aspects of sustainable use of bioresources: plantation of agroforestry belts comprising tree and shrub species: *Prunus 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 entomophag 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.*);* The existence of diversified flora within the protective belts system represents the main factor to ensure richness of the species, survival, increase of abundance and seasonal migration of useful entomophagous arthropods. It is achieved a natural entomocenotic equilibrium and a natural biological control of important zone pests, like *Oulema spp*., cereal flies, aphids, cicades, thrips, bugs etc. No insecticide application was needed, related with the activity of entomophagous natural reservoir. By comparison on the cereal agroecosystem in open field area it is necessary to apply the insecticide treatments, because the development of pest population exceeds the adjusting capacity of entomophagous fauna. During 2000-2008, pest attack in the open field cereal biocenoses has been real risk situations requiring a complexity of repeated insecticide treatments.

The protective and qualitative importance of the agroforestry belts agricultural system has been proven, being extremely favorable to the conservation of the natural reserve of auxiliary entomophags in the Cean-Bolduţ farm founded in 1952. On the agro-ecosystem with protective agro-forest belts it is achieved favorable results on the erosion control and land degradation limitation (see Plate 1), at the last years conditions, characterizing by arid microclimate - excessive dryness and warmth, or excessive rainfalls, hurricanes, windiness and landfalls.

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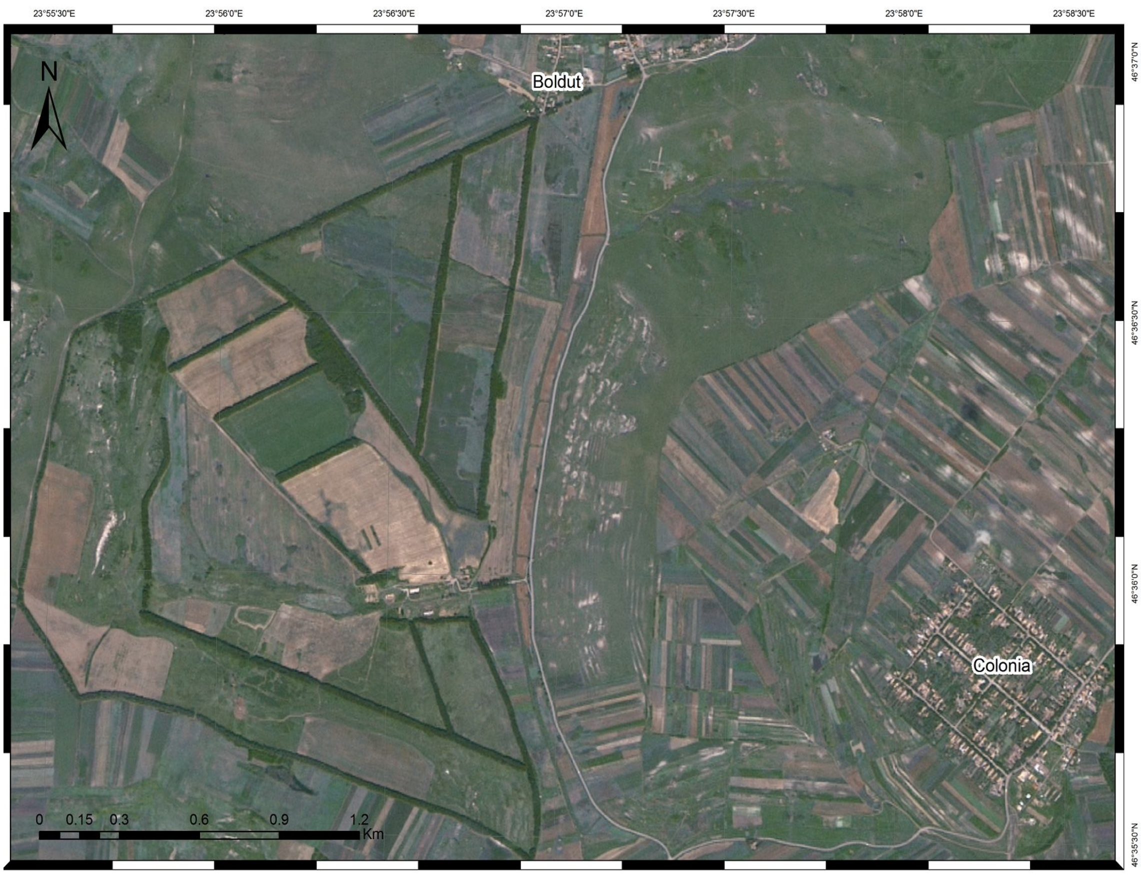

Figure 3. Cean-Bolduţ farm and the antierosional forest belts (left).

Plate 1

A. Cean-Bolduţ farm, 25 October 2008 (photo by Ing. R. Şerbănescu).

B. Cean-Bolduţ farm, 30 October 2008 (photo by Ing. N. Tritean).

C. SCDA Turda Zone (Cean-Bolduţ and Turda farms), 3 July 2009 (photo by student Z. Kruk).

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