Integrated pest management in relation to environmental sustainability. Part II.

Wheat pest management under the dynamics of agroecological changes in Transylvania

Dana Malschi

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FOREWORD

The new book entitled *"Integrated pest management in relation to environmental sustainability. Part II. Wheat pest management under the dynamics of agroecological changes in Transylvania"* elaborated by Dana Malschi, PhD, is a continuation of the previously researches, with other 10 years study results carried out at Agricultural Researches and Development Station Turda of the Academy of Agricultural and Forestry Sciences. These research results have been published in different scientific articles and have been obtained with the collaboration of the researchers involved in performing the scientific field experiments.

The author is well-known within the research community of plant protection, as a dedicated scientist showing scientific accuracy in over 200 published scientific papers. The book, entitled "Environment-agriculture-sustainable development, and the integrated pest management of cereal agroecosystems", standed out by a prize distinction "Constantin Sandu Aldea" of the Academy of Agricultural and Forestry Sciences, in 2007.

The book is remarkable by the systemic approach of the relationships between the sustainable development objectives, environmental protection and integrated pest control as a part of cereal farms environmental management, under the agroecological conditions related to present climate and technological changes.

The author's original contribution consists in the results of the long term research conducted in Central Transylvania where she has tackled the integrated pest control management in cereal ecosystems, including species inventory, understanding the biology, ecology and pest populations dynamics and their control.

The main aspects of the present problems regarding the characteristics of agriculture and agroecosystem sustainable development in relation to the evolution of damaging fauna and entomophagous auxiliary fauna have been described in a logical content structure. Special attention has been given to the monitorization of cereal pest emergence and attack, the book concluding the concept of preventive measures and the pest control strategy. Also, in order to be taken over and continued, the book recalls of specialists some valuable previous research on the importance of auxiliary entomophagous and the negative side effects of insecticides used in wheat pest control, on the mortality of useful arthropods fauna.

The book is intended to the researchers, students and all those who are interested in the integrated pest control in field crops and it is a real contribution to the broadening of knowledge regarding the relation between the objectives of agricultural production and environmental sustainable management in the context of ecological and technological changes.

Prof. dr. Gheorghe SIN
Member of the Romanian Academy
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Summary authors' word

Elaborated in 2018, the paper *"Integrated pest management in relation to environmental sustainability. Part II. Wheat pest management under the dynamics of agroecological changes in Transylvania"* is a synthesis of the author`s research on the plant protection and environmental applied domain of entomology and ecology. This new book is a continuation of the previously published researches, with other 10 years study results carried out at Agricultural Researches and Development Station Turda. These research results have been obtained with the collaboration of the researchers involved in performing the scientific field experiments. The reason for publishing this book has been the knowledge progress in the entomological research domain concerning the agricultural production safety by the development of the pest control technologies, the management of biological resources from agro-ecosystems, the increase and quality of the agricultural productions, in concordance with the concept of sustainable development, under the present climatic and agro-ecological changes.

Based on author's 38 year research studies at the Agricultural Research Station in Turda, in central Transylvania, the paper presents the agro-ecological study on the population dynamics and attack evolution of wheat pests entomofauna: Diptera, Homoptera, Thysanoptera, Coleoptera, Heteroptera etc., and biotechnological experiments on the adequate integrated pest control methods, including insecticides efficiency, cultural measures and entomophagous predators limiters, environmental protection, conservation and sustainable use of biodiversity, involved in the actual pests control strategy, as part of the technological system for sustainable development of cereal crops.

In the book chapters: *1 - The importance of pests and the entomological risk situations to wheat crops in the center of Transylvania; 2-Integrated wheat pest management and the environmental public goods associated with agriculture practice relatet with the environment-agriculture-sustainable development interrelations; 3 - The efficiency of natural entomophags predators involved in wheat pests limitation in the centre of Transylvania; 4 - Wheat pest dynamics, forecasting and current importance of the attack, for the development of an integrated control system in the center of Transylvania; 5 - Dynamics of biological potential of wheat pests in relation to climate changes and auxiliary entomophagous arthropod fauna during 2006-2016; 6 - Agricultural and environmental importance of Cean-Bolduț antierosional foresty belts in Transylvania; 7 - Conclusion on the integrated pest management of wheat crops in Central Transylvania, in the agroecological and technological changes,* the paper presents data on the pests and useful arthropod fauna, biological and agro-ecological aspects, experimental field trials for pest control and preventive measures, in order to achieve the integrated control system of the main species damaging wheat crops, in order to protect and use the natural reservoir of entomophagous in cereal agro-ecosystems.

Under the conditions of actual agro-ecological changes, yielded by climatic warming and dryness and new technological and economic conditions of zone agricultural exploitations, the original research has pointed out the increasing attack of main wheat pests: wheat flies, leafhoppers, aphids, thrips, sun bugs, cereal leaf beetle etc., and the opportunity of insecticide control. The spring months of the last years have been characterized by increasing warming, heating and dryness periods, causing the increase of pests abundance and damages on wheat crops, in Transylvania. A decrease in species diversity has been noticed together with an increasing abundance of the species with a single generation by year: *Delia coarctata* FALL., *Opomyza florum* F., *Phorbia penicillifera* JERMY, *Oulema melanopus* L., *Chaetocnema aridula* GYLL., *Eurygaster maura* L., *Aelia acuminata* L., *Haplothrips tritici* KURDJ., *Zabrus tenebrioides* GOEZE, and of the other species of chloropids, anthomyiids, cecidomyiids flies, leafhoppers (*Psammotettix alienus* DAHLB., *Macrosteles laevis* RIB., *Macrosteles sexnotatus* FALL., *Javesella pellucida* FABR.), aphids (*Schizaphis graminum* ROND., *Macrosiphum*

(Sitobion) avenae FABR., *Rhopalosiphum padi* L., *Metopolophium dirhodum* WALK.) etc., well favored by consecutive wheat crops and by zone cereal ecosystems presence.

The attack critical moments of the different species were recorded 3–4 weeks earlier and superposed. The insecticide treatments were imposed during the spring phase, in April and during the spike appearance phase, in mid May. The paper points out the extension risk of wheat pests attack with an increasing potential, affecting the wheat cropsyields and causing possible crop damages or leading to the compromise especially of the sown fields of consecutive wheat crop and of early sowing in September, and the importance of the elaboration of agro-ecological integrated control strategy (ICS).

The attack diminishing methods of the Wheat Integrated Pest Management are: - agro-technical methods: avoid early planting in autumn to minimize the incidence of insect vectors and diptera species, destroy volunteer wheat, adequate fertility, use good seed quality, the weeds, main pests and diseases control, conservation and use of biological factors: tolerant varieties, entomophagous limiters; - application of selective insecticides, with economic and ecological efficiency, at two different selective moments. Usual insecticides treatments (pirethroids, neonicotinoids etc.) were tested and efficiently used, in the two different selective moments of application: 1 - on the control of wheat flies larvae *(Delia coarctata, Opomyza florum, Phorbia securis, Ph. penicillifera, Oscinella frit etc.)*, in April, at the end of tillering phase (13-33 DC stage), controlling other pests of wheat (cereal leaf beetle-adults, wheat fleas, leafhoppers etc., too; 2 - on the wheat thrips (*Haplothrips tritici*) adults control and on aphides, leafhoppers, cereal leaf beetle, cereal sun bugs control, too, during spike appearance phase in 45-59 DC stage, during May 15^{th}-25^{th}, the treatments being efficient in controlling all dangerous pests of wheat. Integrated pests control strategy is an important section of agrotechnological system for wheat crops sustainable development. High insecticides efficiency and the achieved increasing yield rates of 7-24 % have been the experimental results recommending an adequate technological system and modern insecticides pest control strategy.

The natural predators play an important role in decreasing the wheat pest abundance. The well-known systematic groups of enthomophagous predators: Aranea; Dermaptera; Thysanoptera (Aeolothripidae); Heteroptera (Nabidae etc.); Coleoptera (Carabidae, Cicindelidae, Staphylinidae, Sylphidae, Coccinellidae, Cantharidae, Malachiidae); Diptera (Syrphidae, Scatophagidae, Empididae etc.); Hymenoptera (Formicidae etc.); Neuroptera (Chrysopidae) were represented in the structure of arthropod fauna. Laboratory tests and investigation regarding the role of the main species of predatory entomophagues as regulators of pest populations in cereal agro-ecosystems, has proved that various species feed preferentially on wheat flies, cereal aphids, trips, cereal sun bugs, *Oulema* etc. The results of laboratory feeding trials with cereal pests regarding feeding habits of predators, prey composition and feeding rate per day and individual showed the importance of predatory species. Cereals agroecosystem of central Transylvania are rich in beneficial entomophagous arthropod fauna. The abundance and the quality of activity of entomophagous populations were higher in the system of field crops with protective forest belts, existing since 1952, in the Cean-Bolduţ farm at A.R.D.S. Turda. Therefore, on the farm with protective forestry belts and with field marginal herbs, favorable for the development of entomophagous arthropod fauna, a real natural entomocenotic equilibrium and a natural biological control of important zone pests, like *Oulema melanopus* L., cereal flies, aphides, cicades, thrips, cereal sun bugs has been achieved. 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.

Due to the richness of natural entomophagous fauna in the cereal agroecosystems in Central Transylvania, the treated crops have been intensely re-colonized with entomophags.

The insecticide impact can also be diminished by choosing the selective treatment time to protect the main predatory species taking into account their biology and the specificity of the technological systems both within conservative soil (no tilllage) and in the conventional plowing, in order to achieve high yields, good quality and a reduced negative impact on the environment, biodiversity and quality of agricultural products (Malschi 2007, 2008, 2009, Malschi et al., 2016, 2017, 2018). Recent research and new thesis elaborated at ARDS Turda (Dărab et al., 2017, 2018, Vălean et al., 2017, 2018) will provide details on the interrelation between the current technologies of integrated pest control, pests and auxiliary entomophages in the wheat crops, from the conditions of actual changes on the climatic, eco-biological and technological.

The book is a systemic approach of the relationships between the sustainable development objectives, environmental protection and integrated pest control as part of cereal integrated environmental management. The book is intended to researchers, students and all those involved in the study of the integrated pest control in agricultural crops, in the context of agricultural ecological and technological changes.

The author special acknowledge to Agricultural Research Station Turda, mainly to the working group of entomology and plant protection laboratory for their interest shown in the long term research. The author also thanks to ARDS Turda and to the prestigious National Agricultural Research Development Fundulea for their support in her professional training since their beginnings.

Dana Malschi

Content

1. The importance of pests and the entomological risk situations to wheat crops in the center of Transylvania

Carried out since 1980 until now at the Agricultural Research and Developement Station Turda (NW of Romania, Cluj county), the numerous studies have shown the importance of wheat insect pests pointing out the research evolution on the dynamics of pests attacks and risk situations. The applicative entomological research was conducted in central Transylvania, at the ARDS Turda, for the last four decades. The results show that wheat pest control is an important sequence of the system of the cultural integrated technology. Every year, phytophagous pests have caused significant wheat crop losses with consequences on the chances to attain the objectives of food security, productivity goals, and sustainable development of agriculture and environment (Malschi et al., 2005, Malschi, 2007, 2008, 2009, 2014). Taking into consideration the numerous pests of wheat crops, it is important to point out the significance of the attacks which lead to the failure of productive potential of cultivated varieties and even to harvest compromise in extreme risk situations due to the abundance of phytophagous insects.

During the period 1974-2018, more than 50 species of insect pests have been highlighted in the structure of enthomocenoses of the wheat crops at the Agricultural Research and Development Station Turda. **A specific complex** of pests has been observed through the damage caused consisting of Diptera species (wheat flies)*: Opomyza florum F., Delia coarctata Fll., Phorbia securis Tiensuu, Ph. penicillifera Jermy, Oscinella frit L. etc.;* of aphids: *Schizaphis graminum* Rond., *Macrosiphum avenae* Fabr., *Rhopalosiphum padi* L., *Metopolophium dirhodum* Walk., and of leafhoppers: *Psammotettix alienus* Dahlb., *Macrosteles laevis* Rib., *Javesella pellucida* Fabr., etc.; wheat thrips: *Haplothrips tritici Kurdj.;* cereal leaf beetles: *Oulema malanopus L;* cereal fleas: *Chaetocnema aridula* Gyll.*, Phyllotreta vitulla* Redt.; cereal sunbugs: (*Eurygaster maura, Aelia acuminata* etc.); wire worms and other pests from soil: *Agriotes, Opatrum, Zabrus, Agrotis etc.* (Table 1) (Malschi and Mustea, 1992, 1997, Malschi et al., 1980, 2015, 2016, Malschi, 2001, 2003, 2004).

The damages caused by the pests can reach significant values, from 300 to 1500 kg/ha yield losses, where the spring attack of Diptera larvae reaches the frequencies of 50-90% attacked plants and the intensities of 10-25% destroyed stalks tillers; from 14 to 25% yield losses in wheat and spring barley following the attack of *Oulema* larvae; from 15 to 20% yield losses in case of the spike pests, at the average density of 22 thrips larvae/ear and 32 aphids/ear. In the case of early sowing in September, the cereals flies, aphids and leafhoppers can cause crops compromise (Malschi and Mustea, 1998, Malschi, 1999, 2000, 2001, 2004).

These groups of wheat pests are studied in important works both in the country (Baicu, 1989, 1996, Baicu and Săvescu, 1978, Baicu and Bărbulescu, 1997, Bărbulescu, 1984, Bărbulescu et al., 1973, 2002, Boguleanu, 1994, Balaj, Cantoreanu Margareta, 1982, Bucureanu Elena, 1996, Ciochia, Boeriu, 1996, Crişan et al., 1999, 2000, Hondru, 1985, Hulea Ana et al., 1975, Jilăveanu Aurelia, Vacke, 1995, Knechtel and Knechtel, 1909, Knechtel, Manolache, 1944, Manolache, Boguleanu, 1967, Mărgărit et al., 1984, Mustea, 1970, 1973, 1977, 1997, Munteanu, 1973. Munteanu et al., 1973, 1983, Nagy Elena, 2001, Nagy Elena, Kadar Rodica, 2003, Oltean et al., 2004, Paulian, 1969, Paulian et al., 1971, 1974, Perju, 1983, 1999, Perju et al., 1968, 1971, 1983, 2002, 2004, Popov et al., 1983, 1984, 2007a., Rogojanu, 1968. Rogojanu, Perju, 1979, Ploaie 1973, Ploaie, Mitran, 1983, Pop, 1975, Roşca et al., 2011, Săvescu, 1962 etc.), and abroad (Balachowsky, Mesnil, 1935, Beliaev, 1965, 1974, Benada, 1967, Bienko et al., 2002, Chambon, 1984, Chambon et al., 1985, Dedryver, 1990, Dedryver et al., 1985, Denholm et al, 2002, Dimitijevic et al., 2000, Gal, Burges, 1988, Jones and Jones, 1974, Karpova, 1958, Katis et al., 2004, Ossiannilsson, 1978, 1981, 1983, Remane, Wachmann, 1993, Robert Yvon, 1987, Rosseberg et al., 1986, Sweets Laura, 2004, Walczak Felicyta, 1990, Tanasijevic, 1965 a, b, Tanskii, 1981, Thieme, Heimbach, 1992, Watkins, Lane, 2005, Tsitsipis et al., 1995, 2001, 2004, Wetzel, 1995 etc.).

The research has revealed the presence of a useful natural fund of entomophagous fauna characterized by the species richness and the efficiency of the limiting activity of phytophagous insects (Table 2). All the known groups of auxiliary entomophagous, parasites and especially predators were signaled (*Aranea; Dermaptera; Thysanoptera (Aeolothripidae); Heteroptera (Nabidae* etc.); *Coleoptera (Sylphidae, Coccinellidae, Carabidae, Cicindelidae, Staphylinidae, Cantharidae, Malachiidae*); *Diptera (Syrphidae, Scatophagidae, Empididae etc.); Hymenoptera (Formicidae* etc.); *Neuroptera (Chrysopidae*) etc. The presence of entomophagous in the crops from spring to autumn with a weighting of 25-30% in the structure of the arthropod fauna has the effect of natural limitation of pests.

The ecological research conducted in the laboratory following the model of predator-prey interactions observed in cereal biocoenosis has revealed the role and importance of auxiliary entomophages (Malschi and Mustea, 1995, 1997, 1998, 2003; Malschi, 2007, 2008, 2009) (Table 3). These results are concordant with the literature specifying the importance of entomophagous natural limiters (Basedow, 1990; Cândea, 1986; Chambon, 1984; Ciochia, 1986; Hassan, 1992; Mühle - Wetzel, 1990; Panin, 1951; Perju, 1988; Steiner, 1976; Stark, 1987; Sunderland, 1985; Voicu, 1993; Welling, 1990; Wetzel, 1991, mentioned by Malschi, 2007, 2009; Malschi et al., 2016). Therefore, it proves mandatory the elaboration of Sustainable Development strategies which include the conservation and use of regional biodiversity involved in the achievement of productivity and stability of agro-ecosystems (Malschi, 2007, 2008, 2009, 2014).

Table 1. List of registered pest species in ARSD Turda (1980-2015)
(Malschi, D., 2007, 2008, 2009, Malschi et al., 2016, 2017, 2018)

1. Ord. Collembola	Fam. Sminthuridae: *Sminthurus viridis* L.
2. Ord. Orthoptera	Fam. Tettigoniidae: *Tettigonia viridissima* L. Fam. Cantatopidae: *Decticus verrucivorus* L. Fam. Acrididae: *Dociostaurus marocanus* Th., *Calliptamus italicus* L. Fam. Gryllidae: *Gryllus campestris* L.
3. Ord. Heteroptera	Fam. Scutelleridae: *Eurygaster maura* L., etc. Fam. Pentatomidae: *Aelia acuminata* L., etc. Fam. Miridae: *Trigonothylus ruficornis* Geofr., *Lygus pratensis* L., *L. rugulipennis* P.
4. Ord. Homoptera:	
Sord. Cicadina	Fam. Cicadellidae: *Psammotettix alienus* Dahl., *Macrosteles laevis* Rib., *M. sexnotatus* Fall. Fam. Delphacidae: *Javesella pellucida* Fabr.
Sord. Aphidina	Fam. Aphididae: *Schizapis graminum* Road., *Sitobion avenae* Fabr., *Rhopalosiphum padi* L.,*Metopolophium dirhodum* Walk.
5. Ord. Thysanoptera	Fam. Tripidae: *Stenothrips graminum* Uz., *Limothrips denticornis* Hal. Fam. Phlaeothripidae: *Haplothrips tritici* Kurdj., *H. aculeatus* Fabr.
6 Ord. Coleoptera	Fam. Carabidae: *Zabrus tenebrioides* Goeze. Fam. Elateridae: *Agriotes lineatus* L., *A. ustulatus* L., *A. sputator* L., *A. obscurus* L. Fam. Tenebrionidae: *Opatrum sabulosum* L. Fam. Scarabeidae: *Anisoplia segetum* Hb. Fam. Chrysomelidae: *Oulema melanopus* L., *Lema cyanella* L. *Chaetocnema aridula* Gyll., *Phyllotreta vitulla* Redt., *Crepidodera aurata* Marsham.
7. Ord. Hymenoptera	Fam. Cephidae: *Cephus pygmaeus* L., *Trachelus tabidus* F. Fam Tenthredinidae: *Dolerus haematodis* Klg.
8. Ord. Diptera:	Fam. Tipulidae: *Tipula oleracea* L.

Sord. Nematocera	Fam. Bibionidae: *Bibio hortulanus* L. Fam. Cecidomyiidae: *Contarinia tritici* Kyrby., *Mayetiola destructor* Say., *Haplodiplosis equestris* Wagn., *Sitodiplosis mosellana* Gehin.
Sord. Brachicera	Fam. Opomyzidae: *Opomyza florum* F., *O. germinationis* L., *Geomyza tripunctata* Fall. Fam. Anthomyiidae: *Delia coarctata* Fall., *D. platura* Meig., *D. liturata* Zett. *Phorbia penicillifera* Jermy., *Phorbia securis* Tiensuu. Fam. Chloropidae: *Oscinella frit* L., *O. pusilla* Meig., *Tropidoscinis albipalpis* Meig., *Elachiptera cornuta* Fall., *Chlorops pumilionis* Bjerk., *Meromyza nigriventris* Mac., *Lasiosina cinctipes* Meig., *Cetema elongata* Mg., *Comarota curvinervis* Latr. Fam. Scatophagidae: *Amaurosoma flavipes* Fll. Fam. Agromyzidae: *Phytomyza nigra* Fll. Fam. Ephydridae: *Hydrellia griseolla* Fll.
9. Ord. Lepidoptera	Fam. Tineidae: *Ochsenheimeria taurella* Schiff. Fam. Noctuidae: *Hadena basilinea* F., *Agrotis segetum* Schiff.

Table 2. List of registered entomophagous arthropods in A.R.S.D. Turda (1980-2015) (Malschi, D., 2007, 2008, 2009, Malschi et al., 2016, 2017, 2018)

Cl. Arahnida	
1. Ord. Aranea	Fam. Lycosidae: *Trochosa* sp. Fam. Araneidae: *Araneus diadematus* Clerck ş. a.
2. Ord. Acari	Fam. Phytoseiidae: *Phytoseiulus persimilis* Ath-Hen. Fam. Trombidiidae: *Trombidium holosericeum* L.
Clasa Insecta	
1. Ord. Dermaptera	Fam. Forficulidae: *Forficula auricularia* L.
2. Ord. Heteroptera	Fam. Nabidae: *Nabis ferus* L. Fam. Anthocoridae: *Anthocoris nemorum* L. Fam Miridae: *Daraeocoris ruber* L.
3. Ord. Thysanoptera	Fam. Aeolothripidae: *Aeolothrips intermedius* Bagn.
4. Ord Coleoptera	Fam. Carabidae: *Poecilus cupreus* L., *Amara aenea* De Geer., *Pterostichus melanarius* Ill., *P. macer* Marsh., *Harpalus distinguendus* Duft., *H. rufipes* De Geer., *H. aeneus* L. *H.affinis* Sch., *Brachinus explodens* Duft., *Loricera pilicornis* F., *Platynus dorsalis* Pont; *Dolichus halensis* Schall., *Agonum muelleri* Hbst., Carabus coriaceus L., *Carabus nemoralis* Mull. Fam. Cicindelidae: *Cicindela campestris* L. Fam. Staphylinidae: *Tachyporus hypnorum* L., *Staphylinus* sp. Fam. Sylphidae: *Sylpha obscura* L., *Necrophorus vespillo* L. Fam. Cantharidae: *Cantharis fusca* L., Fam. Malachiidae: *Malachius bipustulatus* L. Fam. Coccinellidae: *Coccinella septempunctata* L., *Propylaea quatuordecimpunctata* L., *Adalia bipunctata* L., *Anattis occellata* L., *Hippodamia tridecimpunctata* L., *Adonia variegata* Goeze., *Chilocorus bipustulatus* L.
5. Ord. Hymenoptera	Fam. Formicidae ş.a.
6. Ord. Planipennia	Fam. Chrysopidae: *Chrysopa carnea* Stephn. (larva)
7. Ord. Diptera	Fam. Empididae: *Platypalpus* sp., Fam. Dolichopodidae: *Medetera* sp., Fam. Scatophagidae: *Scatophaga stercoraria* L. , Fam. Tachinidae: *Lydella* sp., Fam. Syrphidae: *Episyrphus balteatus* Dg., *Syrphus ribesii* L., *Metasyrphus corollae* Fabr.

Table 3. List of entomophagous predators in cereal agrobiocenosis of Transylvania and the pray activity (consumed individuals of phytophagus /day/ individual) in different references (Malschi, D., 2007, 2008, 2009, Malschi et al., 2016, 2017, 2018)

Groups and Families	Genera and Species	Refferences on the entomophagous activity (ratio/day/individual)
Aranea		Cândea, 1986, Mühle-Wetzel, 1990
Forficulidae	*Forficula auricularia* L.	Hassan, 1992

Chrysopidae	*Chrysopa carnea* Stephn. (larva)	Cândea, 1986 (32 aphids/day), Malschi, 2007, 2009 (10 eggs-5 larvae of *Oulema*/day, 10 adults-40 larvae of *Haplothrips tritici/day, 30-50* aphids/day*, 10 eggs of Eurygaster/day, 3 larvae of Opomyza/day, 2 larvae of Phorbia securis/day).*
Nabidae	*Nabis ferus* L.	Wetzel, 1991 (15 aphids/day), Malschi, 2007, 2009 (8 eggs - 5 larvae *Oulema*/day, 42 larvae of *Haplothrips tritici, 60 Sitobion avenae/*day*, 25 Rhopalosiphum padi/* day*, 10 eggs of Eurygaster/* day*, 3-4 larvae-pupa of Opomyza florum or Phorbia/*day*/1 Nabis* adult; 30 larvae of *Haplothrips tritici, 25 Sitobion avenae/*day*, 17 Rhopalosiphum padi/* day//1 Nabis larva).
Anthocorydae	*Orius*	Voicu, 1993, Perju, 1988
Coccinellidae	*Coccinella 7-punctata* L. *Prophylea 14-punctata* L.	Mühle-Wetzel, 1990 (115 aphids/day), Basedow, 1990 (38 aphids/day), Malschi, 2007, 2009 (10 eggs-3 larvae of *Oulema*/day, 35 larvae of *Haplothrips tritici/day, 50 Sitobion avenae/*day*, 25 Rhopalosiphum padi/*day*, 2 larvae of Opomyza florum/*day*/1 Coccinella 7-punctata* adult; and 7 eggs-3 larvae of *Oulema/* day, 20 larvae of *Haplothrips tritici/day, 40 Sitobion avenae/*day*, 25 Rhopalosiphum padi/*day*, 2 larve Opomyza florum/*day*/1 Prophylea 14-punctata* adult*).*
Cantharidae	*Cantharis fusca* L.	Wetzel, 1991 (8 aphids/day), Malschi, 2007, 2009 (6 eggs of *Oulema/* day, 15 adults of *Haplothrips tritici/day, 40 Sitobion avenae/*day*, 2 larvae of Opomyza /* day*, 4 larvae of Phorbia securis/*day.
Malachiidae	*Malachius bipustulatus* L.	Steiner, 1976, Cândea, 1986, Malschi, 2007, 2009 (10 larvae of *Oulema*/day, 15 adults and 30 larvae of *Haplothrips tritici/day, 40 Sitobion avenae/*day*, 3 larvae of Phorbia securis/*day*).*
Staphylinidae	*Tachyporus hypnorum* L. *Staphylinus*	Basedow, 1990 (19 aphids/day), Malschi, 2007, 2009 (8 eggs of *Oulema*/day, 25 aphids/day, *1 larva of Opomyza or Phorbia/*day*)* Chambon, 1984, Sunderland,1985, Malschi, 2007, 2009 (10 eggs of *Oulema*/day, 30 *Sitobion avenae/*day*, 15 Rhopalosiphum padi/*day*, 1 larva of Opomyza/* day*, 4 larvae or pupa of Phorbia/*day*).*
Carabidae	*Poecilus cupreus* L.	Welling M., 1990, Ciochia, 1986, Malschi, 2007, 2009(9 eggs-6 larvae of *Oulema*/day, *60 Sitobion avenae/day, 50 Rhopalosiphum padi/day, 10* eggs *of Eurygaster/day, 5-10 larvae-pupa of Opomyza florum/day, 5-7 larvae-pupa of Phorbia/*day).
	Amara aenea De Geer	Basedow, 1990 (11 aphids/day), Malschi, 2007, 2009 (9 eggs-5 larvae of *Oulema*/day, *50 Rhopalosiphum padi/*day*, 10* eggs of *Eurygaster/*day*, 8 larve Phorbia/*day)*.*
	Harpalus rufipes De Geer	Basedow, 1990 (27-130 aphids/day), Malschi, 2007, 2009 (8 eggs - 9 larvae of *Oulema*/day, *60 Sitobion avenae/day, 50 Rhopalosiphum padi/*day*, 10* eggs *of Eurygaster/*day*, 1 larva of Opomyza florum/*day*, 2-1 larvae-pupa of Phorbi /*day)*.*
	Harpalus distinguendus Duft.	Malschi, 2007, 2009 (8 eggs-3 larvae of *Oulema*/day, *50 Rhopalosiphum padi/*day*, 2 larvae or2 pupa of Phorbia securis/*day).
	Harpalus aeneus L.	Malschi, 2007, 2009 (5 eggs-4 larvae of *Oulema*/day, *50 Rhopalosiphum padi/*day*, 2 pupa of Opomyza florum/day, 4 larvae-2 pupa of Phorbia securis/*day*).*
	Brachinus explodens Duft.	Cândea, 1986, Malschi, 2009 (5 larve *Oulema* / day, *25 Sitobion avenae/* day*, 30 Rhopalosiphum padi/* day.
Sylphidae	*Sylpha obscura* L.	Sunderland, 1985 (afide), Malschi, 2007, 2009 (14 eggs-3 larve *Oulema*/day, *10* eggs *Eurygaster/*day*, 1-4 larvae-pupa of Opomyza florum/*day, *2-4 larvae-pupa of Phorbia/*day.
Cicindellidae	*Cicindela germanica* L.	Panin, 1951, Ciochia, 1986
Emipididae	*Platypalpus*	Chambon, 1984, Stark, 1987
Chloropidae	*Thaumatomyia glabra* Mg	Skufin, 1978
Syrphidae	*Episyrphus baltaeatus* Dg. (larva)	Mühle-Wetzel, 1990 (20-80 afide/day), Malschi, 2007, 2009 (15 adults of *Haplothrips tritici/*day*, 25 Sitobion avenae/*day).

Scatophagidae	*Scatophaga stercoraria* L. (larva)	Chambon, 1984
Aeolothripidae	*Aeolothrips intermedius* Bagnall	Chambon, 1984
Formicidae		Cândea, 1986, Sunderland, 1985

Knowing the pests and their integrated control is an important direction in the phytosanitary practice of wheat crop, in Transylvania (Baicu, 1989, 1996, Bărbulescu, 1984, Bărbulescu et al., 1973, 2002, Bucurean, 1996; Mustea, 1973; Munteanu, 1973; Munteanu et al., 1973, 1983; Malschi et al., 1980, 2005, 2006, 2010, 2013, 2015; Malschi and Mustea, 1992, 1995, 1997, 1998; Malschi, Mustea and Perju, 2003; Malschi, 1980, 1982, 1993, 1995, 1998, 2000, 2001, 2003, 2004, 2005; Mărgărit et al., 1984; Popov et al., 1983, 1984, 2007a; Perju, 1968, 1983, 1999; Perju et al., 1989; Perju and Peterfy, 1968; Rogojanu and Perju, 1979; Roman et al., 1982; Roşca et al., 2011).

The integrated management systems of wheat pest have been extensively studied in Romania (Baicu and Săvescu, 1978 a, b, Baicu, 1989, 1996; Bărbulescu, 1984; Bărbulescu, Popov and Mateiaş, 2002; Hulea et al, 1975; Malschi, 2007, 2008, 2009, 2014; Malschi et al., 2012, 2016; Mărgărit et all., 1984; Paulian et al., 1974; Perju, 1983; Popov, 1979, 1983, 2003; Popov and Bărbulescu, 2001, 2007; Popov et al., 2001, 2003, 2006; Roşca et al., 2011).

In recent decades numerous publications have presented the importance of wheat pests and their control. Comprehensive studies of great importance to practice were performed on cereal sun bugs (Popov 1983, 1984, 1999, 2003), on wheat thrips (Baniţă, 1976; Malschi, 2001); on cereal leaf beetles (Bucurean, 1996; Malschi, 2000; Popov et al., 2005); on wheat stem borer (Baniţă and Popov, 1976; Baniţă et al., 1992); on saddle gall midges (Baniţă, Popov, Paulian, 1971, Petcu and Popov, 1978, Popov et al., 1989), on aphids (Bărbulescu, 1965, 1972, 1975, 1982, Malschi et al., 2003, 2006, Malschi, 2008, 2009); on leafhoppers (Munteanu, 1973); on wheat flies (Bărbulescu et al., 1973, 1984, Malschi, 1980, 1982, 1993, 1998, 2001, 2007) or on the pests from soil and on the seed treatments for *Zabrus* corn ground beetles, wireworms, aphids etc. (Popov et al., 1997, 2001, 2007b, 2010).

More research on biodiversity of entomophagous useful fauna were conducted (Baniţă et al., 1999; Fabritius et al., 1985, Malschi and Mustea, 1995, Malschi, 2007, 2008, 2009, Popov, 1975, 1980, 1984, 1985, 1999, Popov et al., 2009; Roşca et al., 2008 ş.a.). Important studies have been published on the role of biodiversity in the stability of ecosystems influenced by different technologies (Ghidra et al., 2004, Hera et al., 2004), including conservative systems with minimal or no tillage soil cultivation (Carlier et al. , 2006, Ghizdavu et al., 2008, Haş, 2006, Haş et al., 2008), for anti-erosion systems with agroforestry protection curtains (Lupe, Spircez, 1955, Popescu, 1993, Malschi, (2010, 2017, 2018), for organic farming technology systems (Toncea, 1999, 2002) or ecological reconstruction after anthropogenic impact (Cristea et al., 1990, 2004, Cristea, 1993, 2006). The development and sustainability of the concept of integrated pest control were approached by numerous papers based on based on detailed studies of applied ecology (Baicu, 1989, 1996, Berca, 2006, Botnariuc, 1976, Botnariuc, Vădineanu, 1982, Munteanu et al., 2005, Puia et al., 2001, Roman et al., 1982, Sin et al., 2005, Stugren, 1994, Stan et al., 2006, Vădineanu, 1998 etc.).

The integrated wheat pest management in Transylvania includes as an important link the measures for conservation, use and reconstruction of biodiversity, of flora diversity, of arthropods fauna diversity, especially entomophagous, through biological methods in agricultural ecosystems (Malschi et al., 1980, 2005, 2010, 2012, 2013 a, b, c, 2014, 2015 a, b, c, 2016, 2017 a, b, 2018; Malschi, 2003, 2004, 2005, 2007, 2008, 2009, 2014). These biotechnologies are relating to different aspects of sustainable use of bioresources:

- Protection and increase of the use of entomophagous natural activity; - Enrichment of the edges of cultivated field with plants species with attractiveness for entomophagous; - Preservation of the diversity of marginal flora and meadows and pastures flora, consisting of various flowering plants important for the development of entomophagous; - Planting of trees and shrubs strips and of the grassed protective embankments, which are favorable to the development of ecotone areas for the entomophages migration in the cultures; - Planting of agroforestry belts consisting of trees and shrubs species (Lupe, Spîrchez, 1955, Malschi, Mustea, 1995, Malschi, 2003, 2005, Popescu 1993). The existence of diversified flora from the system with agroforestry curtain represents the main factor ensuring the richness of species, the survival, growth and species abundance and the season migration from one field to another of the arthropod useful entomophagous (Malschi, 2007, 2008, 2009, 2014).

2. Integrated wheat pest management and environmental public goods associate with agriculture practice on the environment-agriculture-sustainable development interrelations

Integrated pest management (IPM) is an agro-ecological **system** approach to crop protection that uses different practices to control the pest and minimize the pesticide applications (Baicu 1996; Bărbulescu and Popov 2001; Malschi 2009; Popov et al 2009; Popov and Bărbulescu 2007; Wetzel 1995). Practicing IPM involves the following **steps**: weather forecasting to evaluate the risk of pest outbreaks; monitoring dynamics and attack level of pest populations; determining the thresholds of economical damage; culture controls methods – soil preparation; biological controls; chemical controls - using insecticides, only recommended if the biological methods fail and the threshold limit has been surpassed etc. (FAO, www.fao.org/agriculture/crops/core-themes/theme/pests/ipm/; Bărbulescu et al 2001, 2002; Malschi 2007, 2008, 2014; Popov 1979; Popov et al 2003, 2006).

Common Agricultural Policy specify the importance of providing environmental public goods associated with agriculture and environment - such as agricultural landscapes, farmland biodiversity, soil, water and air quality, climate stability farming practices in order to maintain landscape features and specific habitats. Also, special public goods are associated with agriculture practices of integrated pest management such as: the positive impact of integrated pests control, biological pest control, conservation and use of biodiversity of beneficial entomophags and useful flora, biological agriculture, related to pollution limitation and sustainable development of environmental factors quality; the positive impact of using soil conservative systems with minimum tillage and no tillage, particularly in water stressed areas, related to climate stability etc. (Cooper et al 2009; Carlier et al 2006; Perju, Birică, 2006, Petrescu Ruxandra Mălina, 2007, Guş and Rusu 2008; Malschi 2009).

The study performed from 1980 showed the evolution of main cereal pest such as: Diptera, Homoptera, Thysanoptera, Coleoptera etc. at the Agricultural Research and Development Station Turda, in the center of Transylvania (Malschi 2007, 2008, 2009, 2014). During 2006-2015 period, especially under the conditions of profound agro-ecological changes caused by climate warming and also under the new technological conditions in regional agricultural exploitations, the integrated control strategy of wheat pest was elaborated (Malschi et al 2012, 2013 a, b, c, 2016, 2017, 2018) (Figure 1).

During 1980-1999, the pest structure reflects the eudominance of aphids and leafhoppers, the dominance of Diptera, Chrysomelidae, wheat thrips, the presence of cereal bugs. The warmest years of 2000-2002 have favored the explosive development of

Chrysomelidae (*Oulema, Chaetocnema, Phyllotreta*). The years 2003-2005, being also extremely hot and dry have led to the installation of eudominance of thrips, leafhoppers, wheat flies and of fleas *Chaetocnema*, and to the largest abundance of sunbugs (6.4%).
During 1980-2005, separate schemes and moments to control key pest groups were tested, depending on the biological cycles of the species of Diptera, leafhoppers, *Oulema*, thrips, aphids and on the importance of entomophagous. In this case special **treatment at warning** at different times of insecticides application has been recommended based on preventive measures (especially practicing optimal sowing time after the first decade of October, application of seed treatments with insecticides and fungicides, other phytosanitary and agro-technical measures).

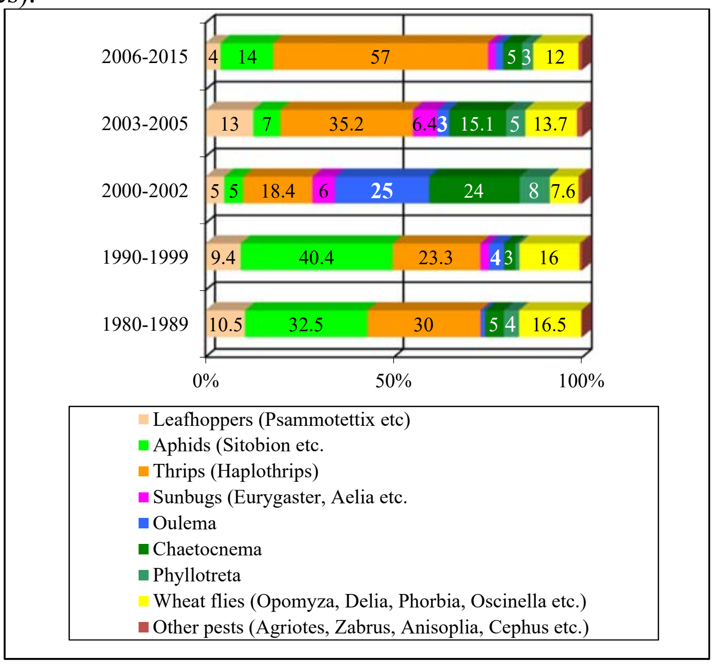


Figura 1. Structure of wheat pests (ARDS Turda 1980-2015) (Malschi et al., 2016, 2017 a, b, 2018)

In the years 1980-2005, the following times of treatment applications at warning were recommended: - for Diptera, in early spring (for *Opomyza florum, Delia coarctata, Phorbia peniciliphera*) and at the end of tillering in May, (for *Phorbia securis, Oscinella* and other chloropidae), as well as for leafhoppers, using a systemic and contact insecticide; - for *Oulema* (pest with a long cycle to June), two treatments were recommended (for adults and larvae), especially pyrethroids to protect the natural entomophagus which are very active in killing eggs and larvae; - For wheat thrips (a pest with long cycle until July to August), two treatments were recommended (for adults and larvae), aiming to protect natural entomophagus which are very efficient in destroying adults, eggs and larvae of thrips (Malschi et al., 1980, 2003, 2005, 2006, 2010, 2013, 2015, 2016, Malschi and Mustea, 1992, 1995, 1997, 1998, Malschi, 1980, 1982, 1993, 1995, 1998, 2000, 2001, 2003, 2004, 2005, 2007, 2008, 2009, 2014).

During 2006-2015, the new study presents the agro-ecological research on the population dynamics of wheat pests and the **adequate integrated pest control methods** under different cultural soil technologies: classical (by ploughing) and conservative (by soil no tillage), in open field agricultural system and in agroforestry belts farming system, in relation to increased pest abundance and attack, **on the current agro-ecological changes** in Transylvania, at the Agricultural Research-Development Station Turda.

The research objectives have comprised aspects of interest such as: systematic and bio-ecological study of pest species; danger of attack expansion; elaboration of agro-ecologically integrated pest control strategy in accordance with technological factors: - selective and efficient insecticides; agro-technical methods; biotic factors: - natural entomophags; environment protection factors and environmental public goods provided and associated with agriculture. The structure and dynamics of the pest species populations interacting with predatory arthropod fauna have been studied in wheat crops. During 2006-2015, the study has revealed data on **species composition changes** and dynamics in wheat crops. Species determination has been achieved by the abundant samples, performed every 10 days, since April to July. The samples of arthropod fauna have been obtained by the method of captures in 100 double sweepnet catches, at the plant level.

The changes in the level of regional climate, represented by warming and excessive draught, especially in spring have caused **the burst of pest populations** which may cause important damages to wheat crops. In the last years of climate heating were recorded **changes in the pest structure** (Malschi 2007, 2008, 2009, 2014). Were pointed out major outbreaks of attack of thrips (*Haplothrips tritici*), **as eudominant species;** aphids (*Sitobion avenae, Schizaphis graminum, Rhopalosiphum padi, Metopolophium dirhodum*); leafhoppers (*Javesella pellucida, Psammotettix alienus, Macrosteles laevis*); cereal flies (Chloropidae: *Oscinella frit, Meromyza nigriventris, Elachiptera cornuta* etc. and Anthomyidae: *Delia coarctata, Phorbia securis, P. penicillifera*); stem flea beetles (*Chaetocnema aridula*), **as dominant species**; bugs (*Eurygaster maura, Aelia acuminata*) etc. (Malschi et al. 2010, 2012, 2013 b, 2014, 2015 b, 2016, 2017 b). During 2006-2015, are highlighted: eudominant wheat thrips, dominant wheat flies, wheat fleas, aphids and leafhoppers. The average of pests structure shows: 57% for thrips, 14% for aphids and 4% for leafhoppers, 12% for Diptera, only 3% for cereal leaf beetles and 8% for cereal fleas, 2% for cereal bugs and to 1% for wireworms and other pests. Compared to the structure of wheat pests in a prior period there was an increase of the **percentage share of thrips and wheat fleas** which frequently records population explosions. Besides these, cereal **bugs in some years** reached dangerous densities in culture. Is remarkable the decrease in the percentage share of wheat flies, leafhoppers, aphids, leaf beetles that were dominant in the structure in the period 1980-2000. Is still important the attack potential of Diptera, leafhoppers and aphids (Figure 1). In open field area, these changes on the structure and populations abundance of referred pest species is a dangerous risk situation of wheat crops. A diminish in the species range and an increase of the population abundance have been recorded in the main pests, especially in the monovoltin species (*Haplothrips tritici, Delia coarctata, Phorbia penicillifera, Chaetocnema aridula, Eurygaster maura, Aelia acuminata, Zabrus tenebrioides* etc.). An increase of the population abundance has been recorded for some polivoltine species of Diptera, Chloropidae (*Oscinella frit, Elachiptera cornuta, Meromyza nigriventris* etc.) and Anthomyiidae (*Phorbia securis, Delia platura)*, for leafhoppers and aphids. Due to aridization and climate warming, **the critical attack moments** has been recorded 3-4 weeks earlier and overlapped. So, the integrated pest management should include specific measures for these dangerous pests of wheat in central Transylvania.

In open field agricultural system, comparative research on the abundance and structure of **wheat pests in classical plowing technology and conservative soil technology** proved a greater abundance and importance of the populations of thrips, flies, aphids, leafhoppers, wireworms reached at conservative no tillage technology. *Haplothrips tritici* is the most abundant and important pest of wheat in classical (by plowing) and conservative (by minimum soil tillage and no tillage) technologies. So thrips as well as aphids and leafhoppers are the dangerous vectors for viruses and other pathogens, favoring their attack.

By practicing successive no tillage conservative soil technologies, recommended for the current conditions of climate aridity in Transylvania, were increased the main pest populations and were accumulated higher biological reserve of thrips, Chloropidae flies, leafhoppers, aphids and soil pests (wire worms *Agriotes* sp. etc.). In 2009-2015, *Haplothrips tritici* reached at **68%**; flies: **5%**; aphids: **12%**; leafhoppers **4%**, wheat fleas **5%**, cereal bugs **1%** in the pest structure, showing an important attack potential. The pests have achieved 81,86% and entomophagous **18,14%** in the structure of entomofauna of no tillage crops in open field area (Figure 2).

In wheat fields with **classical plowing system** *Haplothrips tritici* reached at 66%, cereal flies achieved **7** %, aphids **14%**, leafhoppers **4%**, wheat fleas **6%,** the sun bugs reached at **2%**, more then in no tillage system and the entomophagous achieved at **18,26%** in the structure of entomofauna (Figure 2). In 2009-2015, the abundance of pests in the the open system was 1.4 times higher than in the farm with protective forestry belts. The report on phytophagous/entomophagous was 6/1 in the open field system and only 4/1 in the farm with forest belts for protection. That can explain the appearance of massive development of wheat thrips, fleas, leafhoppers, aphids etc., and the critical attack situations **in the open field** system, in 2012, 2013, 2014 (Figures 3). The mentioned species abundance is a risk situation on wheat crops, which requires special measures for pest control, especially in open field area. As a result, preventive control measures and insecticide treatments of seed and of crop vegetation, on the critical moments of risk overlapping are very important.

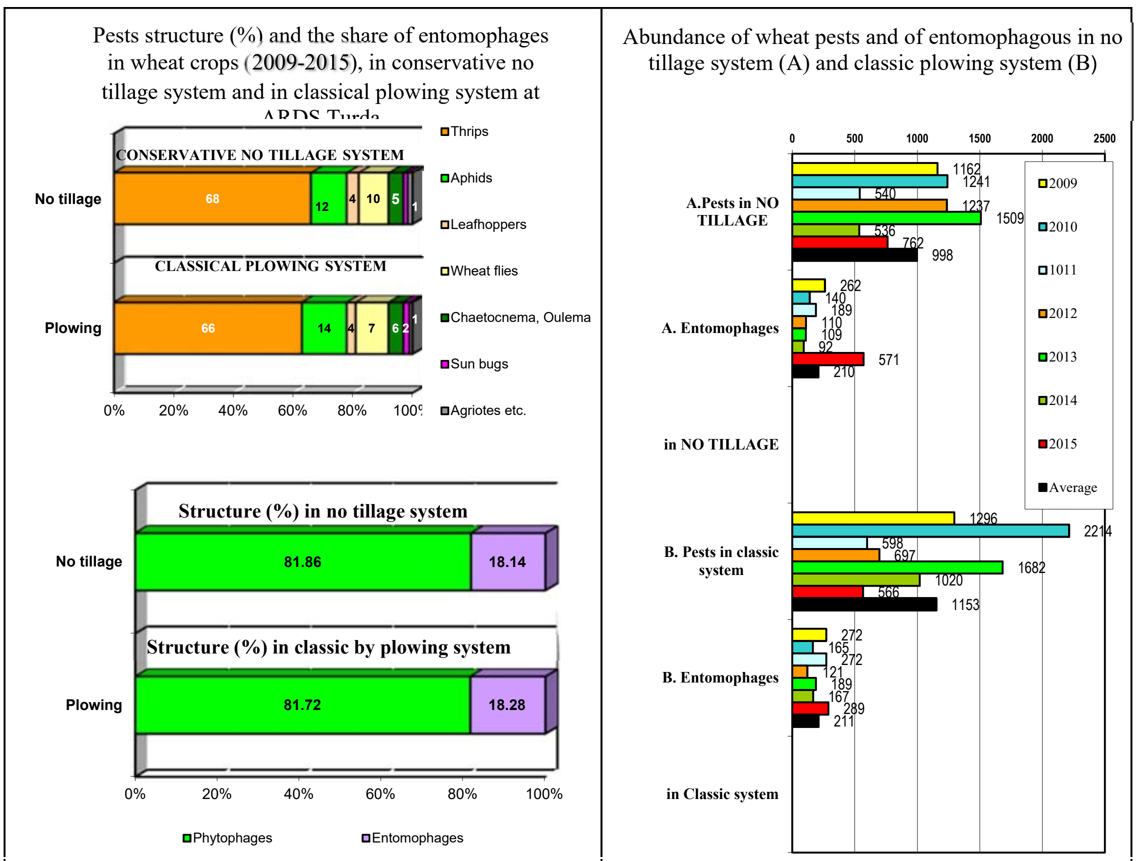


Figure 2. Entomocoenotical relation, dynamics of structure and abondance of wheat pests in no tillage and classical plowing systems, 2009-2015, ARDS Turda. Source: Malschi et al., 2015 a, b, c, 2016, 2017 a, b, 2018)

The applied integrated pest management on favourable agroecological conditions in the **farm with protective forestry belts,** in Cean-Bolduţ (Figure 3), shows the efficiency of biological control using the entomophagous natural resources, without insecticides (Malschi 2009; Malschi et al 2010, 2013 b, 2014, 2015 b, 2016, 2017 b). The wellknown systematic groups of entomophagous predators: Aranea; Thysanoptera (Aeolothripidae); Heteroptera (Nabidae etc.); Coleoptera (Carabidae, Staphylinidae, Coccinellidae, Cantharidae, Malachiidae etc.); Diptera (Syrphidae, Empididae etc.); Hymenoptera (Formicidae etc.); Neuroptera (Chrysopidae) etc. were represented in the structure of arthropod fauna in wheat crops of Transylvania (Malschi 2007, 2008, 2009).

An entomocenotic balance was maintained in agroforestry belts farming system of Cean Bolduţ, also similar to the values in the last three decades (1980-2010) (Figure 1 and 3). The wheat pests had a structural share of **76%** and the entomophagous achieved **24%**, on the favourable conditions due to the forestry belts. Thrips showed 27% only and flies 28%, *Oulema* 3% and wheat fleas 8%, aphids 23%, leafhoppers 5%, sun bugs 5%, other pests 1% in the pest structure (Figures 3).

In **open field farming system** of Turda, the wheat pests had a structural share of **86%** and the entomophagous achieved **14%**. Thrips showed 52% and flies 15%, wheat fleas 12%, aphids 13%, leafhoppers 4%, sun bugs 2%, other pests 1% in the pest structure (Figures 3).

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. The agroforestry belts made of trees and shrubs and also the marginal shelters of herbs are extremely rich in entomophagous 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.

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 (Malschi et al 2010). Therefore, 62 years after their initiation, antierosional protective forestry belts-based farm of Cean-Boldut may constitute a model of ecological agriculture, of conservation and sustainable use of biodiversity, and a strategy of sustainable agricultural development in Transylvania (Figure 4 and 5).

Also **in farming system with soil minimal tillage and no tillage**, practiced to minimize the effects of droughts and global warming, is noted the increased of pests abundances, frequently surprising of the groups of thrips, wheat flies, leafhoppers, aphids etc.), requiring adequate integrated control measures for these entomocenotic risk situations, during 2009-2015 (Figure 4). In the open field area, with conservative soil system with minimal tillage or no tillage is evident in addition, the higher abundances of Diptera Chloropidae and Anthomyiidae, of leafhoppers and aphids (Malschi, 2009, 2014, Malschi et al., 2010, 2013 c, 2015 b). Interesting to note that **in the agro-forestry system** has been maintained an entomocenotic balance, the same structure of damaging entomofauna as well as in the years 1980 to 1989 and the greater abundance of auxiliary entomophages than in the open field crops system **(**Malschi and Mustea, 1995, Malschi, 2003, 2005, 2007, 2008, 2009, 2014, Malschi et al., 2010, 2013, 2015) (Figure 5). The eco-technological model of Cean-Boldut farm regards 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 (Lupe and Spirchez 1955); 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.) (Table 4).

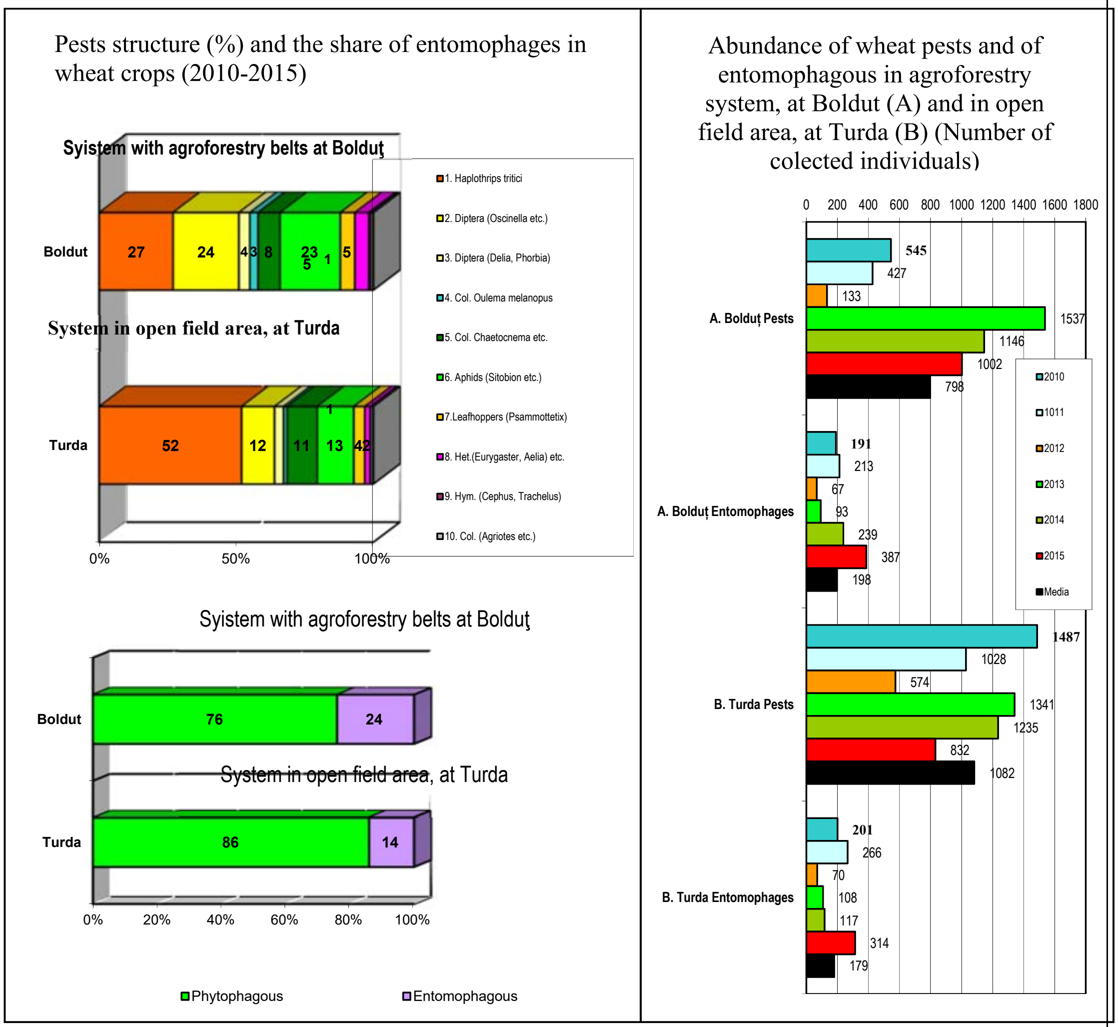
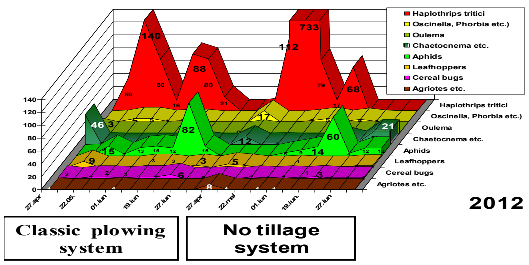
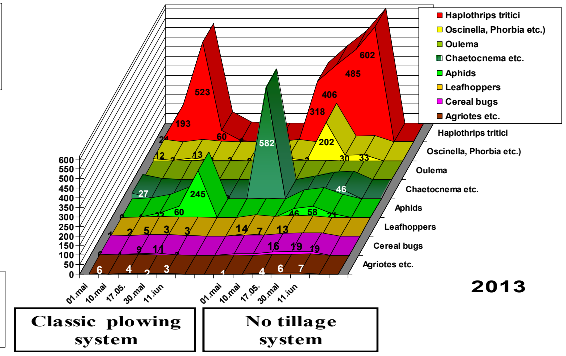


Figure 3. Entomocoenotical relation, structure (%) and abondance of wheat pests in open field area and in agroforestry system, 2010-2015, ARDS Turda. Source: Malschi et al., 2015 a, b, c, 2016, 2017 a, b, 2018)





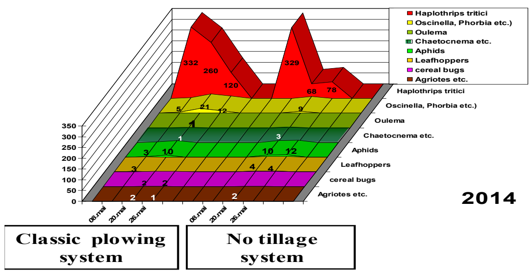
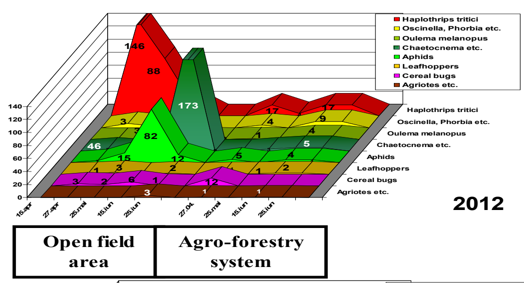
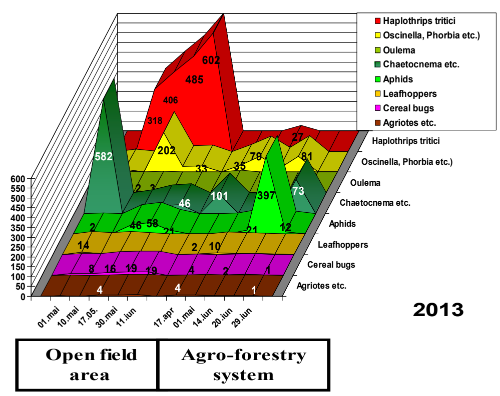


Figure 4. Occurence and dynamics of wheat pests, ARDS Turda, 2012- 2014, in classic plowing and in conservative no tillage systems (nr./100 double sweepnet catches) (Malschi et al., 2015 b)





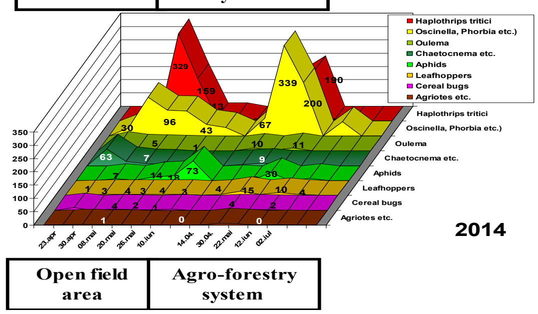


Figure 5. Occurrence and dynamics of wheat pests of cultures in open field area in Turda and in the agro-forestry farm in Bolduţ, in 2012, ARDS Turda (Nr. / 100 sweepnet catches) (Malschi et al., 2015 b)

Table 4. The different types of belts compositions in Cean-Boldut farm with antierosional agroforestry belts (Lupe and Spirchez 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: *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 (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 shrsbs; 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*; *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: *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 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: *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*; 8, 10, 12, 14: *Quercus robur*, *Padus mahaleb*.
The belt number 18 (antierosinal 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*.

In order to provide a sustainable development of winter wheat crop, **the adequate prevention and control measures** have been required, specifying the correct times for the application of insecticide treatments. The efficiency of integrated pest control methods has been carried out under different lots of crop technologies: in open field area (in classical plowing and in conservative no tillage system) and in the agro-forestry belts farming system (Table 5, 6, 7). Within the testing experiments of efficient insecticides, optimal application time, an integrated pest management has been studied including herbicides, fungicides, fertilizers applications. Insecticide application should be carried out when the economic damage threshold values of pest have been exceeded. Also, insecticide application is recommended taking into account the activity of the natural reserve of predatory and parasite entomophags. Especially, the natural predators play an important role in decreasing the pest abundance (Malschi, 2009, 2014, Malschi et al., 2010, 2013 c, 2015 b).

The **integrated pest management** researche on the cereal agroecosystems with **conservative no tillage soil technology**, have recommended the insecticides chemical control, using insectofungicide seed treatment and 2-3 succesive insecticides field treatments (Malschi et al 2012). The application of special insecticide treatments is required especially under unfavorable agroecological conditions of excessive heat and draught during the critical attack periods, in no tillage and minimum soil tillage technologies (Carlier et al 2006; Guş and Rusu 2008; Haş et al 2008; Malschi et al 2013c, 2015 b). In the last years, two critical attack moments and risk situations have been reported to require treatment application (Malschi 2009; Malschi et al 2013b, 2015 b): **the first, in April, at the end of tillering in the 25-33 DC stage** (at latest of herbicidal treatment), or earlier in some years, for Diptera and wheat fleas (*Chaetocnema)*, bug and *Oulema* adults also to reduce thrips and leafhoppers attack potential, has been carried out by using systemic insecticides: neonicotinoids – tiacloprid, thiametoxam, organophosphorous or the pyrethroids etc. At this moment, entomophagous has been at the beginning of its field occurrence and less exposed to insecticides; **and the second insecticidal treatment**, **in May 10-20**, **at the flag-leaf appearance** and **ear emergence, in the 45- 59 DC stage**, has been applied to control wheat thrips adults (*Haplothrips tritici*), aphids, bugs and others. The pyrethroids, neonicotinoids etc. achieved immediate control of the pest complex with a long time effect and efficiencies against the development of thrips larvae on the ears and yield increases.

The study mentions the importance of adjusting the IPM technology on the pests structural changes, which is highlighted in relation to climatic warming and aridization by increasing abundance of wheat thrips (**as eudominant species**), of wheat flies Chloropidae, leafhoppers, aphids, wheat fleas (**as dominant groups**), cereals bugs etc., in open field agro ecosystems and in agro-forestry belts system, in experimental lots, in the vegetation year 2006-2015, in Transylvania. IPM recommends special attention to preventing measures for zone specific pests: cereal flies, leafhoppers, aphids, etc., which still shows a high biological potential, by respecting the optimal sowing time, agrotechnical methods, cultural hygiene, seed treatment with systemic insecticide and the complex plant protection measures. Due to aridization and climate warming, the critical attack moments have been recorded 3-4 weeks earlier and overlapped.

Table 5. Effect of insecticide treatments in wheat crops (Ariesan variety), ARSD Turda, 2013

	Grain yield (Kg / ha)			Thousand Grain Mass (TGM) (g)			Thrips larvae/ear
Insecticide treatments	Kg/ha	%	Differ.	TGM	%	Differ.	
1. Lot ST + Untreated on vegetation	7763	100.0	check	54,57	100,0	check	1,5
2. Lot ST + T1	7710	99.3	- 53	53,43	97,9	-1,133	0,0
3. Lot ST + T1+T2	7922	102.0	159	52,50	96,2	-2,067 ^{OO}	0,5
4. Plowing lot without treatments)	4376	56.4	-3387^{OOO}	52,83	96,8	-1,733^{O}	21,1
5. No tillage lot without treatments)	4590	59.1	-3173^{OOO}	49,73	91,1	-4,833^{OOO}	28,8
6. Lot in agro-forestry system (ST + T1+T2)	5200	67.0	-2563^{OOO}				4,1
7. Lot in agro-forestry system without treatments	5105	65.7	-2658^{OOO}				7,7
LDS p 5%		7.68	596.76		2,322	1,267	
LDS p 1%		10.79	837.66		3,378	1,843	
LDS p 0.5%		15.23	1182.58		5,067	2,765	
F Test	F=69.97*			F=21,336*			
ST = seed treatment with Yunta 246 FS, 2 l/t TS. T1 = field treatment at the end of tillering / 23.04.2013/ with Calypso 480 SC 100ml/ha; T2 = field treatment at the ear emergence / 17.05. 2013/ with Faster 10 CE 100ml/ha							

Table 6. Effect of insecticide treatments in wheat crops (Ariesan variety), ARSD Turda, 2014

	Grain yield (Kg / ha)			Thousand Grain Mass (TGM (g)		
Insecticide treatments	Kg/ha	%	Differ.	TGM	%	Differ.
1. Lot ST + Untreated on vegetation	7576	100,0	check	51.703	100.00	check
2. Lot ST + T1 (Fastac)	8539	112.7	963***	51.927	100.43	0.224
3.a. Lot ST + T1+T2 (Fastac)	8571	113.1	995***	54.135	104.70	2.432 ***
3.b. Lot ST + T1+T2 (Calypso)	8559	112.9	983***	51.105	98.84	-0.598
4. Plowing lot without treatments)	6353	83.9	-1223 ^{OOO}	50.308	97.30	-1.395 ^{O}
5. No tillage lot without treatments)	6551	86.5	-1025 ^{OOO}	48.061	92.95	-3.642 ^{OOO}
6. Lot in agro-forestry system (ST + T1+T2)	7954	105,0	378	51.339	99.30	-0.364
7. Lot in agro-forestry system without treatments	6790	89.6	- 786 ^{OOO}	50.809	98.27	-0.894
LDS p 5%			401			1,186
LDS p 1%			556			1,644
LDS p 0.5%			772			2,285
F Test			F=12.6***			F=7.787**
ST = seed treatment with Yunta 246 FS, 2 l/t TS. T1 = field treatment at the end of tillering / 22.04.2014/ with Fastac 10 CE 100ml/ha .T2 = field treatment at the ear emergence / 21.05. 2014/ with Fastac 10 CE 100ml/ha (a) or Calypso 480 SC 100ml/ha (b)						

Table 7. Structural interactions and comparative abundance between wheat pests and useful entomophagous arthropods in the cereal agroecosystems in open-field at Turda and with forestry curtains at Bolduţ in the conditions of 2014. (Malschi et al., 2014)

At Bolduţ, all variants include TS seed treatment (Yunta 246 FS, 2 l / t). V1 = untreated with insecticides on vegetation; V 2 = two insecticidal treatments: T1-to herbicide / 22.04 / /Calypso 480 SC 100ml / ha + T2-bellows phenophase /17.05 / Faster 10 EC 100ml / ha.				
BOLDUŢ	V1	V1	V2	V2
2014	Abundance (nr.)	%	Abundance (nr.)	%
FITOPHAGOUS	1146	82,7 %	796	91,3%
ENTOMOPHAGOUS	239	17,3 %	76	8,70%
Arthropods total	1385		872	
At Turda, the variants include TS seed treatment with Yunta 246 FS, 2 l / t; V1 = untreated with insecticides on vegetation; V 2 = two insecticidal treatments: T1-to herbicide / 22.04 / Faster 10 EC 100ml / ha + T2-to Bumpy Phenophase /21.05/Calypso 480 SC 100ml / ha				
TURDA	V1	V1	V2	V2
2014	Abundance (nr.)	%	Abundance (nr.)	%
FITOPHAGOUS	1235	91,3 %	840	89,6%
ENTOMOPHAGOUS	117	8,7 %	97	10,4%
Arthropods total	1352		937	

The research results proved the importance of insecticide applications at two different moments: at the end of tillering phase (13-33 DC stage) and at the flag-leaf appearance and ear emergence in 45-59 DC stage, in open field area**. In open field area**, IPM recommends the insecticides application on seed treatment and in two successive treatments in vegetation. The IPM is a major section of successive soil no tillage technologies, comprising a special pest control strategy, with insecticides application on seed treatment and in 2-3 successive treatments in vegetation.

Special environmental public goods are associated with integrated pest management technologies such as: positive impact of using biological control, related to pollution limitation, insecticidal treatments limitation, sustainable development of environmental factors quality (using beneficial entomophags, flora, etc.); positive impact of agro-forestry belts system, related to climate stability, erosion limitation; management of natural resources of water and soils, conservation and use of flora and entomophags biodiversity involved on a natural biological pest control without insecticide; positive impact of soil conservative no tillage systems, particularly in water stressed areas, related to climate stability, to limitation of gas emissions, to carbon management), to conserve soil quality, to the management of water and soils resources etc. Under risky conditions caused by the attack of pests in relation with climate and regional agroecological changes, the IPM objectives are the achievement of yield safety, the attaining economic and ecological efficiency; the protection of environment and food quality; the preservation and use of biodiversity; the achievement of environmental public goods associated with agriculture and integrated pests control technology.

3. The efficiency of natural entomophagous predators involved in wheat pests limitation in the centre of Transylvania

Entomophagous populations are very active and efficient on the pest natural limitation in Transylvania. They are particularly abundant in open field area, in classic and in soil no tillage technologies. In the farming system with protective agro-forestry belts – favourable for increasing of entomophags fauna, the research pointed out the efficiency of biological control, only using the entomophags natural resources, without insecticides application (Table 8 and 9).

One of the most important pest development limiting factors has been the activity of natural entomophagous predators (Malschi, 2007, 2008, 2009). The ear pests, especially thrips (adults, eggs and larvae) have been destroyed by these predators. In May-June, predators occurrence on wheat ears have diminished thrips population under the economic damaging threshold (EDT). Every year, at the beginning of ear emergence, EDT of 5 adults/m^2 (or 5 adults/10 sweepnet catches) has been exceeded, while in the next vegetation stages, at grain ripening the EDT of 8 adults/ear or 10-40 larvae/ear has no longer being achieved due to predators activity. At flowering and milky-ripe stage, in the end of May at the mid June, maximum activity of the following predators (*Chrysopidae, Nabidae, Aranea, Aeolothripidae, Carabidae, Staphylinidae, Coccinellidae, Malachiidae, Cantharidae, Syrphidae, Empidiidae*) in the natural limitation of wheat thrips has been reached.

Table 8. Composition of prey and feed ratio of the main predators of cereal pests in laboratory tests (Malschi, 2007, 2009, Malschi et al., 2017)

	Number of phytophagous consumed / day / individual predator										
Phytophagous: / **Entomophagus predators :**	***Oulema melanopus eggs***	***O. melanopus larvae***	***Haplothrips tritici adults***	***H. tritici larvae***	***Sitobion avenae***	***Rhopalosiphum padi***	***Eurygaster maura eggs***	***Opomyza florum larvae***	***O. florum pupa***	***Phorbia securis larvae***	***Ph. securis pupa***
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	-	-	-	-	-	-

The importance of entomophagous for limiting the abundance of wheat pests is widely studied in the literature from the country (Baniţă, Emilia et al., 1999, Cîndea 1984, 1986, Ciochia et al., 1992, Fabritius et al., 1985, Malschi 2007, 2009, Malschi et al., 2010, 2017, 2018, Perju et al., 1988, 1989, Roşca et al., 2008, Voicu, Mureșan,1989, Voicu, 1990. Voicu et al., 1993) and from abroad (Afonina et al., 2002, Basedow, 1990, Chambon, 1984, Chambon et al., 1985, Derron, Goy, 1996, Hassan, 1985, Holz, WETZEL, 1989, Iperti et al., 1989, Mansour, Heimbac, 1993, Margaritopoulos et al., 2004, Rupert, Molthan, 1991, Stark, 1987, Sabine Stork-Weyhermuller, Welling, 1991, Stern, 1967, Sunderland et al., 1985, 1987, Sustek, 1994, Tomavic et al., 2004, Welling, 1990 a, b, Wetzel, 1992, 1995 a, b etc.).

The study of the evolution and dynamics of wheat thrips has been achieved by entomofauna analyses captured every ten days in 300 double sweep net catches/sample in wheat crops, in 2 comparative studies: in open field and agroforestry belts, while the attack has been established by periodical analysis of 30 ears of the studied variants. The studies on the pest destructive capacity against wheat thrips in the laboratory feeding tests, have shown that 10-15 thrips adults/day/individual of *Chrysopa, Episyrphus, Malachius,Cantharis* have been destroyed, and also 10-42 trips larvae/day/individual of *Chrysopa* and *Episyrphus*, of *Nabis* and *Coccinella*, *Propylaea, Malachius, Pseudophonus pubescens* (Tables 8, 9) (Malschi, 2007, 2008, 2009).

Table 9. The efficiency of the natural entomophagous predators involved in wheat pests limitation expressed by the attack level of the main cereal in the centre of Transylvania (Malschi 2007, 2008, 2009)

The average attack of main cereal pests (2000-2002), in cereal agroecosystems in open area in Turda and with forestry belts in Bolduţ							
Oulema melanopus (larvae/m^2)		*Haplothrips tritici* (larvae/ear)		*Aphids/ear*		*Diptera larvae* (%attacked tillers)	
Turda	Bolduţ	Turda	Bolduţ	Turda	Bolduţ	Turda	Bolduţ
350	9	22	3,8	32	3,2	25	5,5

Attack dynamics of wheat pests in 2007 at agricultural system in open field area (Turda) and at protective agroforestry belts system (Cean-Bolduţ).							
Aphids attack		Thrips larvae attack 5-10.06.2007		Attack of bugs adult and larvae in milky-ripening phase. 5-10.06.2007		Attack of diptera larvae	
Turda	Bolduţ	Turda	Bolduţ	Turda	Bolduţ	Turda	Bolduţ
11 aphids/leaf 25 aphids/ear	5 aphids/leaf 0.5 aphids/ear	21.5 larvae/ear	4.5 larvae/ear	1-3 adults/m^2 3 attacked ears/m^2	0.5 adults/m^2 <0.5 attacked ears/m^2	15.3% dead heart tillers	13,2% dead heart tillers

During the years 1994-1999, winter wheat crops have recorded an increases in thrips populations (*Haplothrips tritici Kurdj*.), their larvae sometimes exceeding the damaging economic threshold densities of 10-40 larvae/ear, in grain formation and milky-wax ripening phenophase. The years 1997-1999 characterized by heavy precipitations and excessive heat in May, June and July favored thrips development on ears, which revealed the regional importance of the study. The study of thrips dynamics in open field wheat crops and forestry belt-protected wheat crops has shown the presence of some strong structural interactions with the predatory entomophags. Especialy in the forestry belted crops they have diminished the abundance of thrips populations (mostly larvae) to values below EDT during the critical attack period. Thrips limitation was with 37% higher in agroforestry belted wheat crops than the open field wheat crops. During 2000-2007, the results have shown significant results of thrips populations level in open field averaging 22 larvae/ear and 3.8-4,5 larvae/ear, in agroforestry belt system (Table 9); the Determination index of 23%-32% and significant correlations with R=0.48 in open field and R=0.59, forestry belts system, respectively, has shown a stronger impact of the entomophagous fauna on thrips populations in the forestry belts-based agroecosystem (Figure 6) (Malschi 2007, 2008, 2009).

During 1994-1999, ecological researches on the effect of the natural predators involved in thrips destruction in wheat ears, have shown significant yield differences (grains yield/ear) of 18,2% average, in the case of the ears visited by predators (Table 10).

In the year 1998, under the conditions of experimental field, observations on wheat thrips and its predators have been carried out in an winter wheat poly-factorial experiment, the ecological factors being as follows:

- wheat phenological stage differentiated by two distinct sowing periods (1 - in technological optimal sowing time /10.11.1998, and 2 - at late sowing time/10.21.1998, factors that caused significant differences among variants through their different phenological phases of grain formation and ripening); **-four varieties:** Transilvania, Arieşan, Apullum, Turda 95; **- two differentiated ecological variants**: 1-by placing **a glue ring at the ear base** which stopped predatory larvae occurrence on thrips-populated ears, and 2-the variant commonly visited by predators, without the glue ring, respectively, both having 30 ears. It has been noticed that in June-July thrips larvae populations developed in accordance with the climate conditions and wheat vegetation stage, being more abundant on the ears of phenologically late wheat lots due to late sowing (Tables 11, 12) (Malschi, 2007, 2009).

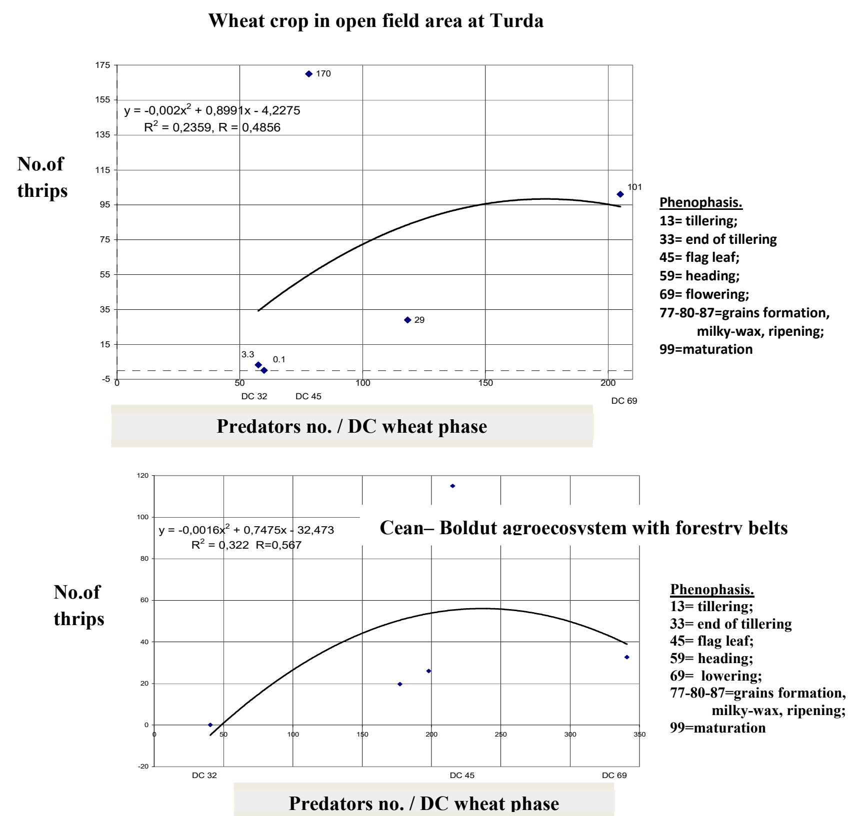


Figure 6. Dynamics of wheat thrips (*Haplothrips tritici*) depending on entomophagous predators abundance and on wheat phenophasis in open field area agroecosystem in Turda and in Cean-Boldut agroecosystem with agroforestry belts (ARDS Turda) (Malschi, 2007, 2009).

Table 10. The effect of predators activity on grain yielded after biological natural control against the ear pests of wheat, 1994-1998, A.RD.S.Turda (Malschi, 2007, 2008, 2009).

Average grain yield / ear (g), in Ariesan variety.						
Marked ears. (10-30 iunie)	**1994**	**1995**	**1996**	**1997**	**1998**	**Average**
	x+sx	**x+sx**	**x+sx**	**x+sx**	**x+sx**	**x+sx**
With predators	2,13+0,05	2,46+0,04	2,59+0,06	2,12+0,06	2,01+0,03	2,26+0,05
Without predators	2,04+0,08	1,81+ 0,04	2,34+0,13	1,63+0,04	1,43+0,06	1,85+ 0,05
d +sdx	0,09+0,06	0,62+0,04	0,25+0,095	0,49+0,05	0,58+0,045	0,41+0,05
Testul t	1,38	15,5***	2,63*	9,8***	12,8***	8,2***
% grain yield increasing	4,2%	25,5%	9,6%	23,1%	28,8%	18,2%
n1=n2=30 spice(ears); t 58 : p 5%=2,004; p 1% =2,669; p 0,1%=3,476						
Pests density / ear (nr.)						
Year.	1994	1995	1996	1997	1998	Average
Halothrips tritici	20	5	26	9	8,9	13,8
Sitobion avenae	10	25	20	2	1	11,6

Table 11. Effect of the activity of natural predators of wheat ear pests, expressed by grain yield in the conditions of 1998, A.R.S. Turda (Malschi, 2007, 2008, 2009)

1. On the wheat zone varieties, with optimal sowing date (at 10 october 1997). Average grain yield (g /ear)						
	Transilvania x+sx	**Turda 81 x+sx**	**Arieşan x+sx**	**Apullum x+sx**	**Turda 95 x+sx**	**Average x+sx**
With predators	2,17 + 0,07	2,24 + 0,06	1,98 + 0,06	1,77 + 0,06	2,13 + 0,07	2,06 + 0,06
Without predators	1,96 + 0,06	1,68 + 0,07	1,60 + 0,05	1,23 + 0,03	1,40 + 0,06	1,57 + 0,05
d +sdx	0,21 + 0,065	0,56 + 0,065	0,38 + 0,055	0,54 + 0,045	0,73 + 0,065	0,49 + 0,055
Testul t	3,231**	8,615***	6,91***	12,0***	11,23***	8,91***
% increasing of grain yield	9,7%	25,0%	19,2%	30,5%	34,3%	23,8%
2. On wheat zone varieties, with later sowing date (at 25 october 1997). Average grain yield (g /ear)						
	Transilvania x+sx	**Turda 81 x+sx**	**Arieşian x+sx**	**Apullum x+sx**	**Turda 95 x+sx**	**Average x+sx**
With predators	2,04 + 0,06	1,68 + 0,05	2,01 + 0,03	2,14 + 0,03	2,57 + 0,08	2,09 + 0,05
Without predators	1,56 + 0,07	1,13 + 0,03	1,43 + 0,06	1,30 + 0,05	1,69 + 0,08	1,42 + 0,05
d +sdx	0,48 + 0,065	0,55 + 0,04	0,58 + 0,045	0,84 + 0,04	0,88 + 0,08	0,67 + 0,05
Testul t	7,385***	13,750***	12,889***	21,0***	11,0***	13,4***
% increasing yield	23,5%	32,7 %	28,8%	39,2%	34,2%	32,1%
t 58 DL 5%= 2,004; DL 1 % = 2,669; DL 0,1%= 3,476; sdx= sx1+ sx2: 2; t + d : sdx; n1=n2=30 spice						

The biological control of *Haplothrips tritici* population with entomophagous predators has been experimented in two variants represented by lots treated with two larvae of *Chrysopa carnea* or *Coccinella 7-punctata* launched / m^2, in the wheat milky-wax ripening phenophase, and untreated controls, respectively (in wheat variants sown later with late ripening) (Table 12). Yields measured as grams of grains/ear, kg/ha and the TGM values have been recorded on the lots or analyzed samples in 3 repetitions.

The effect of predators activity involved in thrips natural limitation on ears has been observed in the ecological field experiments, recording and analyzing grain yields in normal ears visited by predators (during June 10-30), most of them as larvae, compared to the yield of the isolated ears (predators free) (Malschi, 2007, 2008, 2009).

The isolation has been performed by a glue ring at the ear base. The study has been carried out on 30 marked ears/variant, in accordance with the phenological development of the crop in two variants sown at the right time and late, respectively in 5 zone wheat varieties: Transilvania, Turda 81, Arieşan, Apullum, Turda 95.Twenty *Chrysopa carnea* first age larvae/lot have been launched in lots of 10 m^2 and 3 repetitions/variant in wheat milky-ripe phenophase. *Chrysopa* larvae have supplemented the natural entomophagous activity and have lead to yield increases. The importance of the natural biological control has been revealed by the analysis of individual variation performed by the predatory larvae complex on the wheat ears over the thrips larvae under the conditions of year 1999. It has been noticed that in phenologically late wheat (sown late in 10.25.1998), **in the ears visited by predators** significant yield positive differences have been obtained compared to those isolated by glue ring at the ear base (0.48g grains/ear in Transilvania; 0.55 g/ear in Turda 81; 0.58g/spike in Arieşan; 0.84g/spike in Apullum;0.88 g/ear in Turda 95; average of 0,67g grains/spike, that is 32.1 % increase. Significant yield increases **in the non-isolated ears visited by auxiliary entomophagous predators** have been recorded in wheat varieties sown within technological optimal time (10.11.1998), increases of 0.21 g grains/ear in Transilvania; 0.56 g/ear in Turda 81; 0.38g/spike in Arieşan; 0.54g/spike in Apullum; 0.73 g/ear in Turda 95; average of 0,49 g grains/spike, that is 23.8 % yield increase (Table 11).

The TGM values could be analyzed from the data in tables 12, 13. The factors studied in their different scales have provided significant differences among the variants. The non-isolated ears visited by the natural predators reserve have yielded grains with significantly higher TGM values compared to the isolated spikes both in the technologically optimal time sown wheat and the late one. Supplementing the number of natural predators by launching 2 larvae/m^2 of *Coccinella 7-punctata* or *Chrysopa carnea* (first or second stage) has given obvious results, which shows that yield increases resulted from the biological control has been reflected in significant TGM value (Table 13) (Malschi, 2007, 2008, 2009).

Table 12. The effect on TGM of natural biological control of wheat ear pests realized by predators, in relation with the sowing time and wheat (Malschi, 2007, 2008, 2009).

1. Factors influence and interaction.	TGM	%	Dferenţa
Sowing time at 11 oct.1997.	41,35	100	0,00
Sowing time at 24 oct.1997.	38,92	94,1	-2,44^{00}
			DL (p 1%) 0.97 ; DL (p 0,1%) 3,09
2. Ears. * Without predators	37,23	100,0	0,00
* With predators.	43,04	115,6	+5,82***
			DL (p 0,1%) 0,46
Sowing time at 11 oct.1997			
Ears. * Without predators	38,81	100,0	0,00
* With predators.	43,89	113,1	+5,08**
Sowing time at 24 oct.1997.			
Ears. * Without predators	35,64	100,0	0,00
* With predators.	42,19	118,4	+6,55***
			DL (p 0,1%) 0,66
Sowing time at 11 oct.1997			
Transilvania * Without predators	44,03	100,0	0,00
* With predators.	46,73	106,1	2,70***
Turda 81 * Without predators	32,13	100,0	0,00
* With predators.	39,07	121,6	6,93***
Arieşian * Without predators	46,27	100,0	0,00
* With predators.	47,27	102,2	1,00*
Apullum * Without predators	33,63	100,0	0,00
* With predators.	42,20	125,5	8,57***

Turda 95	* Without predators * With predators.	38,00 44,20	100,0 116,3	0,00 6,20***
Sowing time at 24 oct.1997.				
Transilvania	* Without predators * With predators.	38,7 46,13	100,0 121,2	0,00 8,07***
Turda 81	* Without predators * With predators.	29,87 35,20	100,0 117,9	0,00 5,33***
Arieşian	* Without predators * With predators.	44,20 47,30	100,0 107,0	0,00 3,10***
Apullum	* Without predators * With predators.	31,53 40,13	100,0 127,3	0,00 8,60***
Turda 95	* Without predators * With predators.	34,53 42,20	100,0 122,2	0,00 7,67
DL p 5% 0,80; DL p 1% 1,08; DL p 0,1% 1,47				

Table 13. Wheat grain yield after biological control of aphids and trips larvae, at milky-ripening 78-90 DC phase, by launching larvae of *Coccinella 7-punctata* or *Chrysopa carnea* (2 larvae/m^2), A.RD..S. Turda, 1997 (Malschi, 2007, 2008, 2009)

Launching predators.		*Coccinella septempunctata* L. (2 larvae/m^2)					*Chrysopa carnea* Stephn (2 larvae/m^2)				
		Grain yield			TGM		Grain yield			TGM	
Variety	Variante	Kg/ha	Diff.	%	g	%	Kg/ha	Diff.	%	g	%
Transilvania	Untreated	6406	Mt.	100	54,8	100	6406	Mt.	100	54,8	100
	Treaty	6650	+244	104	56,5**	103	6222	-184	97	56,5**	103
Turda 95	Untreated	5703	Mt.	100	51,2	100	5703	Mt.	100	51,2	100
	Treaty	5789	+86	102	56,8***	111	6188	+485	109	56,8***	111
	DL 5 %		682					571		-	
	DL 1 %		-							1,65	
	DL 0,1%		-							2,43	

The importance of the marginal flora from wheat crops in favoring the concentration of entomophagus has been highlighted by the ecological experience about fago-attractiveness of flower plants (*Daucus, Achillea, Sambucus*) in capturing of predators (adults of Chrysopidae, Staphylinidae, Coccinellidae, Syrphidae, Emipidae, Dolichopodidae, Tachinidae) on glue white plates (Table 14). Also, the presence of flora biodiversity of trees, bushes, lawns and grassy at the crop edges in agroforestry farm with protective curtains cause a greater abundance of entomophagous and the effectiveness of their limiting activity on pests (Table 15, 16) (Malschi, 2007, 2009).

Table 14. The atractive action on the polyphagous entomophages determined by the flowering plants of spontaneus flora in wheat crops margins herbs (June-July, A.R.D.S. Turda) (Malschi, 2007, 2009)

Polyphagous entomophages	Number of captured insects/white glue tiles (χ^2) / Collecting period.					
	24 VI - 4 VII 1997			**15 VII - 25 VII 1997**		
	Check	***Sambucus***	***Achilea***	*Check*	***Daucus***	***Achillea***
Chrysopidae	2	7(16,7***)	8(21,1***)	-	-	-
Staphylinidae	-	-	-	7	11(2,9)	9(1,1)
Coccinellidae	1	0(3,1)	3(12,3***)	4	11(12,5***)	3(0,8)
Syrphidae	1	14(48,3***)	7(34,5***)	0	1(4,2*)	7(20,4***)
Emipidae	2	2(0,02)	1(8,8**)	4	6(2,4)	10(10,5***)
Dolichopodidae	1	1(0,02)	5(93,5***)	0	22(33,5***)	19(31,8***)
Tachinidae	1	4(18,5***)	2(8,8**)	1	25(56,5***)	11(44,1***)
TOTAL	8	27(14,7***)	6(13,9***)	16	76(26,3***)	59(19,8***)
GL=10; χ2 tabelar (p 0,1%=29,6(38,9***)				χ2(p0,1%)=29,6(51,6***)		
GL=1; χ2 tabelar (p 5%)=3,8; (p 1%)=6,6; (p0,1%)=10,8						

Table 15. Average abundance of aphids and theirs predators of wheat in open field area, at Turda and with agroforestry belts in Boldut (1997-1999, A.R.D.S Turda)(Malschi, 2007)

Annual average aboundance.			
Location.	Turda	Bolduţ	χ 2
Aphids	346,6	154	120,54 xxx
Prredators total	519,0	971,8	26,37 xxx
Aranea	49,6	56,9	5,89 xx
Nabidae	28,0	28,9	5,26 x
Aeolothripidae	4,0	11,6	9,97 xxx
Carabidae	320,4	515,7	23,41 xxx
Staphylinidae	10,7	4,4	0,169
Sylphidae	33,7	283,7	125,65 xxx
Cantharidae	1,3	4,3	3,41
Malachiidae	7,3	5,0	0,17
Coccinellidae	22,3	11,6	0,04
Chrysopidae	3,3	4,3	1,22
Syrphidae	3,4	6,7	4,05 x
Empididae	35,0	38,7	9,44 xx
Total	865,6	112,6	
χ 2 tabelar: (p 5%=3,84), (p 1%= 6,62), (p 0,1%=10,8)			

Table 16. Structure, dynamics and dispersal of Carabids in cereal agroecosystems in open field area at Turda and with agroforestry belts in Boldut (1997-1999, A.R.S Turda) (Malschi, 2007, 2009)

Comparative structure and aboundance of Carabids					
Place of gathering.	TURDA		BOLDUŢ		χ 2
Carabidae:	Nr.	%	Nr.	%	
Total	688	-	2362	-	-
Poecilus cupreus L.	231	34,0	447	19,0	26,39 xxx
Harlpalus rufipes Deg.	83	12,1	606	25,6	26,46 xxx
H. distinguendus Duft.	41	6,0	72	3,0	10,07 xx
H. aeneus F.	5	0,7	46	2,0	3,82
Amara aenea Deg.	1	0,1	-	-	9,80 xx
Pterostichus melanarius Ill.	221	32,3	72	3,0	291,79 xxx
Pterostichus macer Marsh.	49	7,2	3	0,1	132,72 xx
Dolichus halensis Schall.	3	0,4	35	1,5	5,38 x
Brachinus explodens Duft.	3	0,4	1024	43,3	191,19 xxx
Agonum dorsalis Pont.	9	1,3	46	2,0	0,83
Agonum muelleri Hbst.	30	4,4	-	-	100,43 xxx
Anisodactylus sygnatus F.	7	1,0	-	-	28,34 xxx
Carabus coriaceus L.	-	-	11	0,5	2,01
Cicindella germanica L.	1	0,1	-	-	9,80 xxx
Comparative dynamics and dispersal of Carabids.					
Place of gathering.	TURDA		BOLDUŢ		χ 2
	Nr.	%	Nr	%	
May. Forestry belts.	-	-	50	2,1	12,85 xxx
Marginal grasses.	-	-	366	15,5	88,24 xxx
Wheat.	22	3,2	206	8,7	17,66 xxx
Barley.	19	3,0	6	0,3	33,43 xxx
June. Forestry belts.	-	-	56	2,4	14,49 xxx
Marginal grasses.	-	-	134	5,7	35,02 xxx
Wheat.	49	7,2	228	9,6	2,62

Barley.	15	2,2	88	3,7	2,96
Maize.	-	-	30	1,3	7,31 xx
Bean.	-	-	135	5,7	35,27 xxx
Clover.	3	-	0,4	-	15,18 xxx
July. Forestry belts.	-	-	41	1,7	10,56 xxx
Marginal grasses.	-	-	166	7,1	42,77 xxx
Wheat.	157	23,0	41	1,7	260,76 xxx
Barley.	57	8,3	330	14,0	4,88 x
Maize.	31	4,5	91	3,8	0,71
Bean.	14	2,1	232	9,8	33,30 xxx
Clover.	317	46,3	-	-	624,71 xxx
AUGUST. Forestry belts.	-	-	-	-	-
Marginal grasses.	-	-	102	4,3	26,78 xxx
Maize	-	-	39	1,6	9,81 xx
Bean.	-	-	21	1,0	4,64 x
TOTAL. May.	41	6,0	628	26,6	123,69 xxx
June.	67	9,8	671	28,4	47,60 xxx
July.	576	84,2	901	38,1	65,78 xxx
August	-	-	162	6,9	42,03 xxx
Annual.	684	-	2362	-	-
$\chi 2$ tabelar GL=1: p 5%=3,84; p 1%=6,62; p 0,1%=10,8					

Insecticide toxicity and selectiveness to auxiliaries. Closely correlated with the sequential activity of the entomophagous predators against crop pests is the study of the impact magnitude of some insecticide treatment. The abundance of auxiliary species in the crops has been influenced by insecticide applications. Thus, the wheat seed treatments applied to autumn with Lindan-based products have caused a significant decrease of useful epigeous fauna concentration during the crop colonization period in April-May (Malschi 2007, 2008, 2009). The side effect of wheat seed treatments with neonicotinoids (Yunta 246 FS 2 l/t seed) on the mortality of auxiliary epigeal fauna (Carabidae, Sylphidae, Scarabeidae, Aranea) (table 17) and on the entomophagous mortality and dynamics at wheat plants level (Coccinellidae, Cantharidae, Malachiidae, Syrphidae, Empididae (Platypalpus), Hymenoptera – parasites, Formicidae, Aranea) (table 18) represents important applied research of the previous period, carried out at ARDS Turda (Malschi, 2008, 2009).

Table 17. The side effect of Yunta 246 FS insecticide against auxiliary epigeal fauna in wheat classical system (ARDS Turda, 2008) (Malschi, 2009)

Summe of individuals in Barber traps catches						
	29.05			24.06		
Varianta	**V 1**	**V 2**	**Mortality %**	**V 1**	**V 2**	**Mortality %**
Brachinus explodens	3	1	66.7	25	15	40.0
Poecilus cupreus	84	28	66.7	250	150	40.0
Pseudophonus rufipes				50	30	40.0
Pterostichus melanarius	12	1	91.7	125	75	40.0
Harpalus distinguendus	2		100.0	15	9	40.0
Dolichus halensis	17	3	82.3			
Sylpha obscura	10	2	80.0	25	15	40.0
Necrophorus vespillo				10	6	40.0
Scarabeus	2		100.0			
Aranea	13	2	84.6			
Total	145	37	74.5	500	300	40.0
Variants: V1- untreated; V2-Yunta 246 FS 2 l/t seed treated						

Table 18. Entomophagous dynamics at wheat plants level, after Yunta 246 FS treatment (ARDS Turda, 2008) (Malschi, 2009)

No. individuals /100 sweepnet catches				
Variants: Variants: V1- untreated; V2-Yunta 246 FS 2 l/t seed treated.				
Data of sample	14.05		27.05	
Variants	**V 1**	**V 2**	**V 1**	**V 2**
Coccinellide (P. 14- punctata)	1		1	1
Cantharidae	17	2		
Malachiidae			2	2
Syrphidae			1	
Empididae (Platypalpus)			2	
Hymenoptere - paraziti	13	6	8	
Furmicidae	2	3	3	1
Aranea	3		2	3
Total entomofagi	**36**	**11**	**19**	**8**
Mortality %		**69**		**42**

Table 19. Side-effect of insecticides on beneficial arthropods. Results of field and semi-field toxicity tests on the wheat pest control treatments, in Transylvania (1994-1996) (Malschi, 2007, 2008, 2009)

			Harpalus distinguendus	*Poecilus cupreus*			*Pseudophonus pubescens*	*Aranea*	*Coccinella 7-punctata*			*Chrysopa carnea*	*Nabis ferus*	*Tachyporus hypnorum*	*Malachius bipustulatus*
Date of treatments			02 05	02 05	31 05	20 06	31 05	20 06	02 05	20 06 *	20 06 *	20 06	20 06	20 06	20 06
Insecticides	Products	Dose/ ha	**Initial toxicity on beneficial predators**												
Endosulfan	Thionex 35 EC	2,01	**4**	-	-	**4**	**4**	**4**	-	**3**	**3**	**4**	**4**	-	**4**
Dimethoate	Sinoratox 35 EC	1,51	-	-	**4**	**3**	-	**1**	-	**4**	-	-	-	-	-
Dimethoate	Sinoratox 35 EC	3,51	-	-	**4**	**3**	**4**	**4**	-	**4**	**4**	**4**	**4**	**4**	**4**
Diazinon	Basudine 600 EC	1,01	-	-	**4**	-	**4**	**4**	-	**4**	-	-	**4**	**4**	**4**
Diazinon	Diazol 48 EC	0,91	-	-	-	**4**	**4**	**4**	-	**3**	**2**	**4**	**3**	-	**4**
Chlorpiryphos	Pyrinex 50 EW	2,01	-	-	-	**4**	**4**	**4**	-	**3**	**3**	**4**	**4**	-	-
Cypermethrin	Polytrin 200 SC	0,11	**2**	**1**	**2**	**1**	**4**	**4**	**4**	**1**	**2**	**3**	**4**	-	-
Alphamethrin	Fastac 10 EC	0,11	**1**	-	-	**1**	**4**	**4**	**2**	**3**	**2**	**4**	**3**	**4**	**4**
Zetamethrin	Fury 10 EC	0,11	-	-	**1**	**1**	**4**	**4**	-	**3**	-	**4**	**4**	**4**	**4**
Deltamethrin	Decis 2,5 EC	0,31	-	-	-	**2**	**4**	**4**	-	**4**	**2**	**2**	**3**	**4**	**1**
Esfenvalerat	Sumi–Alpha 5EC	0,21	-	-	**1**	-	**3**	**3**	-	**4**	-	**4**	**3**	**4**	**4**
Bensultap	Victenon 50 WP	0,5 kg	-	-	**1**	-	**4**	**4**	-	**4**	-	-	**4**	**4**	**4**
Acetamiprid	Mospilan 20 SP	0,1 kg	-	-	**1**	-	**4**	**4**	-	-	**2**	**4**	-	-	**4**
Fipronil	Regent 80 WG	25 g	-	-	**2**	-	**3**	**3**	-	**4**	-	**4**	**4**	-	-
**Larvae*. Scale (percent mortality): 1=harmless (<25%); 2=slightly harmful(25-50%); 3=moderately harmful (51-75%); 4=harmful (>75 %), (Hassan & colab.1985).															

The experimental treatment applied in April with different insecticides for phytophagous diptera attack prevention has an instant depressive effect on the aranea, staphylinids and carabids species (*Poecilus cupreus* L.), already found in the crop. In comparison with the untreated control carabid species have proved to rebuild their abundance in May-June by continuing their migration and concentration in the crops.

The experimental treatments applied in May and June to control ceral leaf beetle (*Oulema* sp.) and ear pests has strongly affected the useful fauna with the exception of a restricted range of pyrethroids (tables 19, 20).

Due to the richness of natural entomophagous fauna in the cereal agroecosystems in Central Transylvania, the treated crops have been intensely re-colonized with entomophags. The insecticide impact can also be diminished by choosing the selective treatment time to protect the main predatory species taking into account their biology and the specificity of the technological systems both within conservative soil (no tilllage) and in the conventional plowing, in order to achieve high yields, good quality and a reduced negative impact on the environment, biodiversity and quality of agricultural products (tables 21, 22) (Malschi 2008, 2009). Recent research and new thesis elaborated at ARDS Turda (Dărab et al., 2017, 2018, Vălean et al., 2017, 2018) will provide details on the interrelation between the current technologies of integrated pest control, pests and auxiliary entomophages in the wheat crops.

Table 20. Entomophagous dynamics after insecticides treatments in wheat crop (ARSD Turda 2008) (Malschi, 2009)

Treatment:30.05.2008	Treatment immediate side effect/after 4days							Insecticide side effect after 12 days.						
No./100 sweepnet catches.	3.06.2008							11.06.2008						
	C	**V3**	**V4**	**V5**	**V6**	**V7**	**V8**	**C**	**V3**	**V4**	**V5**	**V6**	**V7**	**V8**
Cantharidae								4			4			
Malachiidae	2				1									
Nabidae	2													
Chrysopidae	2	1						6						
Syrphidae	1		1					4	2					
Empididae (*Platypalpus*)	9	3	4	4	4	6		1	5	9	1	5	8	
Hymenoptere	5	1	5	1		3	2	19	4	5	16	2	4	9
Aranea	2	1	1		1	2								
Total entomofagi	**23**	**6**	**11**	**5**	**6**	**11**	**2**	**44**	**11**	**14**	**31**	**7**	**12**	**9**
Mortality %		**74**	**52**	**78**	**74**	**52**	**91**		**75**	**68**	**30**	**84**	**80**	**80**
Treatment:30.05.2008	Insecticide side effect after 26 days.							Insecticide side effect after 34 days.						
No./100 sweepnet catches	25.06.2008							3.07.2008						
	C	**V3**	**V4**	**V5**	**V6**	**V7**	**V8**	**C**	**V3**	**V4**	**V5**	**V6**	**V7**	**V8**
Aeolothripidae	6					1		20	29	21	12	6	4	40
Coccinellidae	2			1	1	1		1		1			1	
Cantharidae	1				1	1		1			1			
Malachiidae								3		3				
Nabidae	1			1		1		1						
Chrysopidae									1	3	3	1	1	
Syrphidae	2				2	1		2		2				
Empididae (Platypalpus)	1		4	2	4	4	1	3		3			2	1
Hymenoptere	5	5	15	13	3	8	10	37	48	39	40	21	21	22
Aranea	30	10	7	9	7	22	10	28	22	33	33	38	46	39
Total entomofagi	**48**	**15**	**26**	**26**	**18**	**39**	**21**	**96**	**110**	**103**	**89**	**66**	**75**	**82**
Mortality %		**69**	**46**	**46**	**63**	**19**	**56**				**7**	**31**	**22**	**15**
Variants: C = Control =without insecticidal treatment); V2=Seed treated with *Yunta 246 FS, 2 l/t, V3=Cylothrin 60 CS 80 ml/ha; V4=Alphamethrin 10 CE 100 ml/ha; V5=Decis 25 WG 0,030 Kg/ha; V6=Proteus OD 110 400 ml/ha; V7=Calypso 480 SC 100 ml/ha; V8=Grenade SYN 75 ml/ha.*														

Table 21 . Efficiency of insecticides appliaction at May the 30-th 2008, in the wheat flag-leaf stage (Ariesan variety), ARDSTurda, 2008 (Malschi, 2008, 2009)

Biological efficiency on ear pests (aphids and thrips)

	Aphids/ear / 11.06.2008			Thrips larvae/ear / 11.06.2008		
Treatments.	Average	%	Difer.	Average	%	Difer.
1.Netratat. Untreated.	2.50	100.0	-	3.70	100.00	-
2.Yunta 246 FS, 2 l/t TS	2.50	100.0	0.00	3.70	100.00	0.00
3.Cylothrin 60 CS 80 ml/ha	0.20	8.0	- 2.30	0.10	2.70	- 2.60 ° ° °
4.Alphamethrin 10CE 100ml/ha	0.60	24.0	- 1.90	0.05	1.35	-1.65 ° ° °
5.Decis 25 WG 0,030 Kg/ha	0.40	18.0	- 2.05	0.10	2.70	-2.60 ° ° °
6.Proteus OD 110 400 ml/ha	0.50	20.0	- 2.00	0.05	1.35	-1.65 ° ° °
7.Calypso 480 SC 100 ml/ha	5.35	214.0	2.85	4.00	108.11	0.3
8.Grenade SYN 75 ml/ha	0.05	2.0	- 2.45	0.10	2.70	- 2.60 ° ° °
DL p 5%			3.171		28.00	1.037
DL p 1%			4.396		38.80	1.438
DL p 0.5%			6.107		53.90	1.998
	F= 3.09(2.76)			F= 31.91 (2.76)		

Effect of insecticidal treatments applied at fleg-leaf stage on the wheat grain yields and TGM, in 2008 (ARDS Turda)

	Kg / ha			TGM		
Treatments.	Media	%	Difer.	Media	%	Difer.
1.Netratat. Untreated.	5456	100	martor	45.100	100.0	martor
2.Yunta 246 FS, 2 l/t TS	5650	104	194	45.800	101.5	0.700
3.Cylothrin 60 CS 80 ml/ha	6850	126	1394 ***	50.167	111.2	5.067 ***
4.Alphamethrin 10CE 100ml/ha	7170	131	1714 ***	48.567	107.7	3.467 ***
5.Decis 25 WG 0,030 Kg/ha	6793	125	1337 ***	48.000	106.4	2.900 ***
6.Proteus OD 110 400 ml/ha	5990	110	534 *	50.377	111.7	5.277 ***
7.Calypso 480 SC 100 ml/ha	6150	113	694 *	45.067	99.9	-0.033
8.Grenade SYN 75 ml/ha	5540	102	84	49.267	109.2	4.167***
DL p 5%		9.2	503.5		2.7	1.237
DL p 1%		12.8	687.9		3.8	1.715
DL p 0.5%		17.7	969.5		5.3	2.383
270 l solutie/ha	F= 15.9 (2.76)			F=29.13 (2.76)		

Gluten, protein and cinder content of wheat grains of Ariesan variety by the insecticide treatments in flag-leaf stage application/ May the 30-th 2008, (ARDS Turda)

	Gluten	Protein	Cinder
Treatments.	%	%	%
1. Untreated.	19.40	9.45	1.67
2. Yunta 246 FS, 2 l/t TS	21.50	9.85	1.81
3. Cylothrin 60 CS 80 ml/ha	18.00	9.00	1.64
4. Alphamethrin 10 CE 100 ml/ha	18.15	8.90	1.65
5. Decis 25 WG 0,030 Kg/ha	21.10	9.45	1.79
6. Proteus OD 110 400 ml/ha	18.95	10.65	1.15
7. Calypso 480 SC 100 ml/ha	18.55	10.50	1.16
8. Grenade SYN 75 ml/ha	17.80	10.30	1.13

Table 22. Abundance of wheat pests and entomophagous after insecticides and application moments in comparative system, ploughing and un ploughing, in 2008 (Malschi 2008, 2009).

Application moments: C - Control untreated; 1 (at early spring)/28.03.2008-Calypso 480 SC 100 ml/ha; 2 (at the end of tillering) /14.04.2008 - Calypso 480 SC 100 ml/ha; 3 (at flagleaf and ear apparition) /21.05.08-Proteus OD 110 400 ml/ha
(no.individuals / 50 duble sweet net cathes).

Collecting data	28.052008							
Technology	Ploughing system				No tillage system			
Variants /Treatments data	C.	1 / 28.03	2 / 14.04	3 / 21.05	C	1 / 28.03	2 / 14.04	3 /21.05
PHYTOPHAGOUS								
Thrips (*Haplothrips tritici*-adults)	62	27	14	33	111	76	64	84
Diptere total	2	2				2	2	2
Chrysomellide (*Oulema, Chaetocnema, Phyllotreta*)	1	1		2		1	4	
Aphids(*Sitobion avenae* etc.)	35	3	4	3	16	6	16	20
Cicads (*Psammottetix*)					1		1	
Heteroptera (*Eurygaster, Aelia*)	4		1		5	1	1	
Hymenoptera (*Cephus*).								
Total phytophagous	**102**	**33**	**19**	**38**	**133**	**86**	**88**	**106**
Biological efficiency %		**67.6**	**81.4**	**62.7**		**35.3**	**33.8**	**20.3**
ENTOMOPHAGOUS								
Coccinellidae	1				1			
Cantharidae			1		0			
Malachiidae	2	1	2	1	1	2		2
Nabidae		1			2			
Syrphidae	1				2	1		
Empididae (*Platypalpus*)	1	3	1		1	1	2	2
Hymenoptera parasites	4				12		1	6
Hym. Formicidae	2				3			
Chrysopidae					1			
Aranea	2	3			1	3		2
Total entomophagous	**13**	**8**	**4**	**1**	**24**	**7**	**3**	**12**
Entomophagous mortality %		**38.5**	**69.2**	**92.3**		**70.8**	**87.5**	**50.0**

4. Wheat pest dynamics, forecasting and current importance of the attack, to develop of an integrated pest control system in the center of Transylvania (ARDS Turda, 2006-2015)

During 2006-2015 the importance of wheat pest in central Transylvania has been highlighted by noting the dynamics, the numerical abundance and the structural percentage share of the main groups of arthropod fauna. The study presents the importance of wheat pest in the Transylvanian Plain specifying the entomocenotic risk situations. The investigations were conducted in wheat crops in large experimental lots, in different cultural systems (in protective agroforestry system with curtains, in open field system with traditional plowing or with conservative-no tillage). In the no-intervention research lots all zonal recommendations of technology and phytosanitary complex have been applied, including optimal sowing time, seed treatments and phytosanitary complex treatments on vegetation (Malschi, 2007, 2008, 2009, Malschi 2014). The studied variants on the effect of authorized insecticidal treatment have included an untreated plot and an integrated pests control plot with insecticides application for two different treatment moments: 1 - at the end of tillering in the 25-33 DC stage, at herbicides time, applying neonicotinoids, and 2 - at flag leaf stage and ear appearance in the 45-59 DC stage, applying pyrethroids.

Pest monitoring was performed based on the samples collected with entomological net, by decadal 100 sweep-net catches/sample, during the vegetation period of each year. The species inventory, the abundance and dynamics of populations according to the density factors (technological and climatic factors, entomophagous biological limiters) were carried out. In the investigations carried out since 1980, the same methods of sample collection of wheat insect pests and of entomophagous auxiliary artropods have been used at the Agricultural Research-Development Station Turda. In relation to the technological systems of the crop and to the climate change, the results were presented in an evolutionary and comparatively way by graphics of pest numerical abundance and dominance (%), by correlations and quadratic regressions in order to study wheat pests evolution, depending on climatic conditions and abundance of entomophages etc.

In the years 2006-2016, the permanent attention granted of the study on the dynamics of wheat pests attack in correlation with the evolution of agri-environmental complex zonal factors led to the observation of the impact caused by climate change on wheat crop enthomocenoses (Figures 7, 8).

The global warming, the installation of some periods that are extremely hot, heat and drought in spring-summer, represented particularly strong ecological factors that have determined **different changes in species composition**, favoring population development of a narrow-spectrum of species which have become dominant and dangerous by the numerical increases and even by numerical explosions, by local invasions and powerful attacks (Figure 9). In contrast to the previous periods (1980-2005) of the study when the weight of different groups of pests was evenly distributed (Figures 1) and separate schemes and moments to control at warning of key pest groups were tested, there are obvious changes in the structure of harmful entomofauna, during 2006-2015: - the increase of abundance and the eudominance of wheat thrips in the annual structure of harmful entomfauna and the large variations of seasonal abundance and of attack potential; - certain monovoltine species are dominant: thrips, wheat flies (*Opomyza florum, Delia coarctata, Phorbia penicillifera*), *Oulema, Eurygaster* and *Aelia*, the soil pests (*Zabrus, Agriotes*), and some polivoltine species linked to the cultivation of cereals: *Oscinella* and other Chloropidae, leafhoppers, aphids (Figure 7, 8) (Malschi, 2007, 2008, 2009, 2014, Malschi et al., 2010, 2013, 2015, 2016).

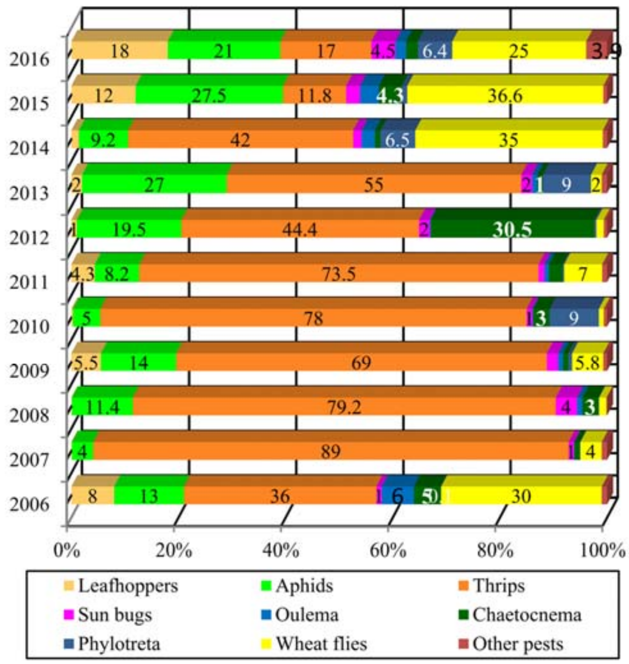


Figura 7. Annual structure of wheat pests (ARDS Turda 2006-2016) (Malschi et al., 2017, 2018)

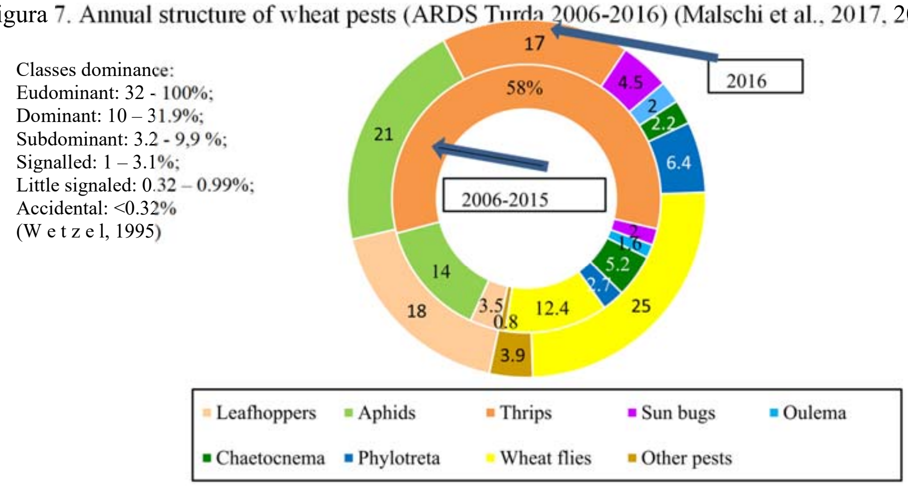


Figure 8. Structure of wheat pests in 2006-2015 period and in 2016 (ARDS Turda) (Malschi et al., 2018)

In 2006 pest structure of earlier periods was maintained. The annual average temperature with normal values (8,9°C) and the annual precipitation (589 mm) higher than normal (520.6 mm) were favorable to an equilibrated evolution of zonal pests which registered the structural percentages of 36% to thrips, 30% to Diptera, 13% to aphids, 8% to leafhoppers, 6% to *Oulema*, 5% to *Chaetocnema*, 1% to *Eurygaster* and *Aelia*, 1% to other species. Years 2007-2011 characterized by climatic warming and heat, have favored thrips population explosions, reaching the highest values into the annual structure of damaging entomofauna, accounting for 69-89% (Figures 7, 8).

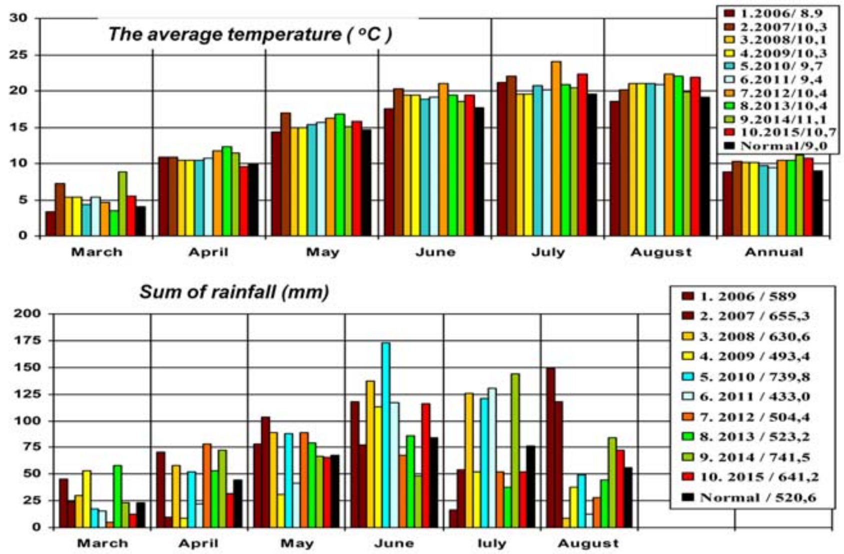


Figure 9. Average temperatures and sum of rainfall at Turda conditions by month,

from March to August and by year, in 2006-2015. Source of data:meteorological

The years 2012-2015, characterized by increasing warming, have recorded an annual average of temperatures of 10,4 - 11,1°C with 1-2°C more than normal. The 2012 and 2013, hot and dry and having the annual rainfall below the normal values (from 433 to 504.2 mm, respectively) were still favorable for thrips, aphids, wheat fleas and sunbugs. The years 2014-2015, warm and rainy (with annual rainfall more than normal, by 741.5 and 641.2 mm) were favorable to eudominant Diptera populations and to the further development of those of thrips, aphids, leafhoppers, cereal leaf beetles, sunbugs. The increase in rainfall of 2014 and 2015 influenced the increase of thrips abundance and of their **entomophages abundance** too, which caused the decrease of the structural share of trips at 12%-17%, in the next period (2015-2016) (Figures 7, 8, 9, 10). The different types of farms, fragmentation of cultivated areas, mosaic of agroecological conditions, incomplete and incorrect application of cultural techniques, such as the practice of monoculture, the sowing outside the regional optimal time of the second decade of October in order to prevent autumn pests attack, failure to apply the agrotechnical and phytosanitary measures have contributed to these changes.

The study provides the basis for the modelling and forecasting of the attack in relation to the biological potential of the pests and auxiliary entomophagus as well as to climatic and technological conditions**.** The biological potential of the pests (their numerical abundance) was studied, especially in relation to the specific climatic conditions of the important months for population development of main groups of pests (thrips, aphids, wheat flies), respectively: April for diptera, May for thrips, June for aphids (Figures 10, 11, 12).

The oscillations of the annual abundance of wheat thrips over the last 10 years in Transylvania were highly correlated with the increase in average annual temperatures (R^2 = 0.36; r = 0.60), the optimum temperatures being grouped around 10°C, favoured by the conditions of the current climate. The increase in rainfall in May influenced the increase in the yearly abundance of thrips (R^2 = 0.13; r = 036). The limitation of the annual abundance of wheat trips due to the abundance of auxiliary entomophages in crops was correlated by a positive correlation coefficient (R^2 = 0.27; r = 0.52) (Malschi et al., 2016) (Figure 10).

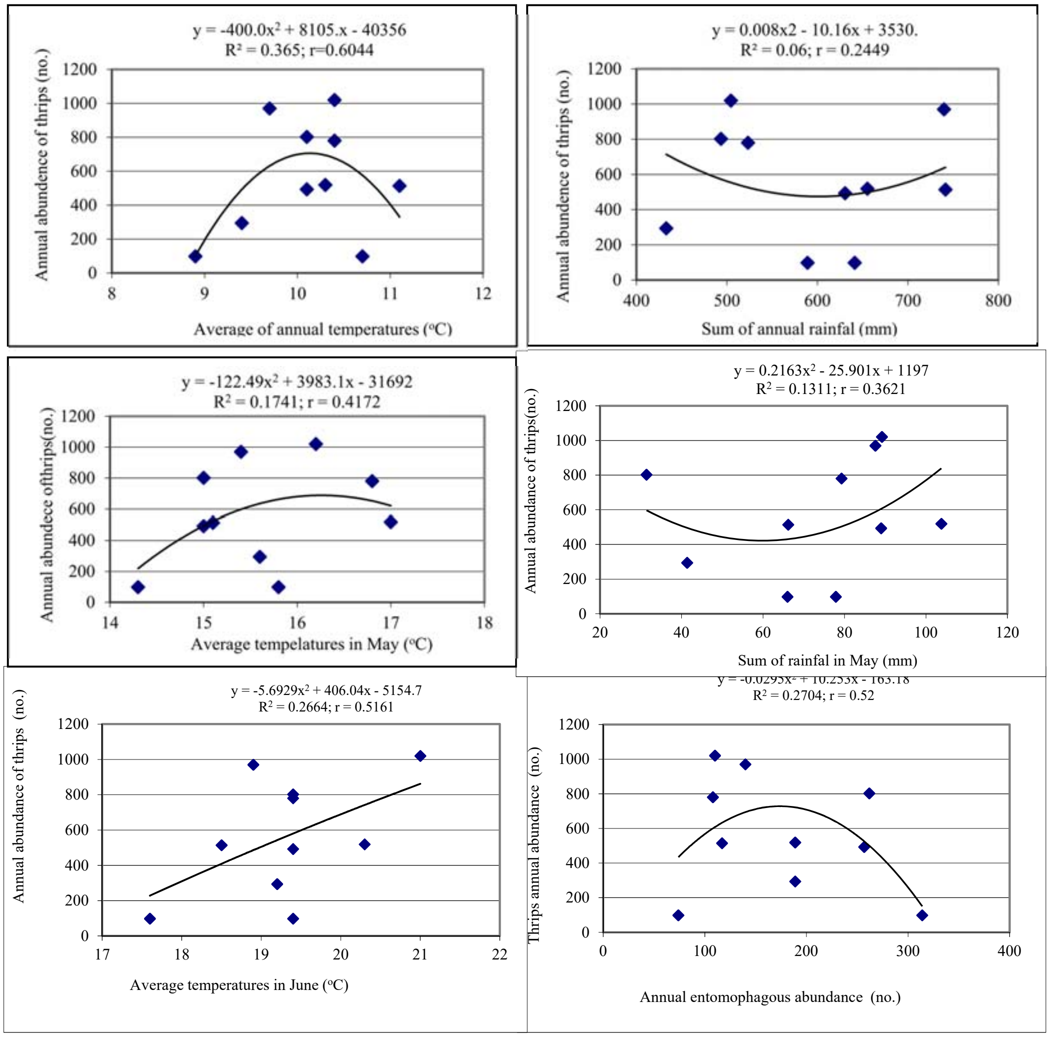


Figure 10. Dynamics of wheat thrips depending on climate and entomophagus during 2006-2015, ARDS Turda (Malschi et al., 2016, 2017, 2018)

The annual abundance of wheat aphid populations in Transylvania in the last 10 years increased according to the increase in the average annual temperatures ($R^2 = 0.12$; $r = 0.34$) and the annual precipitation increase ($R^2 = 0.17$; $r = 0.41$). Especially the increase in average temperatures in June determined the increase in aphids populations ($R^2 = 0.23$; $r = 0.47$), with a thermal optimum around 19.4°C. The annual abundance of the natural aphidophage arthropod was determined by a high correlation of the development of wheat field aphid colonies ($R^2 = 0.53$; $r = 0.73$), resulting in the annual natural limitation of aphids (Figure 11) (Malschi et al., 2016).

For the interaction between the annual abundance of wheat flies and the annual average temperature a high correlation with a positive correlation coefficient ($R^2 = 0.95$; $r = 0.97$), is observed. The annual abundance of wheat flies is regulated by the abundance of the natural entomophagus through a poor correlation ($R^2 = 0.16$; $r = 0.40$), the regression curve being predominantly negative for most cases (Figure 12) (Malschi et al., 2016).

Over the past 10 years, these interactions of pest abundance with climatic and biological factors led to fluctuations in the structural weight of different pest groups.

The increase in the annual abundance of zonal pests decreased **the yield of wheat grain**, the impact of high correlation being represented by a negative regression ($R^2 = 0.30$; $r = -0.56$). In this interaction the secondary impact of entomophagus activity ($r = 0.17$; $D = 17\%$) resulted in increasing the yield of wheat by limiting the pests (Figure 13) (Malschi et al., 2016).

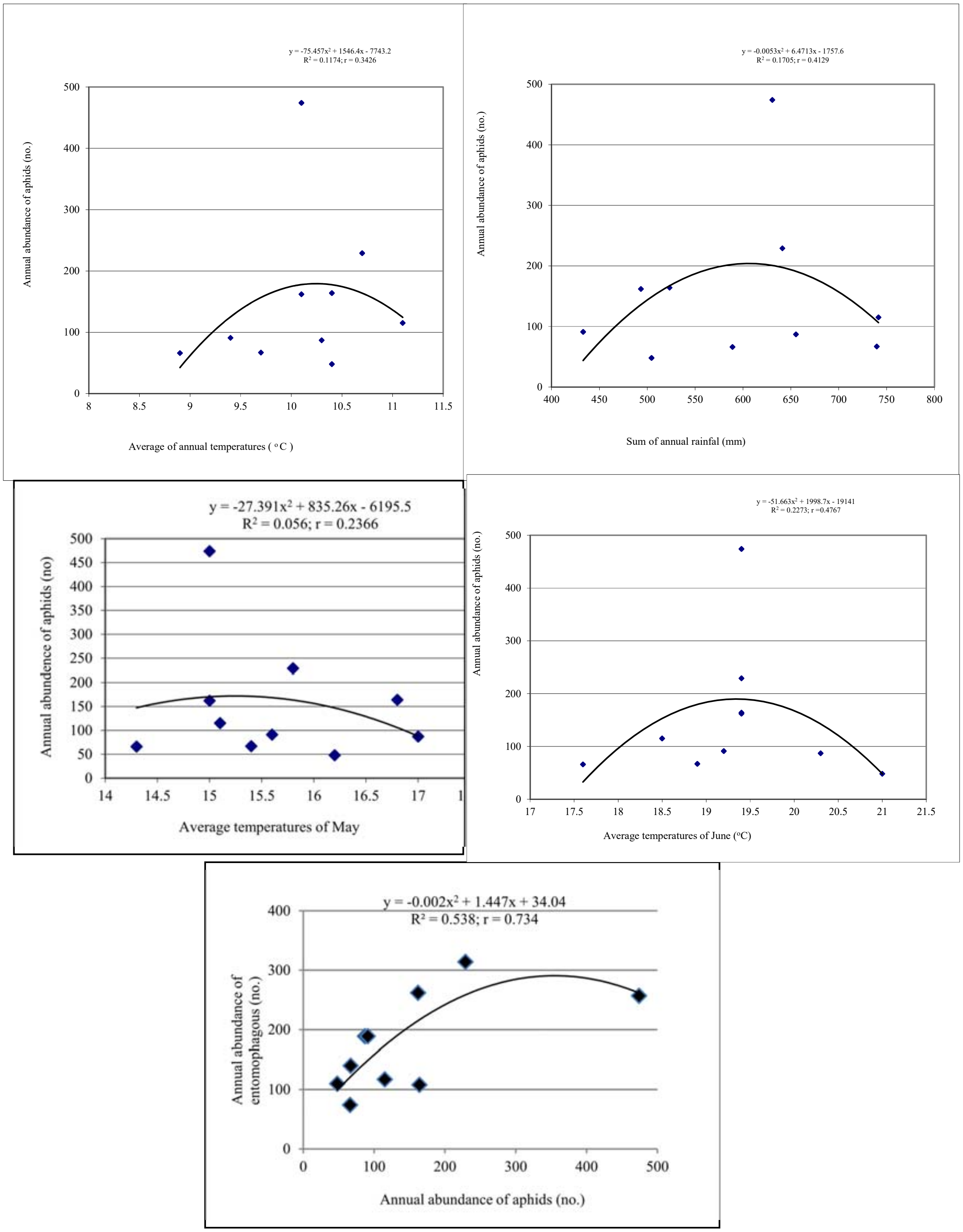


Figure 11. Dynamics of wheat aphids depending on climate and entomophagus during 2006-2015, ARDS Turda (Malschi et al., 2016, 2017, 2018)

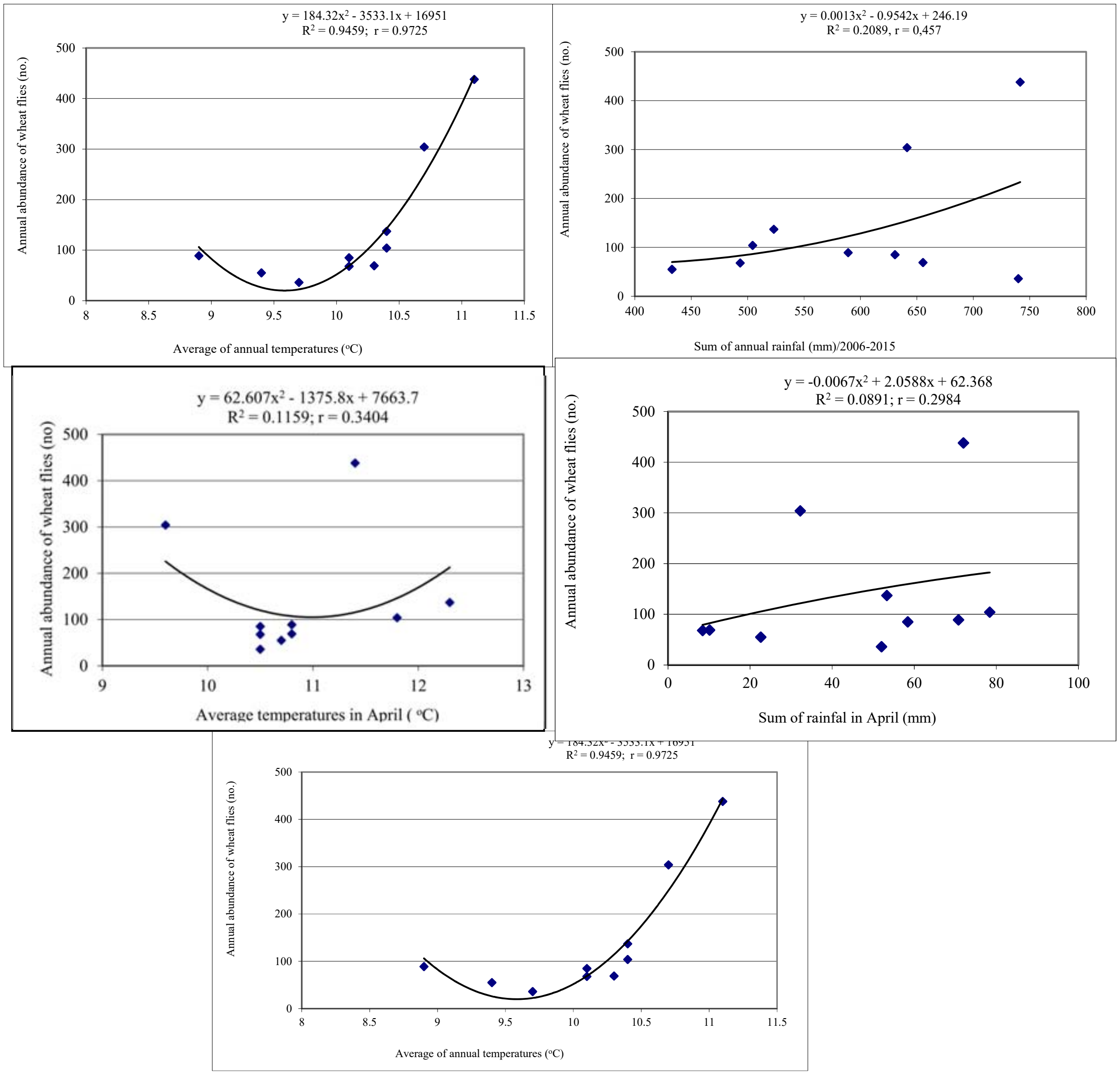


Figure 12. Dynamics of wheat flies depending on climate and entomophagus during 2006-2015 at ARDS Turda (Malschi et al., 2016, 2017, 2018)

At the conditions of entomocenotical risk caused by warming and drought has increased the danger of pest abundance, since the beginning of April, when were reported the wheat flies of Chloropidae: *Oscinella, Elachiptera*, *Meromyza* etc., Anthomyidae: *Phorbia, Delia*, Opomyzidae: *Opomyza*; the concentration of *Chaetocnema aridula* and *Oulema melanopus*, concomitantly with the flight of leafhoppers (*Javesella, Psammotettix, Macrosteles*). The wheat thrips (*Haplothrips tritici*) was the most abundant pest, dangerous for the ear formation in bellows and for the grains development. Of particular importance were the wheat flies, the leafhoppers and aphids (*Sitobion, Schizaphis, Rhopalosiphum* etc.) being extremely dangerous for autumn early crops**.** In Transylvania, the technological system of wheat pest integrated control must include agrotechnical preventive measures (especially respecting the sowing time in the second decade of October) and applying insecticide treatments: seed treatments and spraying treatments on vegetation (the treatment 1: in the spring no later than the end of tillering - at the herbicides application; the treatment 2: at the phenophase of bellows and ear emergence; and other treatments at warning.

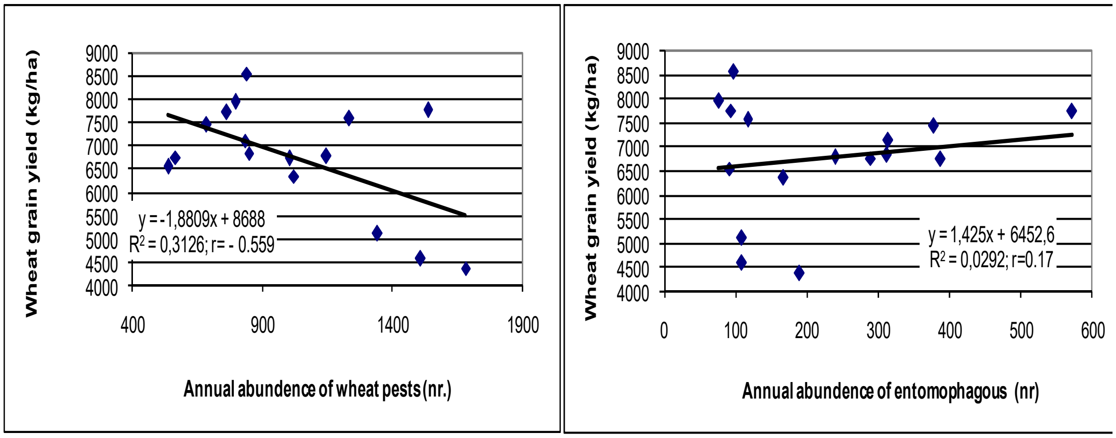


Figure 13. Entomocenotical risk situations on wheat yield, during 2006-2015, in relation to climate change and cultural technologies, at ARSD Turda. Source: Malschi et al., 2016, 2017

Conclusion on the dynamics of wheat pests. In the long-term research carried out at the Turda Agricultural Research and Development Station, in the central of Transylvania, the dynamics of wheat pests, the level of attack and the methods of controlling them were studied. In the last four decades (1980-2016), wheat pest dynamics were studied according to the climatic conditions of different periods of years, with particular impact on the main groups of pests, as well as the importance of the natural fund of auxiliary entomophagus in cereal agroecosystems. The global warming, the installation of some periods that are extremely hot and dry in spring-summer, represented particularly strong ecological factors that determined different changes in species composition, favouring population development of a narrow-spectrum of species which have become dominant and dangerous by the numerical increases and even by numerical explosions, by local invasions and powerful attacks (Figure 1). In contrast to the previous periods of the study, when the weight of different groups of pests was evenly distributed, there are obvious changes in the structure of harmful entomofauna, during 2006-2016 (Figures 7, 8): - certain monovoltine species are dominant in the annual structure of harmful entomofauna: thrips (*Haplothrips tritici*), wheat flies (*Opomyza florum, Delia coarctata, Phorbia penicillifera*), *Oulema, Eurygaster* and *Aelia*, the soil pests (*Zabrus, Agriotes*), and some polivoltine species linked to the cultivation of cereals: *Oscinella* and other Chloropidae, leafhoppers, aphids (Malschi, 2007, 2008, 2009, 2014, Malschi et al., 2010, 2013, 2015). Warming and aridisation led to changes in the structure of the pests, gaining eudominance values of the thrips (58%), the dominance of aphids (14%) and flies (12%), subdominance of Chrysomelidae and increasing abundance of entomophagus (14-18% in the structure of collected arthropod fauna) (Malschi et al., 2016).

Fluctuations in the structure, dynamics and attack of the populations of the major harmful species are observed under the impact of bio-eco-climatic and technological conditions, mainly due to climate change, heating and aridisation. In 2000-2002, characterized as warm years, there was a strong attack caused by *Oulema*. During 2003-2005, with hot and dry years, a particularly strong attack was caused by wheat flies, *Chatocnema*, thrips, cereal bugs. In the period 2006-2013, with warm and dry years, the eudominance of the populations of thrips and the reduction of the structural weight of wheat flies, aphids, Chrysomelidae were revealed. During 2014-2016, warm and more abundant annual rainfall, have strongly influenced the structure of the pests, causing a decline in the structural weight of the thrips, the restoration of the dominance of the wheat flies populations, the aphids, the leafhoppers, the increase in the importance of the cereal bugs and the leaf beetle *Oulema* (Figures 7, 8, 9) (Malschi et al., 2016, 2017).

Between 2006 and 2016, under the impact of climate change (high temperatures, drought, aridisation, excessive rainfall phenomena) and according to the technologies applied, increases were reported in the abundance and attack of certain pests, changes in the structure of the pests and entomophagus. Between 2007 and 2013, the highest values in the structure of the pests were recorded for the **wheat thrips**, oscillated between 44.4 and 89%. In the years 2014-2015 there were over-normal increases in annual average temperatures, annual rainfall and wide spring temperature oscillations, with cold periods that caused delays in the phenological development of wheat, in the development of pests and entomophagus, favouring new structural changes. The structural weight of **flies** (35-36.6%), aphids and leafhoppers, Chrysomelidae and sun bugs increased (Figure 7), (Malschi et al., 2016).

At the level of **2016**, the share of the dominant groups of wheat flies (25%), aphids (21%), leafhoppers (18%), and subdominance of Chrysomelidae (10%) and cereal sun bugs (4,5%), also changed. The wheat thrips structural weight was reduced to only 17% in the structure of the wheat pest (Figure 8). Entomophagus had a high weight of **29%** in the structure of arthropod fauna collected from wheat (Malschi et al., 2015, 2016, 2017, 2018).

Therefore, the elaboration of sustainable development strategies of wheat pests control have to include the conservation and use of biodiversity of auxiliary arthropods fauna (Malschi, 2009, 2014; Malschi et al., 2015, 2016).

5. Dynamics of biological potential of wheat pests in relation to climate changes and auxiliary entomophagous arthropod fauna during 2006-2016

The study is related to plant-pest-entomophag interactions in cereal agroecosystem of Agricultural Research-Development Station Turda, in Transylvania. Under the conditions of actual agroecological 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. The attack diminishing recommended methods of the integrated control strategy 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 research conducted in the laboratory following the natural model of predator-prey interactions has revealed the role and importance of auxiliary entomophages (Malschi and Mustea 1992, 1997, 1998, Malschi, 1997, 2007, 2009, Malschi et al. 2016) (Table 8).

.Based on research conducted in over 40 years, in central Transylvania, on the dynamics and importance of wheat pests and the analysis of the data of the last ten years in the changes of population and wheat pest attacks under the current climate and eco-technological changes, the study brings important clarifications, checked year after year, in experimental lots.

The dynamics of the annual biological potentials of the pests was studied according to annual climate conditions and structural interactions with entomophagus (Figures 14, 15, 16, 17) (Malschi et al., 2017, 2018). In 2006-2015, the optimal level of pests / entomophagus interactions was different: for wheat flies - 2.74 flies / 1 entomophagus (189 flies / 69 entomophagus), for aphids - 1.2 aphids / 1 entomophagus (340 aphids / 280 entomophagus), for wheat thrip - 4.7 thrips / 1 entomophagus (660 thrips / 140 entomophages) (Malschi et al., 2016).

The annual value of these interactions can be expressed by the **annual ratio phytophagus /entomophagus**, indicating the annual potential of the ratio of phytophagus number / 1 entomophagus at the end of the wheat growing period (Malschi et al., 2017, 2018). The climatic warming, the installation of particularly hot and dry periods in the spring and summer months represented strong environmental factors ($R^2 = 0.43$), (Figure 14) which led to changes in the species structure. Changes in entomocenotic interactions in wheat crops, in the pest dynamics, staging of optimal control moments important in the development of control systems occurred.

In regional conditions, the annual abundance of entomophagus was determined by the annual abundance of phytophagus insects through a positive correlation $R^2 = 0.46$ and D% = 46.4% (Figure 15). The annual ratio of the number of phytophagous/entomophagus fluctuated between 2.35 and 12.42, under the conditions of the last 10 years, characterized by the average of annual temperatures of 10.1°C (higher than normal of 9.1°C) and the annual average rainfall of 515.3 mm (from the normal of 615.3 mm).

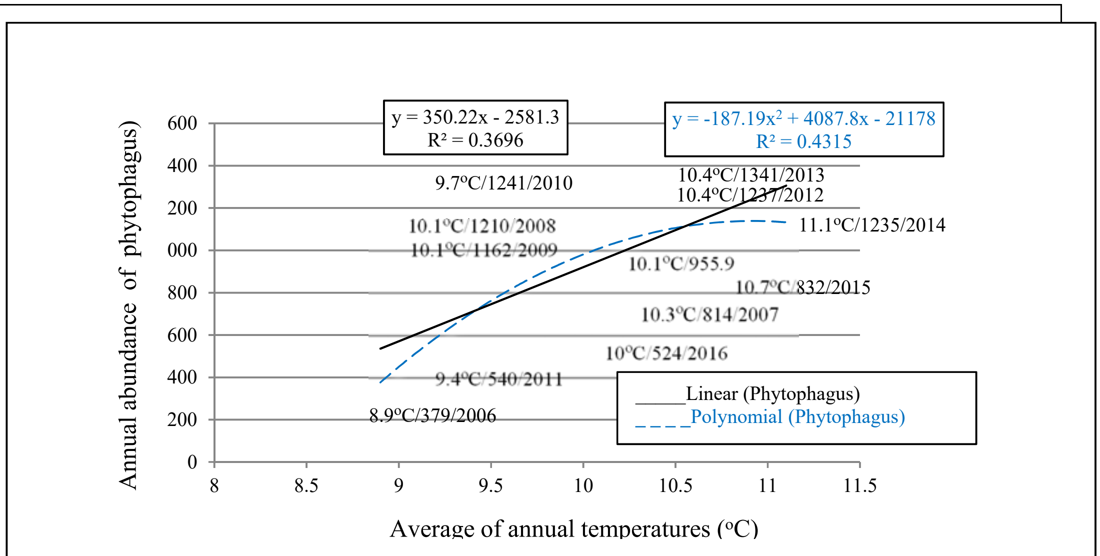


Figure 14. The correlation of the annual abundance of wheat pests and the average annual temperature during the period 2006-2016, at ARDS Turda (collected by decadal 100 double, sweep-net catches). (Malschi et al., 2018)

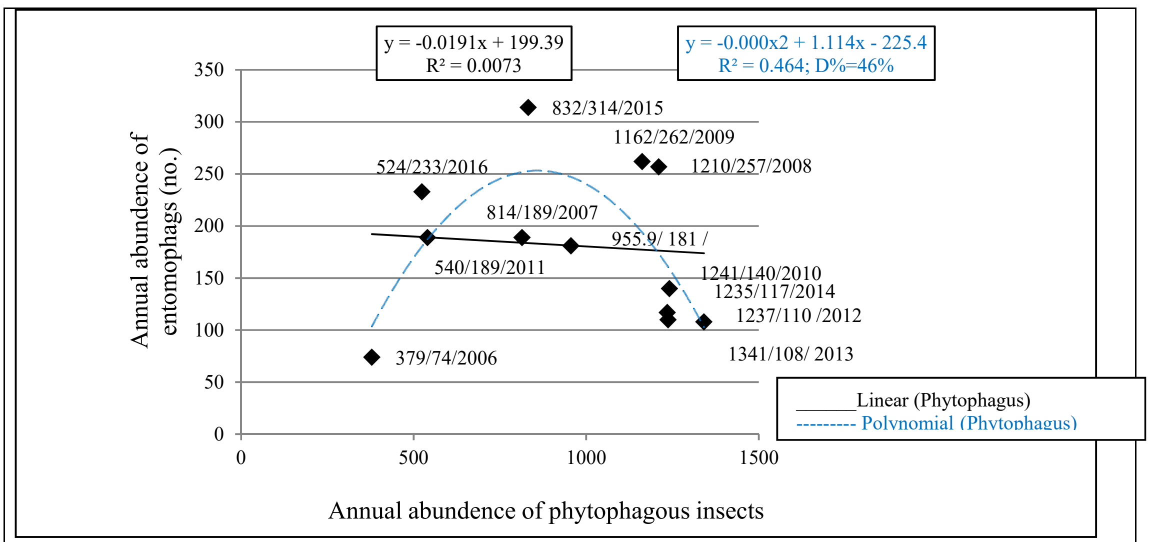


Figure 15. The annual abundance of entomophagus according to the abundance of wheat pest insects, during 2006-2016, at ARDS Turda (collected by decadal 100 double, sweep-net catches) (Malschi et al., 2018)

The size of the phytophagous/entomophagus ratio was strongly correlated with the increase of the average annual temperatures, with a percentage determination coefficient D%=15.5%, having an optimum of the interactions at values of 6.3 phytophagous/1 entomophagus (Figure 16) and less well correlated with the annual rainfall (Figure 17) (Malschi et al., 2017, 2018).

At the level of 2015, under the current climate and eco-technological changes, obvious changes in species composition and some entomocenotic risk appeared, justifying the implementation of differentiated strategies for integrated management of pests of wheat (Figures 18, 19, 20, 21). In the open field system, the large oscillations of the phytophagus and entomophagus species were noted, under the impact of climatic changes and insecticide treatments in the applied phytosanitary complex.

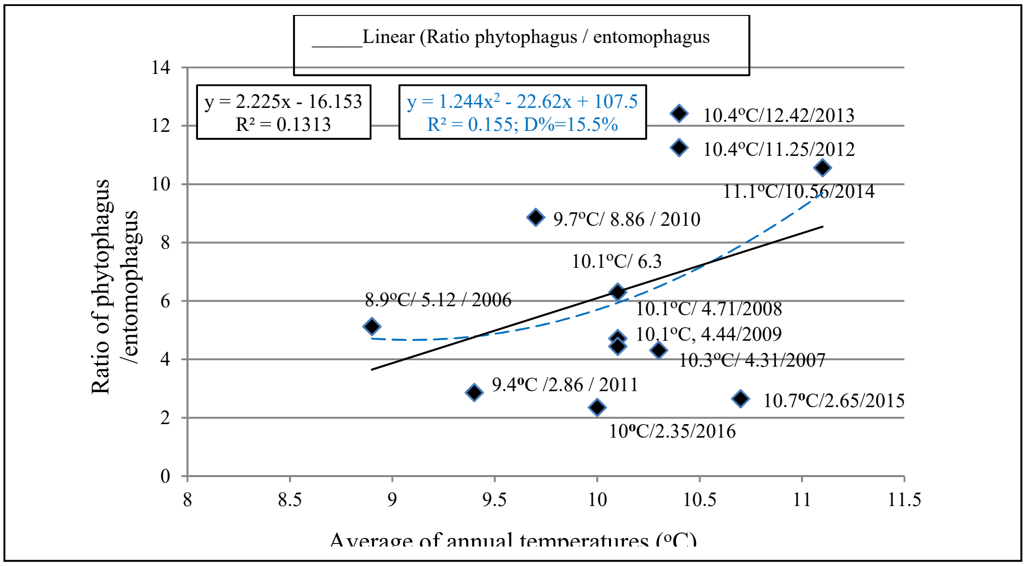


Figure 16. Ratio of annual number of pests of wheat and entomophagus according to average of annual temperatures, under the impact of climate warming in 2006-2016, at ARDS Turda (collected by decadal 100 double, sweep-net catches) (Malschi et al., 2018)

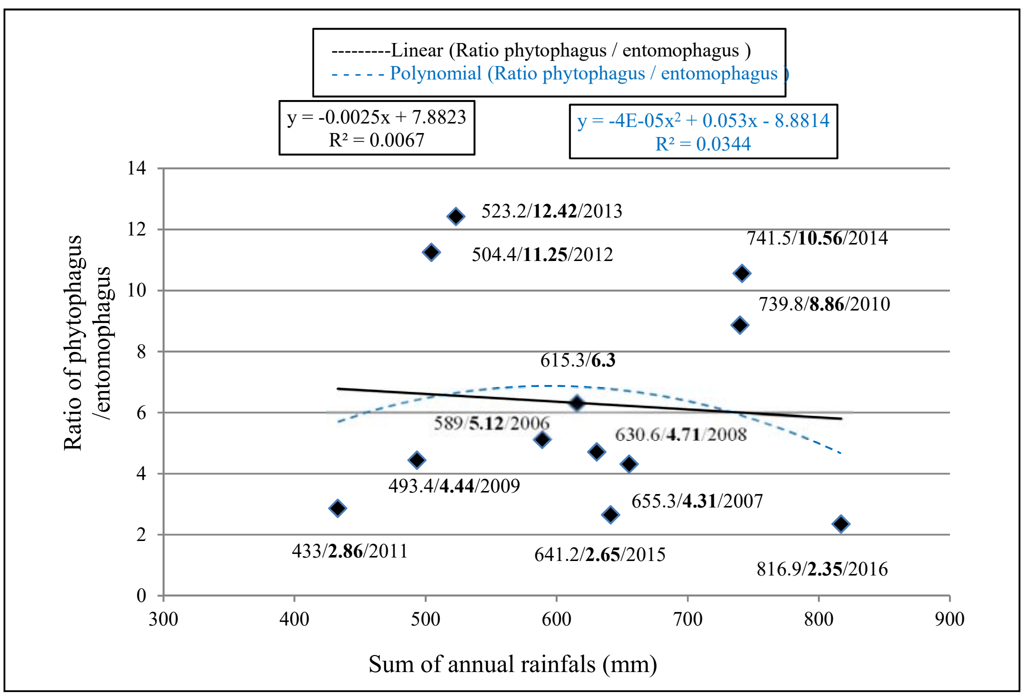


Figure 17. Annual numerical ratio between wheat pests and auxiliary entomophages according to annual rainfall (mm) between 2006-2016 at ARDS Turda (by decadal 100 double, sweep-net catches) (Malschi et al., 2018)

In the agro-forestry curtain system, for the last 10 years, the entomocenotic balance gained in the 66 years since planting protection curtains has been maintained, the natural limitation of the pests being effective, so that insecticide treatments were not required.

However, in some years, there are also some disturbances, massive concentrations of pests in the crop (flies Chloropidae, aphids, cereal sun bugs), in the conditions of **global warming**, **reduction of the abundance of auxiliary entomophagus from fields** (Carabidae) and **insecticide treatments applied to the seed and vegetation**, in the situation when the wheat cropping system is the type extensively practiced for the production of grain. Interesting to note that in the agro-forestry system an entomocenotic balance has been maintained, the same structure of damaging entomofauna as well as in the years 1980 to 1989 and the greater abundance of auxiliary entomophages than in the open field crops system (Malschi and Mustea, 1995, Malschi, 2003, 2005, 2007, 2008, 2009, 2014, Malschi et al., 2010, 2013, 2015) (Figures 18, 21, 22, 23).

In the no-tillage farming system, after 10 years of observations, the dominant groups of pests (thrips, wheat flies, leafhoppers, aphids) have been stabilized with higher structural weights than in the conventional-ploughed farming system, as a result of consolidating entomocenotic interactions under the action of no tillage technology, which includes the effects of: no ploughing, maintenance of the ground plant residues after harvest, green cover crop land with for maintaining soil moisture, etc., which stimulated the development of pest populations and entomophagus. In the phytosanitary applications, particular attention must be directed to preventive methods and treatments with insecticides, pest monitoring, forecasting and warning of insecticide treatments. In the farming system with soil minimal tillage and no tillage, used to minimize the effects of drought and global warming, the increase of pest abundance of the groups of thrips, wheat flies, leafhoppers, aphids etc. has been noted, requiring adequate integrated control measures for these entomocenotic risk situations**.** In the open field area, with conservative soil system with minimal tillage or no tillage, the higher abundance of Diptera Chloropidae and Anthomyiidae, of leafhoppers and aphids is evident (Malschi, 2009, 2014, Malschi et al., 2010, 2013, 2015, 2017, 2018) (Figures 24, 25).

These changes in wheat entomocenoses, the biological potential accumulated over the last 10 years and in 2015 (Figures 15, 17, 18, 19) indicated the importance of adapting pest control strategies, which should include preventive methods, insecticide treatments on seed and vegetation, at warning or at optimal times of application (Figures 20, 21, 22, 23, 24, 25). It is necessary to protect and use entomophagus and flora biodiversity. The data on the abundance of wheat pests (Figure 20) and the abundance of entomophagus (Figure 21), accumulated in 2015 under different technological conditions, demonstrated the increase in the numerical potential of the aphids populations, of the flies Chloropidae and Anthomyiidae, of the leafhoppers and of the cereals sun-bugs, as well as the maintenance of high population values for wheat thrips, especially in untreated insecticide lots and in the non-ploughed conservative system, which justifies the application of complex measures of the integrated system of control, especially preventive.

It was also noted that in the variants with insecticidal treatments and in no tillage system the annual abundance of pests (especially aphids) was almost as high or even higher than untreated variants and ploughing variants respectively, demonstrating that under the conditions of 2015 the application of insecticide treatments had partial final effectiveness. At the same time, it was noticed that insecticide treatments applied at the optimum recommended moments did not have any side effects of limiting the activity of entomophagus, which reached higher numerical potential in the mentioned crop variants, especially the limiters of the thrips and aphids (Empididae - *Platypalpus* sp., Syrphidae, Aranea, Coccinellidae, Cantharidae, Nabidae) (Figure 21). These optimum moments of treatment were carried out: the first - applied on 17.04.2015, in Turda, in the open field area and on 19.04.2015 at the farm with the agroforestry curtains in Bolduţ; the second - applied on 2.06.2015, in Turda and on 25.05.2015, in Boltuţ (Figures 22, 23, 24, 25).

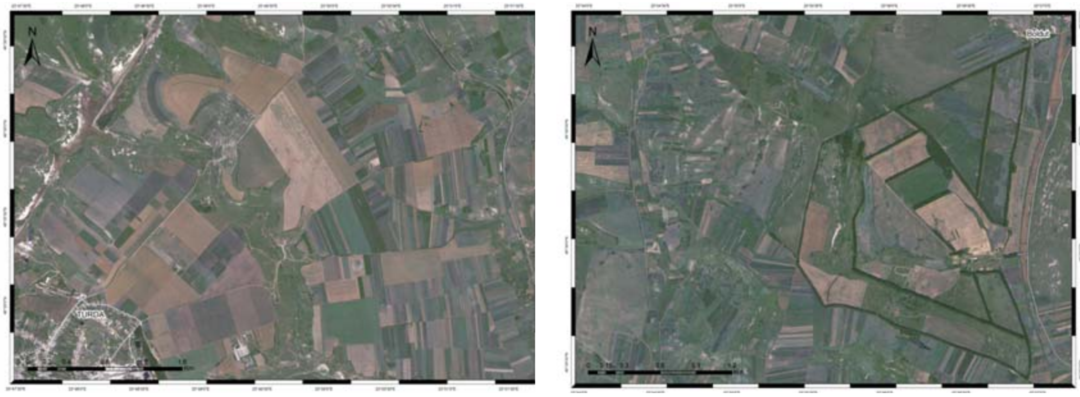


Figure 18 . Experimental plots from the ARDS Turda farms, in open field area at Turda with classical plowing and no tillage technology (left); in agroecosystem with foresty curtains, in Bolduţ (right), (Google Earth images).

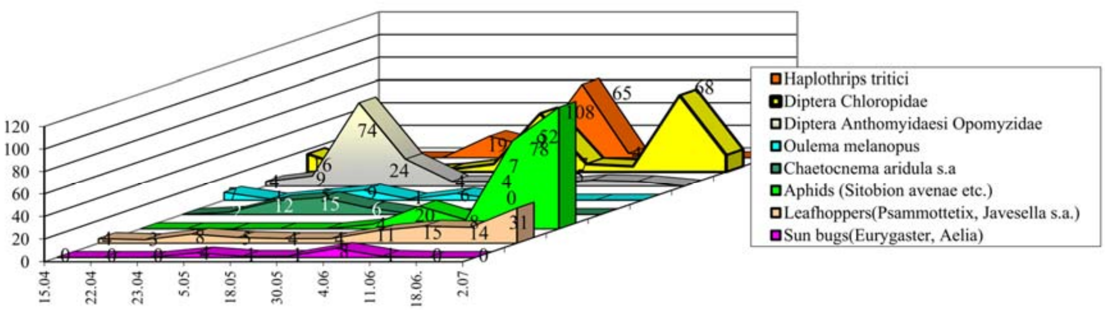


Figure 19. Pests dinamics in wheat crop at ARDS Turda, in 2015.

It was noted that the second treatment helped to limit the development of the larval stage of wheat thrips, along with the significant activity of entomophagus which developed abundant populations in wheat crop (Figures 22, 24). The development of aphid colonies on wheat spikes was initially limited by abundant aphidophagus populations, but developed in the last half of June, accumulating a significant biological and attack potential (Figures 23, 25), which required the use of specially integrated methods for aphids. Thus, for the population level and the current biological potential of the main groups of wheat pests, the recommendations on the application of an integrated agroecological system for the control of wheat pests specific to the central of Transylvanian area are justified, having a good efficiency on the pest control and being protective for entomophagous (Figures 26, 27, 28).

This integrated pest management system for wheat must include: - Respecting the optimum sowing period and seed treatment with insecticides, to prevent the attack of wheat flies, leafhoppers, aphids; - Planning of two vegetation treatments with insecticides, applied at the optimum time for the groups of pests that simultaneously attack: first treatment - in April, at the end of tillering phenophase, for wheat flies, leafhoppers, *Chaetocnema, Oulema* and others; 2nd treatment - in May, in the flag leaf phenophase - ear apparition phenophase, for the adults of thrips, aphids, cereal bugs, etc. In the case of a level above the Economic Threshold Damage of the ear pests (*Oulema*, thrips larvae, aphids, cereal bugs etc.), special treatments at warning may be required.

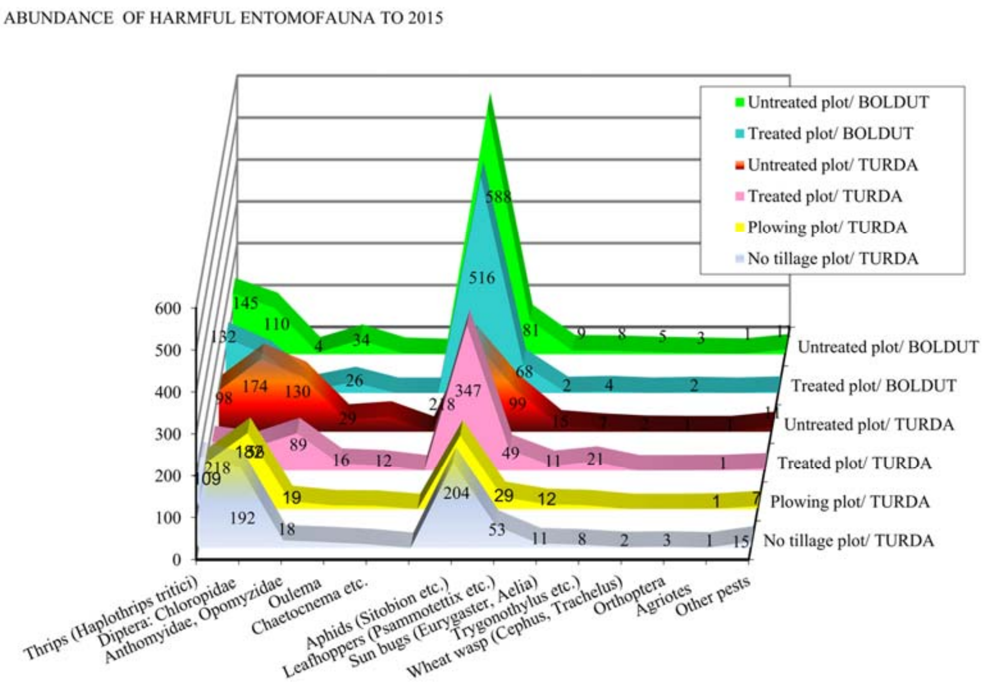


Figure 20. The annual abundance of pest populations from wheat crops at ARDS Turda in 2015 in different technological systems (the farm with the agroforesty curtains of Bolduţ, the Turda open field farm, the conservative technology with minimal soil tillage, with plowing and no tillage variants) (No. athropods collected annually by decadal 100 double sweep-net catches)

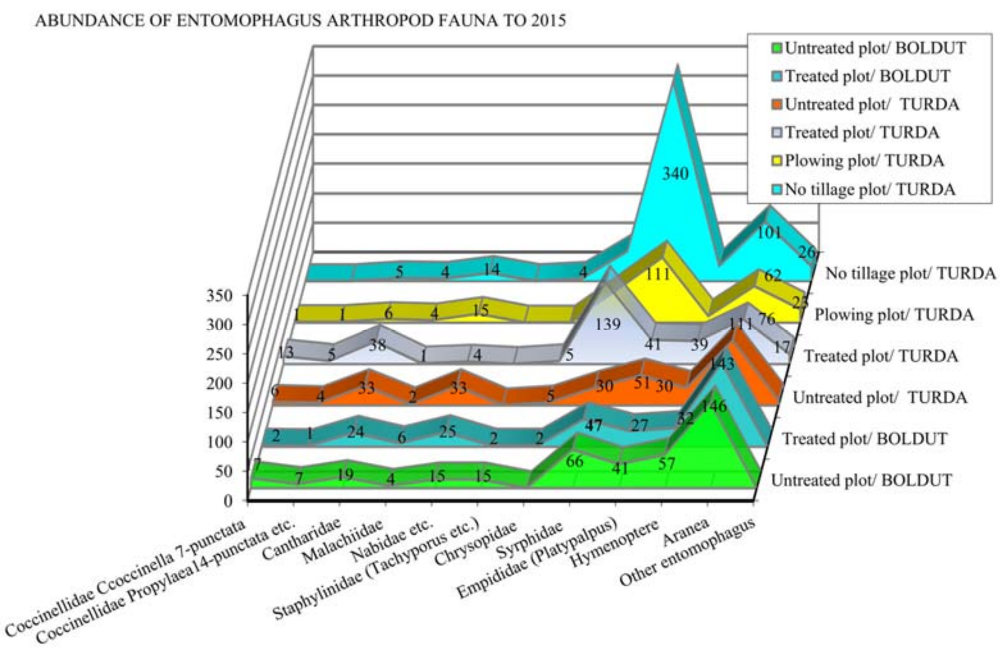


Figure 21. The annual abundance of entomophagus arthropods from wheat crops at ARDS Turda in 2015 in different technological systems (the farm with the agroforesty curtains of Bolduţ, the Turda open field farm, the conservative technology with minimal soil tillage, with plowing and no tillage variants) (No. athropods collected annually by decadal 100 double sweep-net catches / sample)

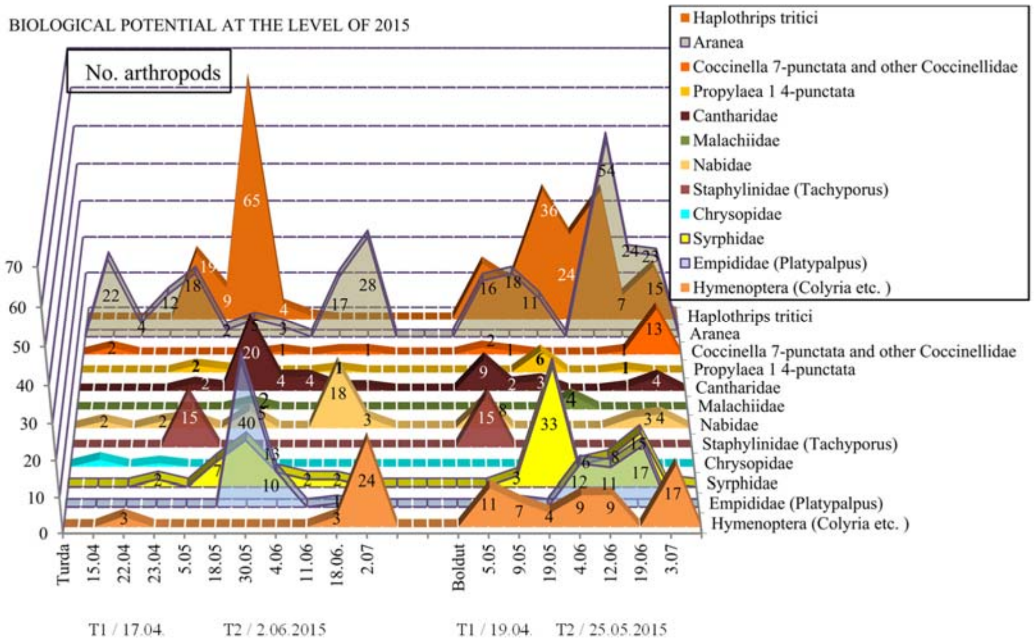


Figure 22. Structural interactions on the abundance and dynamics of thrips populations (*Haplothrips tritici*) in relation to the natural active entomphagus arthropods, indicating the moments of insecticide treatments (T1, T2) from wheat crops in open field conditions at Turda and in the farm with agroforestry courtains at Boldut (ARDS Turda, 2015) (No. athropods collected by decadal 100 double sweep-net catches/sample)

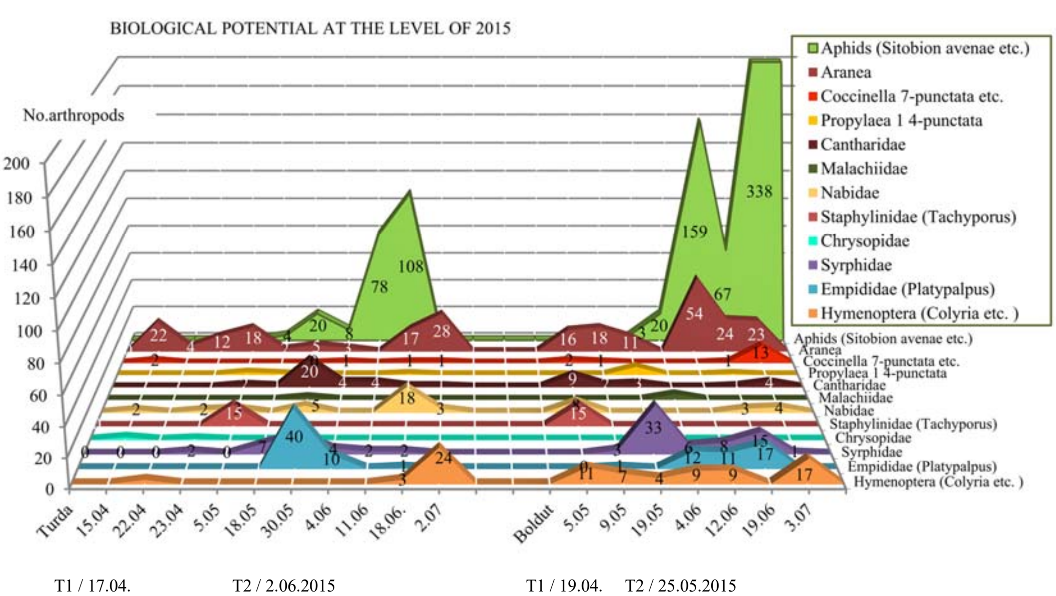


Figure 23. Structural interactions on the abundance and dynamics of aphids populations (***Sitobion avenae*** etc.) in relation to the natural aphidophagus arthropods, indicating the moments of insecticide treatments (T1, T2) from wheat crops in open field conditions at Turda and in the farm with agroforestry courtains at Boldut (ARDS Turda, 2015) (No. athropods collected by decadal 100 double sweep-net catches / sample)

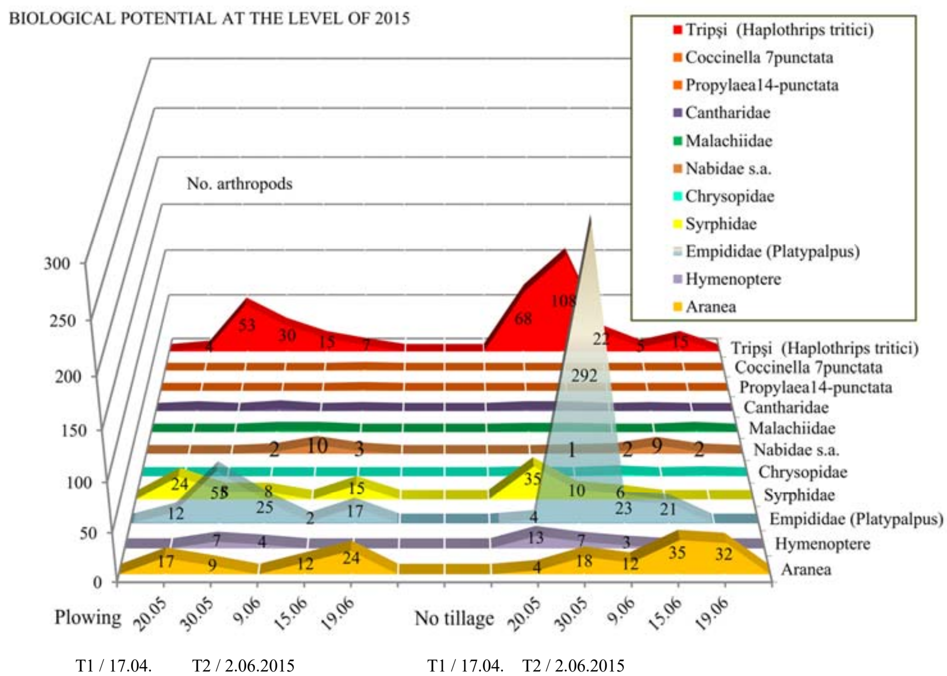


Figure 24.Structural interactions on the abundance and dynamics of ***Haplothrips tritici*** populations in relation to the natural active entomofage arthropods from wheat crops, indicating the moments of insecticide treatments (T1, T2), in the technology with plowing (classical) and no tillage (conservative) technology, at ARDS Turda, 2015.)

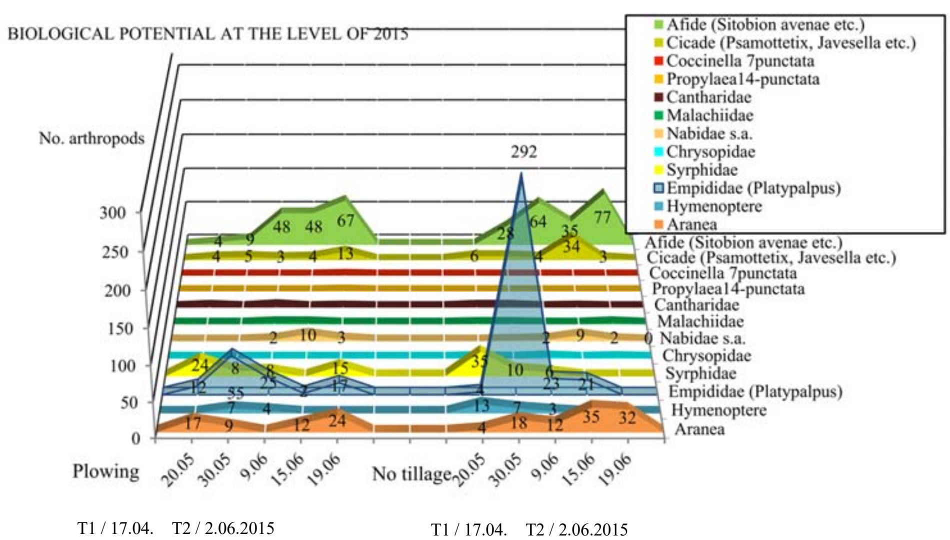


Figure 25. Structural interactions on the abundance and dynamics of aphids (*Sitobion avenae* etc.) and leafhoppers (*Psammotettix alienus* etc.*)* in relation to the natural active entomofage arthropods, indicating the moments of insecticide treatments (T1, T2) from wheat crops, in technology with plowing (classical) and no tillage (conservative) (ARDS Turda, 2015) (No. athropods collected by decadal 100 double sweep-net catches / sample)

Impact of treatments and technologies. Biological efficiency (E%), Entomophagous mortality (M%), positive effect on pest or entomophagous abundance (+Eff.%)

The immediate biological efficiency of insecticides applied at the two recommended treatment times in 2015, on pest abundance, at **Turda**, highlights (figure 26) the highest values after the first treatment: respectively 100% for Chloropidae and *Chaetocnema*, 84% for *Lema* adults, 53% for leafhoppers, and after the 2nd treatment, 91% for leafhoppers and 88% for sunbugs. As a particularity of the year, it is noted that the late explosive development of aphids colonies on ears occurred with higher values in the treated parcels compared to the untreated control. At the **Bolduţ** farm, the efficiency of the first treatment of 56% for *Lema*, 50% for sunbugs and 79% for leafhoppers is registered, and after the second treatment there are immediate good efficacy, 81% for Chloropidae, 80% for aphids, 54% for leafhoppers and 100% for sunbugs, but in June the populations of these pests developed more strongly in treated parcels, demonstrating the strong impact and secondary effects of application of insecticides on entomophagous natural limmiters of ear pests.

The immediate impact of insecticides on entomophagous mortality (Figure 27) after the first treatment was strong, reaching **Turda**: 50% for Coccinellidae, 67% for Nabidae, 78% for Aranee, 100% for Staphylinidae, and at Bolduț reaching: 63% for Nabidae and 87% for Staphylinidae.

The 2nd treatment had stronger side effects on entomophagous **at Turda**: 100% for Syrphidae and Empididae, 50% for Malachiidae and Chrysopidae. Towards the end of the wheat growing and maturing period, linked to the development of aphids colonies and other pests, Coccinellides with 80%, Cantharides with 90%, Chrysopides with 100% increased in treated parcels. The negative impact on Aranea was strong (-92%). **In Bolduţ**, the second treatment had immediate side effects on Coccinellids (-100%) and Hymenoptera (-67%). Long-term negative effects on Syrphidae (-87%), Empididae (-88%), Hymenoptera (-76%), and Aranea (-56) have been shown demonstrating the negative impact of treatments on the abundance of entomophagous.

Percentual total annual impact of insecticides and technologies on wheat entomocenoses, on pests and enomophagous population levels (Figure 28).

In the year 2015, the oscillations of various factors influenced the level of wheat pest populations, especially the ears pests: climatic conditions, delayed phenological development of wheat maturity, fluctuations of the population of entomophagous populations, impact of insecticide treatments, etc.

Throughout the vegetation period, from the spring until the harvest, the percentual total annual impact of insecticide technology (seed treatment + two vegetation treatments) on the thrips population was only -9% in Bolduţ and E = -29% in Turda. For the cereal bugs, the total annual impact of insecticides was: in Bolduț of -78%, in Turda of -27%.

In relation to the limiting activity of entomophagous, the pest dynamics in 2015 highlight the complex impact of insecticides in agroecosystems. Thus, on the entomophagous dynamics, the insecticides determined an annual mortality of 88% for Coccinelidae, 87% for Staphylinidae (Tachyporus) and 36% for Syrphidae, at Bolduţ, which means that the limiting activity of these entomophagous on thrips did not take place, being much diminished by application of insecticides. The annual numerical level of the population of thrips was similar in the two variants, treated and untreated, the annual biological efficiency of the treatments being only 9%.

As a result of the insecticide treatments in Turda, an 88% mortality was recorded only for Nabidae, the other entomophagous having a total positive impact on the development of the populations (for Coccinellidae by + 54% and for Nabidae by + 88%).

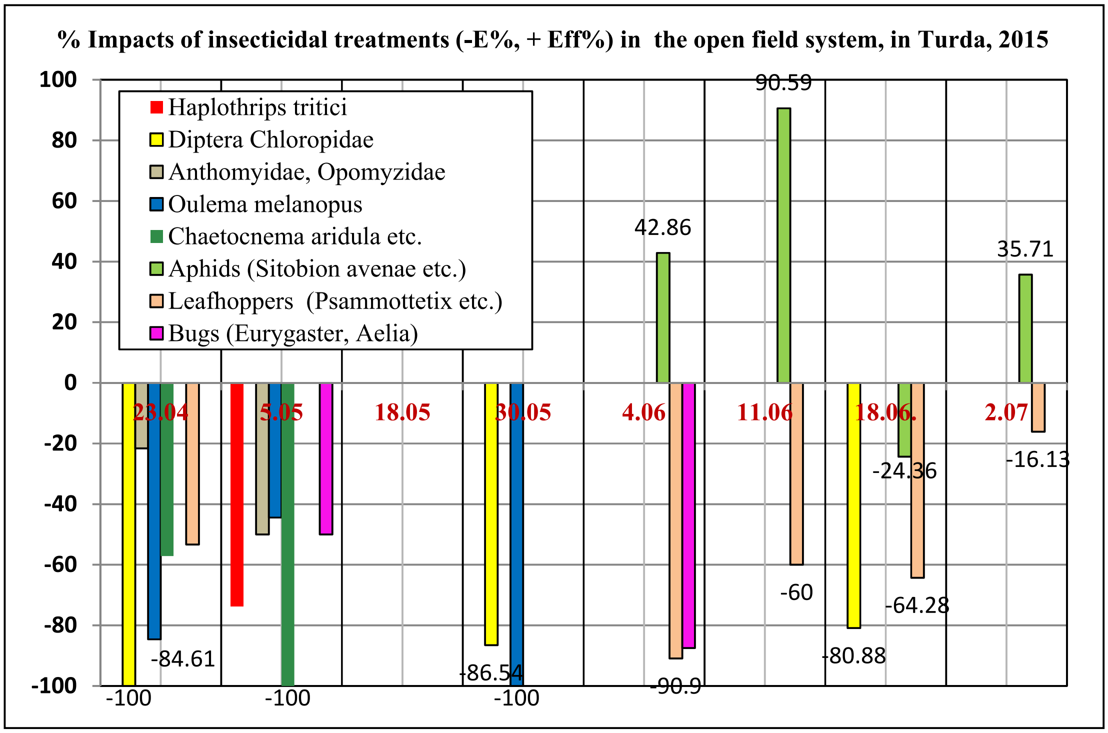
In the limitation of pests, the following annual total insecticide application efficiencies are reported: at *Lema* (-24% at Bolduţ and -45% at Turda); at Chaetocnema (-67% at Turda), at Chloropidae (-20% at Bolduţ and -58% at Turda), at Leafhoppers (-16 in Boltuţ and -51% at Turda) at aphids (-12% and + 37% in Turda), in the sunbugs (-78% in Bolduț and -27 in Turda). Except for the situation reported in sun bugs and aphids, the other pests recorded higher annual biological efficiency in Turda insecticide batches in the open field system compared to the annual efficacy achieved in the treated plots on the farm with protective forestry belts. The agro-forestry system in Bolduț favors the conservation of biodiversity, the numerical development of the arthropod entomofagous populations and their efficient activity in the natural limitation of the wheat pests.

Application of insecticides affects these auxiliaries in treated plots. It is noted that the activity of entomophagists in untreated plots on the Bolduţ farm has led to a level of pests similar to that of the treated parcels, which means that the natural entomophagus fund has a pest-limiting activity similar to that of the insecticides applied in the treated parcels and, at the same time, it is found that the total biological effectiveness of insecticides is lower on the farm with agroforestry curtains than at the farm in open field area from Turda. Thus, insecticides have caused an annual mortality in Boltuţ of 88% for Coccinelidae, 87% for Staphylinidae (Tachyporus) and 36% for Syrphidae; in Turda there was a mortality of 88% for Nabidae alone, while the other entomophagous found a positive impact on the development of populations of Coccinellidae (+54%) and Nabidae (+88%).

Under the conditions of 2015, the other groups of entomophagous active in the biological control of the wheat pests were more abundant in the treated plots, on the Bolduţ farm (Cantharidaele with +21%, Malachiidae with +33%, Nabidae with +40%) and also, at the Turda farm (Syrphidae with +78%, Coccinellidae with +54%, Cantharidae with +13%, Hymenoptera parasites with +32%), in direct relation to the late explosive development of aphids colonies on ears.

In the no tillage technology, compared with plowing technology (including insecticide treatments), the effect was on the growth of harmful populations, which highlights the fact that under the no tillage technology there is a development of harmful thrips (+50%), leafhoppers (+45%), *Lema* (+36%), aphids (+14%), flies (+5%). Under the experimental conditions, the no tillage system did not influence the final annual mortality of the entomophagous, the data caming from the variant treated with pyrethroids (Faster).

The no tillage system has not influenced the final annual mortality of the entomophagous who have rebuilt their populations, highlighting the fact that a number of very important entomophagous involved in limiting the thrips and aphids have been favored in the development of their populations by the no tillage system, respectively, a numerical increase by +67% of the Empidiidae (Platipalpus), 58% of the Hymenoptera parasites and 39% of the Aranea), this increase in numerical potential being in direct relation to the increase of the thrips and aphids at the no tillage system.



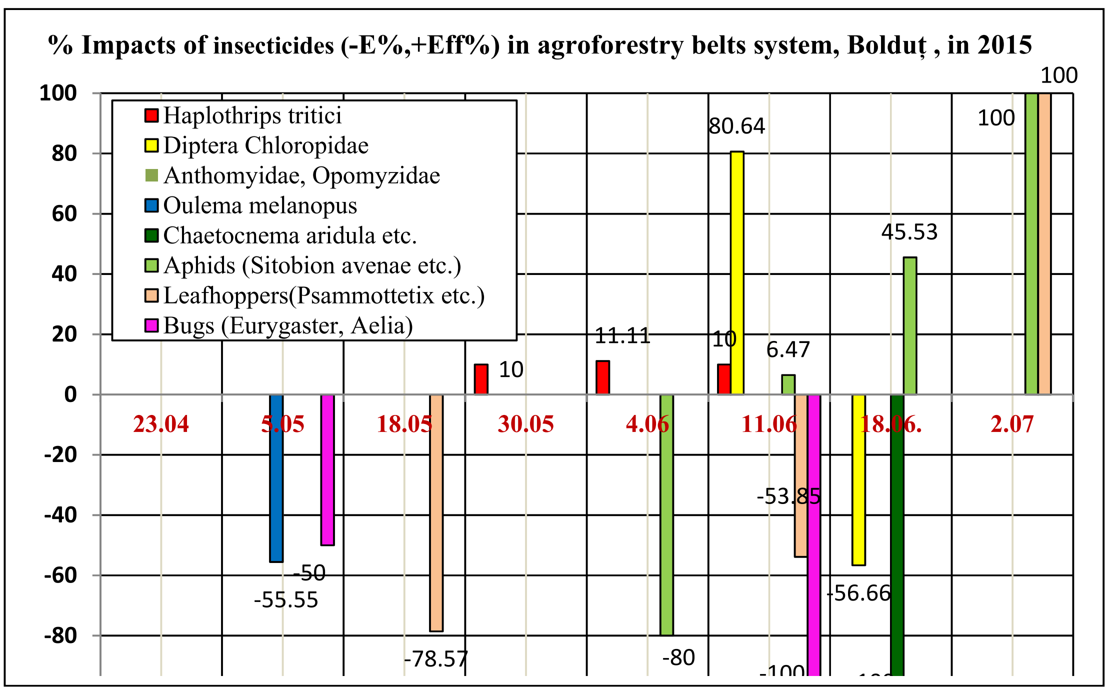


Figure 26. Biological efficiency or the side effect of insecticidal treatments (T1 and T2) on pests abundance, in open field at Turda and in agro-forestry belts system at Bolduț, in 2015.

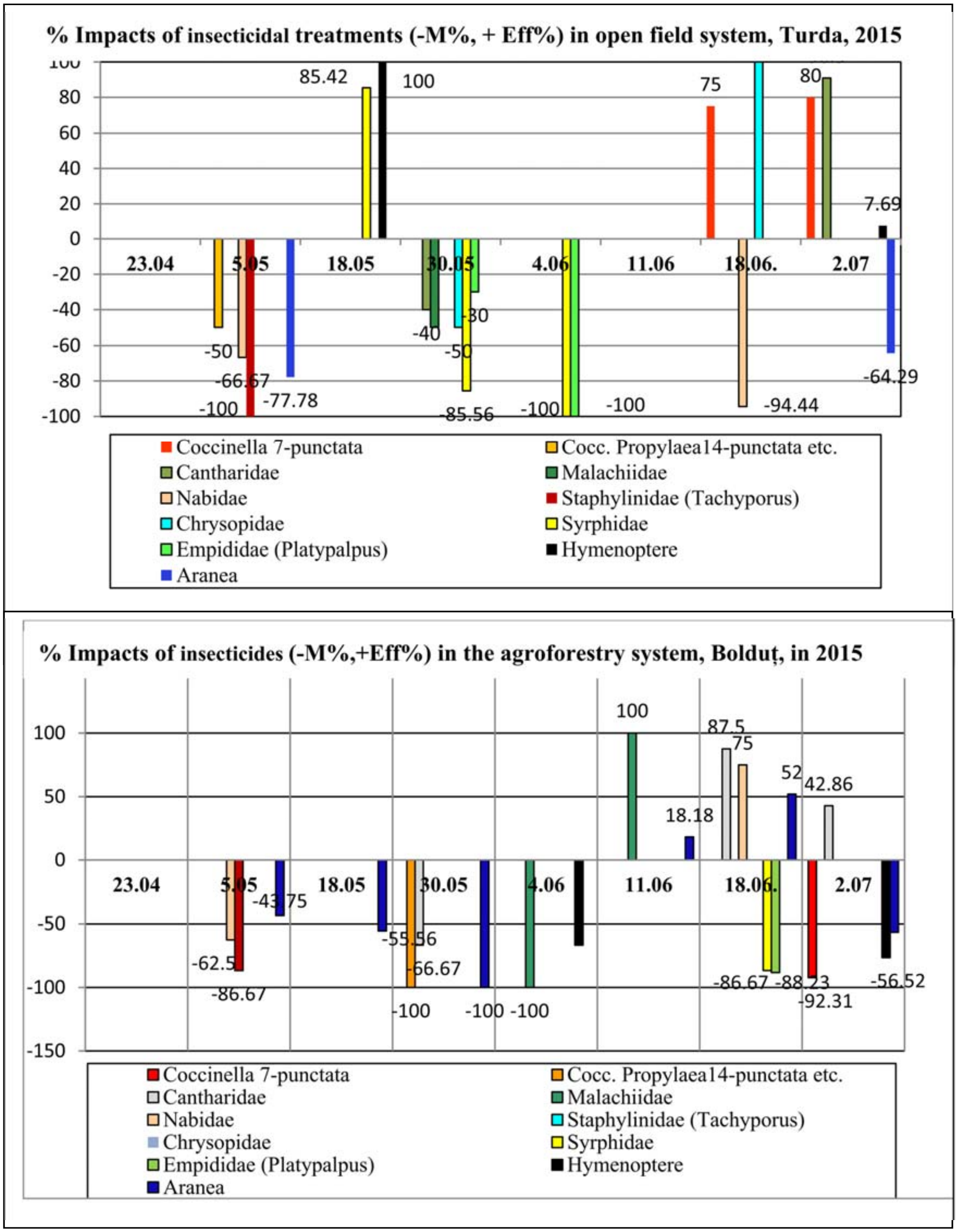
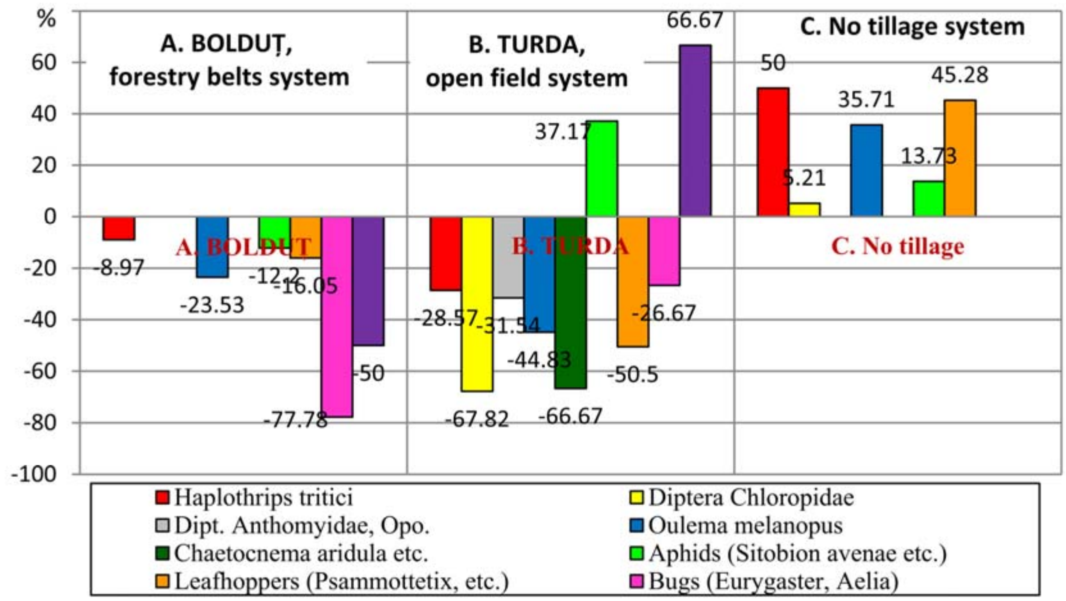
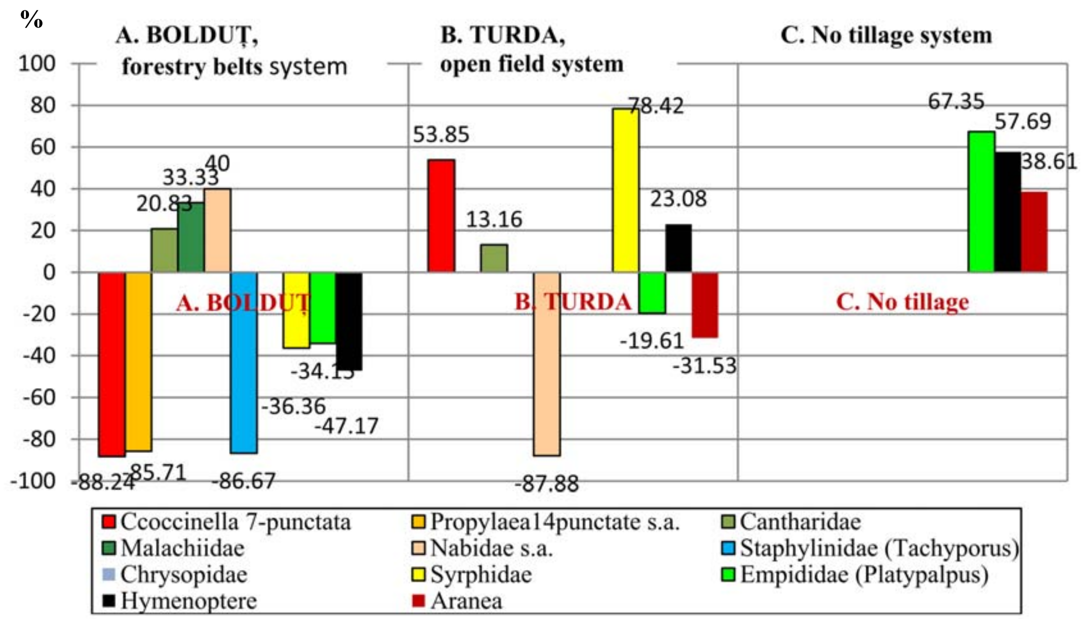


Figure 27. Percentual mortality or the +side effect after insecticidal treatments (T1 and T2) on entomophagous abundance, in open field at Turda and in agro-forestry belts system at Bolduț, in 2015.
Applications: in Turda: T1 / 17.04. and T2 / 2.06; in Bolduț: T1 / 19.04; T2 / 25.05.



% Impacts of the insecticidal treatments and technologies on the yearly abundance of wheat pests in 2015 (Annual efficiency/-E% or +Side effect /+ Eff.%)(TURDA: the I treatment/17.04 and II treatment/2.06. BOLDUT: the I treatment /19.04 and II treatment/25.05.2015)



% Impacts of insecticidal treatments and technologies on yearly abundance of entomophagous in 2015 (Annual Mortality/-M% or the +Side effect /+Eff.%)

Figure 28. Annual % Impact of the insecticidal treatments and technological systems on the early abundance of wheat pests and auxiliarly entomophagous.(In TURDA, in open field area: I treatment/17.04; II treatment/2.06ș in BOLDUȚ farm with protective forestry belts system: I treatment/19.04; II treatment/25.05.2015) and in Turda no tillage system)

6. Agricultural and environmental – entomological importance of Cean-Bolduț antierosional forest belts in Transylvania

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, 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, increasing of abundance and seasonal migration of useful entomophagous arthropods (Malschi and Mustea 1992, 1995; Malschi 2007, 2008, 2009).

From 1990 to the present, 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 (Plate 1, 2 and 3) 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 repetitions, in the three testing sites located 30 m away from the border and 30 m spacing between them in the middle of each lot (figures 29, 30).

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 (Plate 1, 2 and 3). Pest and live entomophags have been collected for laboratory studying of pest activity.

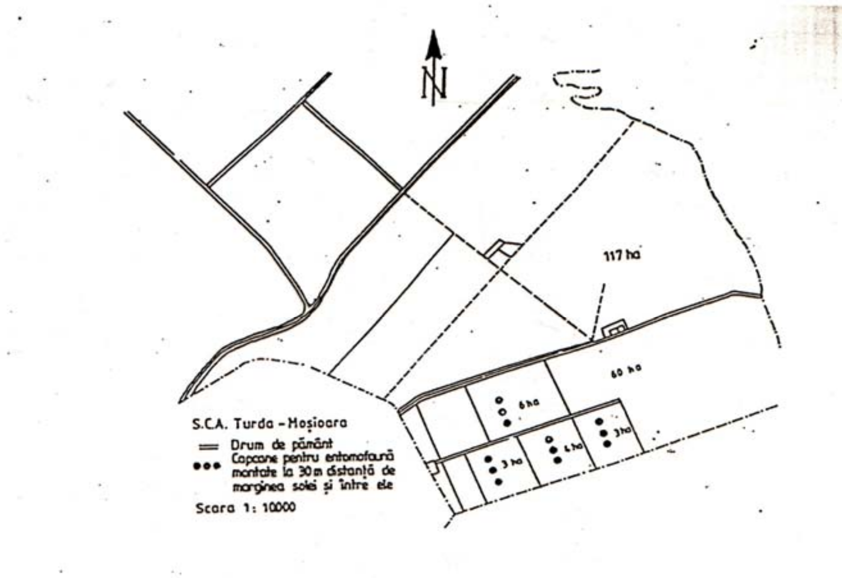


Fig. 29. The map of crop plots in Turda open field area and the place of catches for entomofauna.

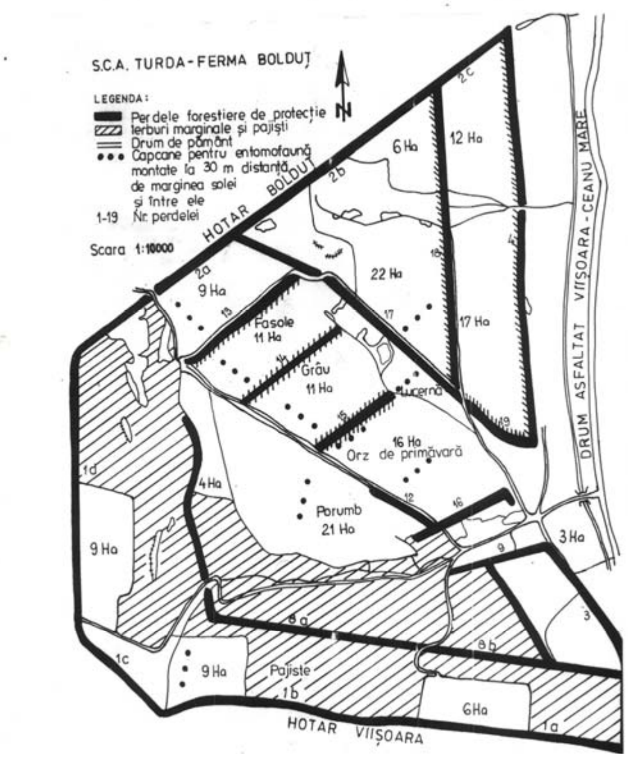


Fig. 30 . The map of forestry belts net in Cean-Boldut and the fields place of catches for entomofauna

(Agricultural Research and Development Station Turda

With 2 decades ago, at the level of 1997, 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 crop marginal grasses (Table 23, 24, 25).

Table 23. Structure and interactions between pests and entomophagous arthropod fauna in cereal agroecosystems in central Transylvania (1997)

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
Entomophagous	1230	41	462	19	219	52	-	-	1911	33
Total	**3017**		**2390**		**424**		**-**	**-**	**5831**	**40**
În agroecosistemul cu perdele forestiere, la Cean-Bolduţ. In the cereal agroecosystem with protective forestry belts, at Cean-Bolduţ										
Pests	715	18	485	27	115	21	609	25	1924	21
Entomophagous	3357	82	1307	73	438	79	1846	75	6948	78
Total	**4072**		**1792**		**553**		**2455**		**8872**	**60**
Total fields	7089		4182		977		2455		14703	

Table 24. Comparative abundance of pest and entomophagous arthropod fauna in the agroecosystem in open area (Turda) and with forestry belts (Bolduţ) (1997).

Cereal crops	Location	Winter wheat	Spring Cereals	Cereal crops	Location	Winter wheat	Spring Cereals
Pests		***No.***	***No.***	***Entomophagous***		***No.***	***No.***
Coleoptera- *.Phylotreta, Chaetocnema*	Turda Bolduţ	571 136	1029 215	Heteroptera-Nabidae	Turda Bolduţ	158 38	88 4
Col. *Oulema melanopus*	Turda Bolduţ	450 13	295 31	Neuroptera-Chrysopidae	Turda Bolduţ	5 6	1 11
Thysanoptera-*Haplothrips*	Turda Bolduţ	330 230	191 60	Coccinellidae	Turda Bolduţ	16 13	26 5
Homoptera-*Aphidina*	Turda Bolduţ	90 111	124 25	Malachiidae, Cantharidae	Turda Bolduţ	9 9	6 21
Homoptera-*Cicadina*	Turda Bolduţ	91 68	123 38	Carabidae	Turda Bolduţ	759 2814	139 938
Diptera-*Anthomyidae*	Turda Bolduţ	6 6	9 18	Sylphidae	Turda Bolduţ	78 161	2 99
Diptera-*Chloropidae*	Turda Bolduţ	131 65	107 35	Dipt.Empididae, Syrphidae ş.a.	Turda Bolduţ	45 15	15 11
Heteroptera-*Aelia Eurygaster etc.*	Turda Bolduţ	107 79	45 49	Hymenoptera	Turda Bolduţ	33 34	57 118
Hymenoptera etc.	Turda Bolduţ	11 0	5 5	Thysanoptera-Aeolothripidae	Turda Bolduţ	18 86	0 25
Ortoptera	Turda Bolduţ	0 7	0 9	Aranea	Turda Bolduţ	109 171	128 75
Pests total	Turda Bolduţ	1787 715	1928 485	Entomophagous	Turda Bolduţ	1230 3357	462 1307
Pests total		2502	2413	Entomophagous		4587	1769

Table 25. Annual abondance and structre of entomophagous carabid and sylphid in cereal agroecosystems in open area (Turda)and with forestry belts (Bolduţ) (1997)

Agroecosystems	**Turda (No.)**	**Bolduţ (No.)**
Total Carabidae	***1093***	***5265***
Poecilus cupreus L.	715	3643
Harpalus aeneus L.	28	200
Harpalus distinguendus Duft.	55	72
Harpalus rufipes De Geer.	224	480
Pterostichus melanarius Ill.	31	12
Dolichus halensis Schall.	27	389
Brachinus explodens Duft.	11	31
Carabus coriaceus L.	-	16
Carabus nemoralis Mull.	2	366
Sylphidae total	***94***	***974***
Sylpha obscura L.	81	894
Necrophorus vespillo L.	13	80
TOTAL	**1187**	**6239**

Agroforestry Belts and Sustainable Agricultural Development model of Cean-Bolduţ farm from ARDS Turda. Laying in the South-Western part of the Transylvanian Plain, the farm of Cean-Bolduţ is the beneficiary of a field crop antierosional system with protective forestry belts, planted since 1952. The farm comprises 323 hectars of arable land and pastures (183 ha of arable land, 105 ha of pasture land and 35 ha of hay meadows), surrounded by the 32 hectars of forestry curtains made of more than 36 tree and shrub species, maintaining almost completely the initial planting plan, and thus being the only one of this type in Romania**.** 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, 2009). 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 (Malschi 2009, 2014, Malschi et al., 2010, 2017, 2018).

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 (Figures 26, 27). 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*), (Lupe and 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 and 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). 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. The agroforestry belts made of trees and shrubs 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. Therefore, 66 years after their initiation, antierosional protective forestry belts 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 real entomocenotic equilibrium in the field crops with antierosional forestry belts 66 years after planting; thus, no critical pest attack situations have been recorded, and no insecticide treatment application has been required.

Under the conditions of climate warming during 2000-2008, in the open field 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 farm under the conditions of the climate warming and aridization, complete natural control of cereal leaf beetle *(Oulema melanopus)* and the limitation of some other cereal pest populations: aphides (*Sitobion avena* etc.) and thrips (*Haplothrips tritici*), at levels under the damaging economic threshold has been recorded.

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. The climate conditions and pest attacks represented real risk situations, and the application of insecticide treatment has been required, in the open field agriculture. 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 preserving auxiliary species in the crops.

Entomocenotic Characteristics of Forestry Belt 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 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 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 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; 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 exceeds the possibilities of natural self regulation through entomophags, insectidide treatments being required. **P**est aggression has shown value increases. Especially the climate warming, draught and aridization during the decisive periods of the crops, 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 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.

6. Conclusions on the integrated pest management of wheat crops in Transylvania in the agroecological and technological changes

Based on research conducted for over 40 years in central Transylvania, on the dynamics and importance of wheat pests and the analysis of the data of the last ten years in the changes of population and wheat pest attacks under the current climate and eco-technological changes, this work brings important clarifications, checked year after year in experimental lots at The Agricultural Research and Development Station Turda.

The study performed from 1980 showed the evolution of main cereal pest such as: Diptera, Homoptera, Thysanoptera, Coleoptera etc. at the Agricultural Research and Development Station Turda, in the center of Transylvania. During 2006-2015 periode, especially under the conditions of profound agro-ecological changes caused by climate warming, the integrated control strategy of wheat pest was elaborated in relation to increased pest abundance and attack. The study presents the adequate integrated pest management (IPM) methods under different wheat technologies: classical (ploughing), conservative no tillage system and protective agro-forestry belts farming system. The research results have comprised the IPM aspects of interest such as: dynamics of pest species; integrated pest control in accordance with technological factors, biotic factors, environment protection and the providing of environmental public goods associated with agriculture.

1. **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, 2007, 2008, 2009). 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 leafhopers (*Psammotettix*, *Macrosteles*, *Javesella*); thrips (*Haplothrips tritici*); wheat flea beetles (*Chaetocnema aridula*), cereal leaf beetles (*Oulema melanopus*), cereal bugs (*Eurygaster, Aelia*); ground pests (*Agriotes*, *Opatrum*, *Zabrus, Anisoplia*) etc. (Plates 4 and 5). 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).
2. **The current importance of pest and entomological risk situations for wheat crops in Central Transylvania.** Since 1980 until now numerous studies have shown the importance of wheat insect pests and entomophagous auxiliary artropods, pointing out the research evolution on the dynamics of pest attacks and risk situations. The study presents the importance of wheat pest in the Transylvanian Plain specifying the entomocenotic risk

situations in relation to climate change and cultural technologies, in agroforestry system and the open field area with traditional plowed system or with soil conservative no tillage system.

During 2006-2015, under open field area conditions at Turda, the entomocenotical particularities have revealed the eudominance of thrips – 57%; the dominance of dangerous populations of Chrysomelidae – 10%; of wheat flies –12%, of aphids – 14%, the important presence of leafhoppers – 4%, and of sunbugs – 2% in the pests structure. The abundance of pests represents a risk situation for the wheat crops. In Turda, the pest population explosions are reported in relation with the fluctuations of climate manifestations and also with the reduced abundance of entomophagous, which account for only **14%** in the arthropods structure. As compared to the traditional plowing system, in the conservative no tillage system the importance of the main pests such as thrips, flies, aphids, leafhoppers and soil pests (*Agriotes, Zabrus* etc.) should be highlighted. The large share of Chloropidae flies, aphids and leafhoppers has been observed. In open field area at Turda, this reality requires particular attention toward integrated control. 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.

In the case of Cean Boldut farm with agroforestry curtains a multiannual maintaining entomocenotic balance has been noted. The weight of the pest groups is equilibrated, the annual pest levels are constant without evidence of populational explosion. The entomophagous represents **24%** of arthropods fauna structure and has an effective natural pest limiting, therefore the insecticide treatments are not required.

3. In the study of wheat pest dynamics, of forecasting and current importance of the attack, to develop integrated pest control system in the center of Transylvania have been presented data about wheat pest attack in Transylvania in the last periode (2006-2016), under the different climatic, phenological and technological conditions, with details on the correlations of the climatic factors with the bio-ecology of species or pest groups. Such data may be important for modelling and forecasting wheat pest attacks.

The climatic warming, represented strong environmental factors (R^2=0.43), which led to changes in the species structure, favouring the development of the populations of a narrow spectrum of species becoming dominant and dangerous by numerical increases. Changes in entomocenotic interactions phytophagus-entomophagus, changes in pest dynamics, and of optimal moments for treatments important in the development of integrated pest control systems, have occurred in wheat crops.

In the conditions of the area, the annual abundance of entomophagus is determined by the annual abundance of phytophagous insects, as expressed by a positive correlation (R^2=0.464 and D%=46.4%). Under the conditions of the last 10 years**, the annual ratio of the number of phytophagous / entomophagus** fluctuated between 2.35 and 12.42. The size of the phytophagous / entomophagus ratio was strongly correlated with the increase of the average annual temperatures, with a percentage determination coefficient D%=15.5%, having an average values of the interactions at 6.3 phytophagous / 1 entomophagus, and less well correlated with the annual precipitations.

These changes in wheat entomocenoses, the biological potential accumulated over the last 10 years and at the level of 2016 indicate the importance of adapting pest control strategies, which should include preventive methods (respecting the optimum sowing time, agro-technical and phytosanitary methods), insecticide treatments on seed and on vegetation, at optimal application times for the groups of pests whose attacks overlap. Respectively, the first treatment is recommended in the spring, no later than the end of tillering, for wheat flies, leafhoppers, Chrysomelidae etc.; the second treatment is recommended at the phenophase of flag leaf stage and ear appearance, for thrips, aphids, bugs etc.; and other treatments are recommended at warning. Given the importance of entomophagous arthropod fauna in limiting wheat pests it is necessary to protect and use the auxiliary entomophagus, flora biodiversity involved in achieving the productivity and stability of wheat crops.

The study highlights the importance of long-term research (1980-2016) for specifying the structural changes in the weight of major pests and justifying the adaptation of the integrated pest management (IPM) system to the changing bio-eco-climatic and technological conditions. Thus, in the current period, not only thrips is a very important wheat pest but, **again become important wheat flies, leafhoppers, aphids** (especially by the autumn attack); **wheat flies, Chrysomelidae, leafhoppers** (mostly by the spring attack); **thrips, aphids, cereal bugs** and so on (especially by the attack of May and June-July).

The study allows the modelling and forecasting of the attack in relation to the biological potential of the pests and auxiliary entomophagus, as well as to the climatic and technological conditions.

For the current period, **the importance of adapting IPM to the groups of pests** that are simultaneously attacking and / **or updating the IPM by species** (based on previous research patterns) for certain Warnings Treatments was demonstrated. Under risky conditions caused by the attack of pests in relation with climate and regional agro-ecological changes, the IPM objectives are the achievement of yield safety, the attaining economic and ecological efficiency; the protection of environment and food quality; the protection and sustainable use of natural resources of biodiversity,

The following methods of control are recommended as p**reventive methods:**

- practicing the optimum sowing period in the second decade of October, to prevent the infestation of crops with wheat flies, leafhoppers, aphids;
- the seed treatment with insecticides;
- the choice of wheat varieties with high compensatory capacity after pests attack (especially after attack of Diptera larvae);
- the using and preserving the natural auxiliary entomophagus;
- the treatments with insecticides on vegetation, for the groups of pests whose attacks overlap as a result of climatic warming; the first optimal moment of treatment application is in April, at the end of tillering, and the second optimal moment of application is in May, in the flag leaf to the ear apparition phenophase; and the other special treatments at warning for *Oulema*, thrips larvae, aphids, sun bugs etc., with the protection of the auxiliary entomophagus present in the culture.

4. **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 (Plate 1, 2 and 3). The study proved the important role of biodiversity on farming model of agro-ecosystem with protective agro-foresty 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 pest 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*) (Plate 6).

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.

The auxiliary bio-ecotechnologies 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, increasing 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. The pest attack in the open field cereal biocenoses has been real risk situations requiring a complexity of repeated insecticide treatments. However, in the agro-forestry system, in some years, especially in the current period characterized by marked agro-ecological changes and **global warming**, there are also some disturbances, such as massive concentrations of pests in the crop (flies Chloropidae, aphids, cereal sun bugs), **reduction of the abundance of auxiliary entomophagus from fields** (Carabidae) after the **insecticidal treatments applied to the seed and in vegetation**, in the situation when the wheat cropping system is the type extensively practiced for the production of grain. Interesting to note that in the agro-forestry system an entomocenotic balance has been maintained, the same structure of damaging entomofauna as well as in the years 1980 to 1989 and the greater abundance of auxiliary entomophages than in the open field crops system (Malschi and Mustea, 1995, Malschi, 2003, 2005, 2007, 2008, 2009, 2014, Malschi et al., 2010, 2013, 2015).

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 agroecosystem with protective agro-forest belts it is achieved favorable results on the erosion control and land degradation limitation, at the last years conditions, characterizing by arid microclimate with excessive dryness and warmth, or excessive rainfalls, hurricanes, windiness and landfalls; it is achieved favorable results on the evolution of soil quality by the accumulation of organic nitrogen residues (especially chitin), important resource for the formation of humic compounds and important results on the farm productivity and sustainable development.

This agroecosystem with protective agro-foresty belts can be a model of organic farming, of conservation and biodiversity use, a strategy for sustainable development of agriculture in the area of central Transylvania.

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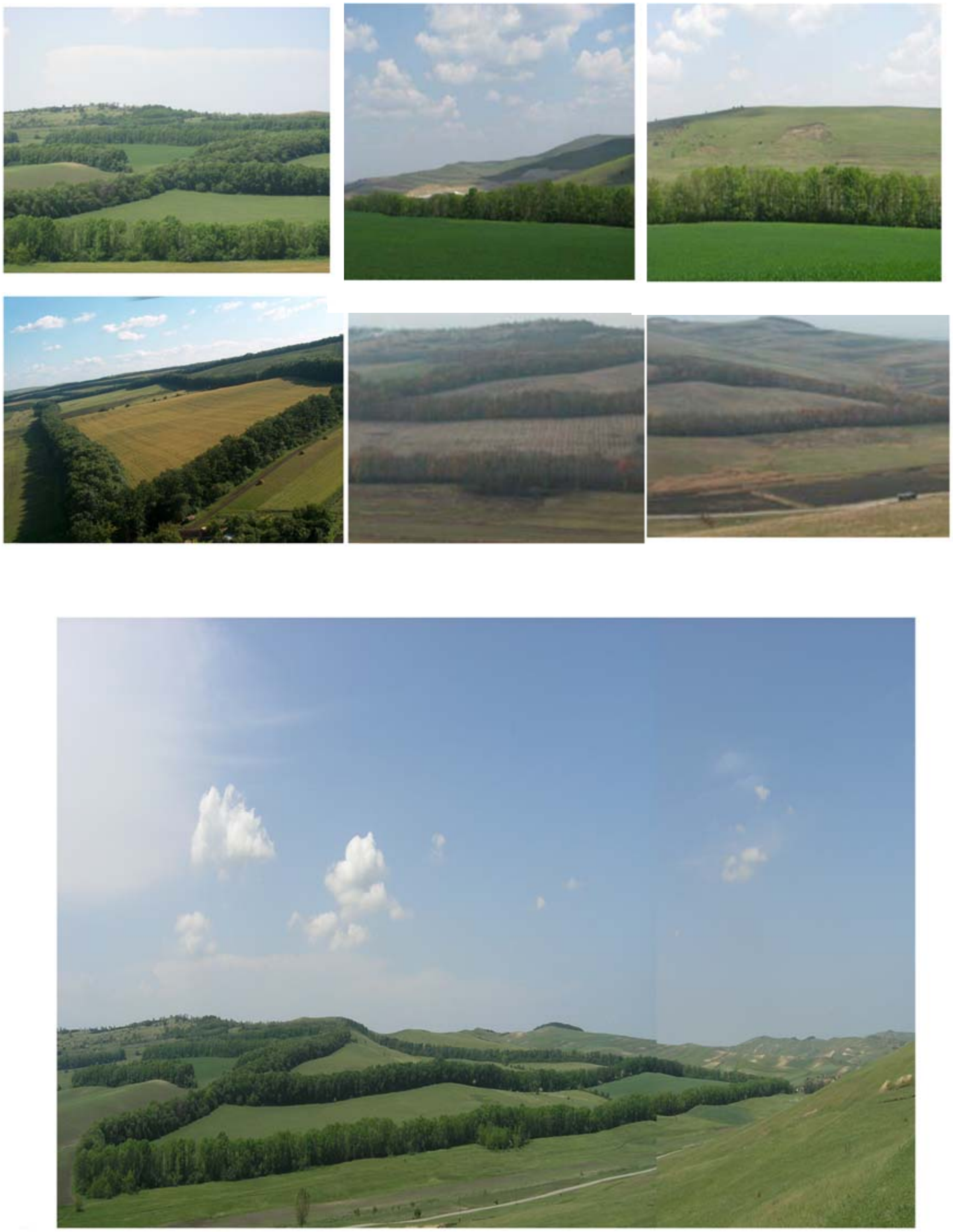

Plate 1. Aspects of the farming system with protective agro-forestry belts at Cean-Bolduț (2007, 2011)

Plate 2. Aspects of cereal agroecosystems situated in open field area with antierosional terraces

at A.R.D.S. Turda (2007, 2009).

Plate 3. Aspects of cereal agroecosystems situated in open field area, with no tillage soil conservative technology, in 2018 at A.R.D.S. Turda.

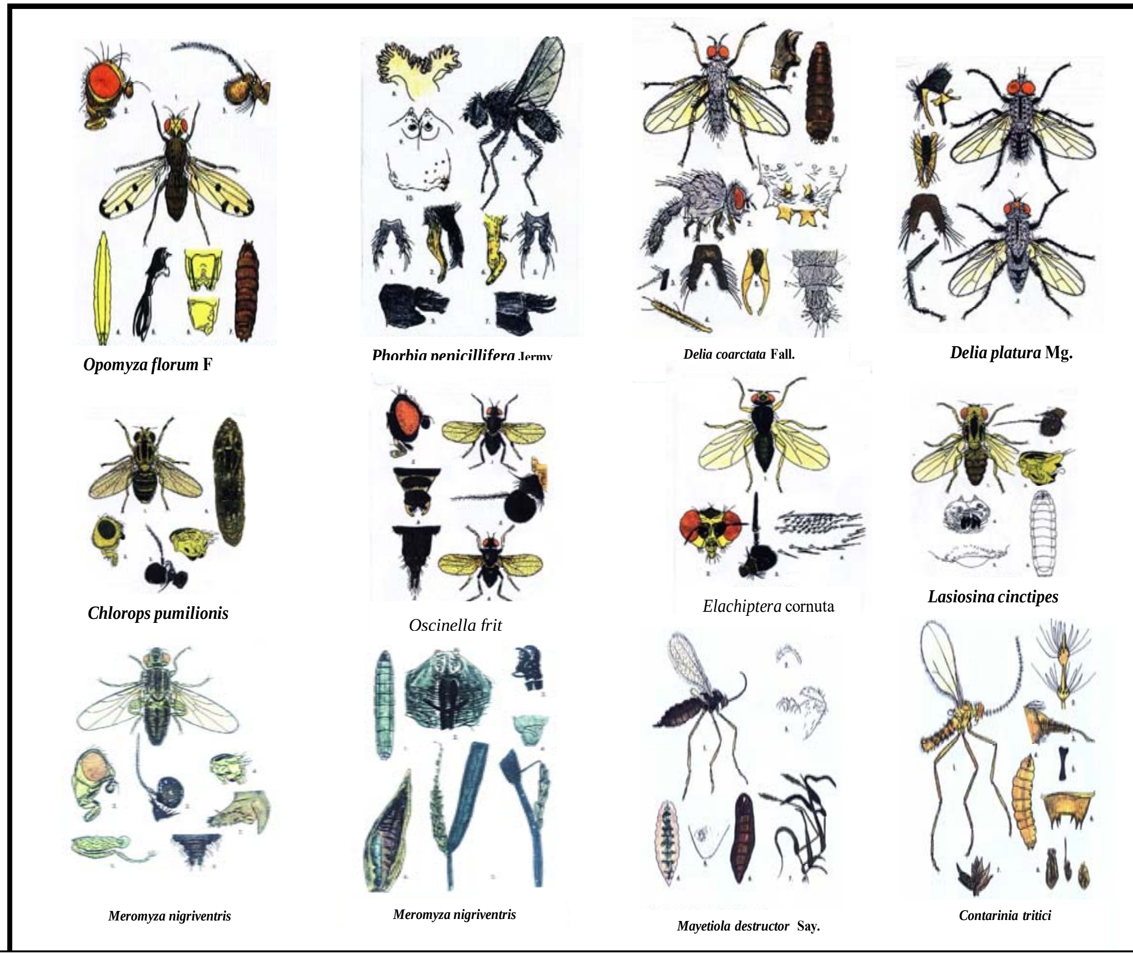

Plate 4. Phytophagous wheat flies (Malschi, 1975, 1976, 1997, 2007, 2009, from Radu V.Gh. & Florica Vasile, 1967, Balachowschy & Mesnil, 1935)

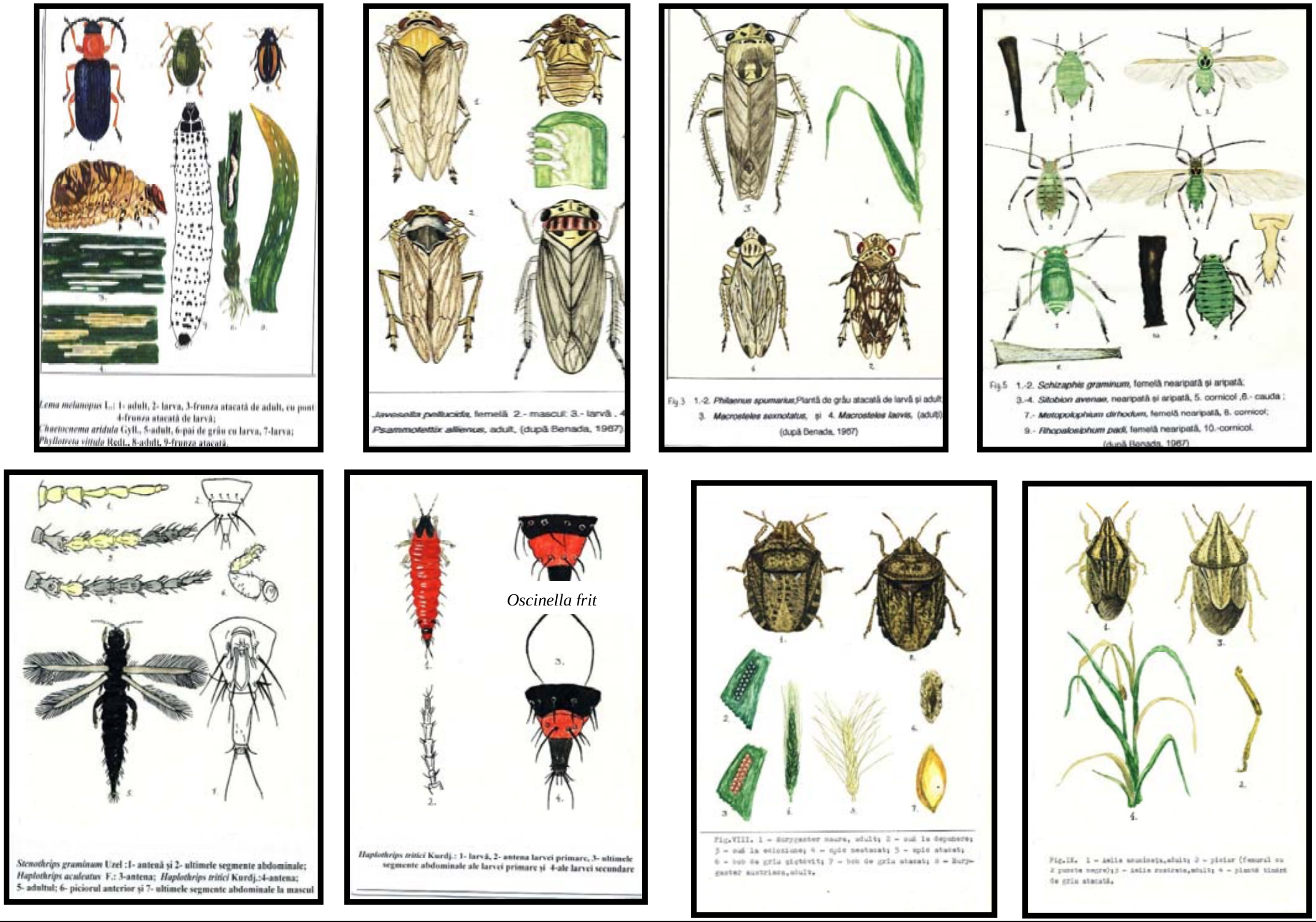

Plate 5. Wheat pests (Malschi, 1975, 2007, 2009, from Emilia Baniță, 1974, Benada, 1967, Săvescu, 1962).

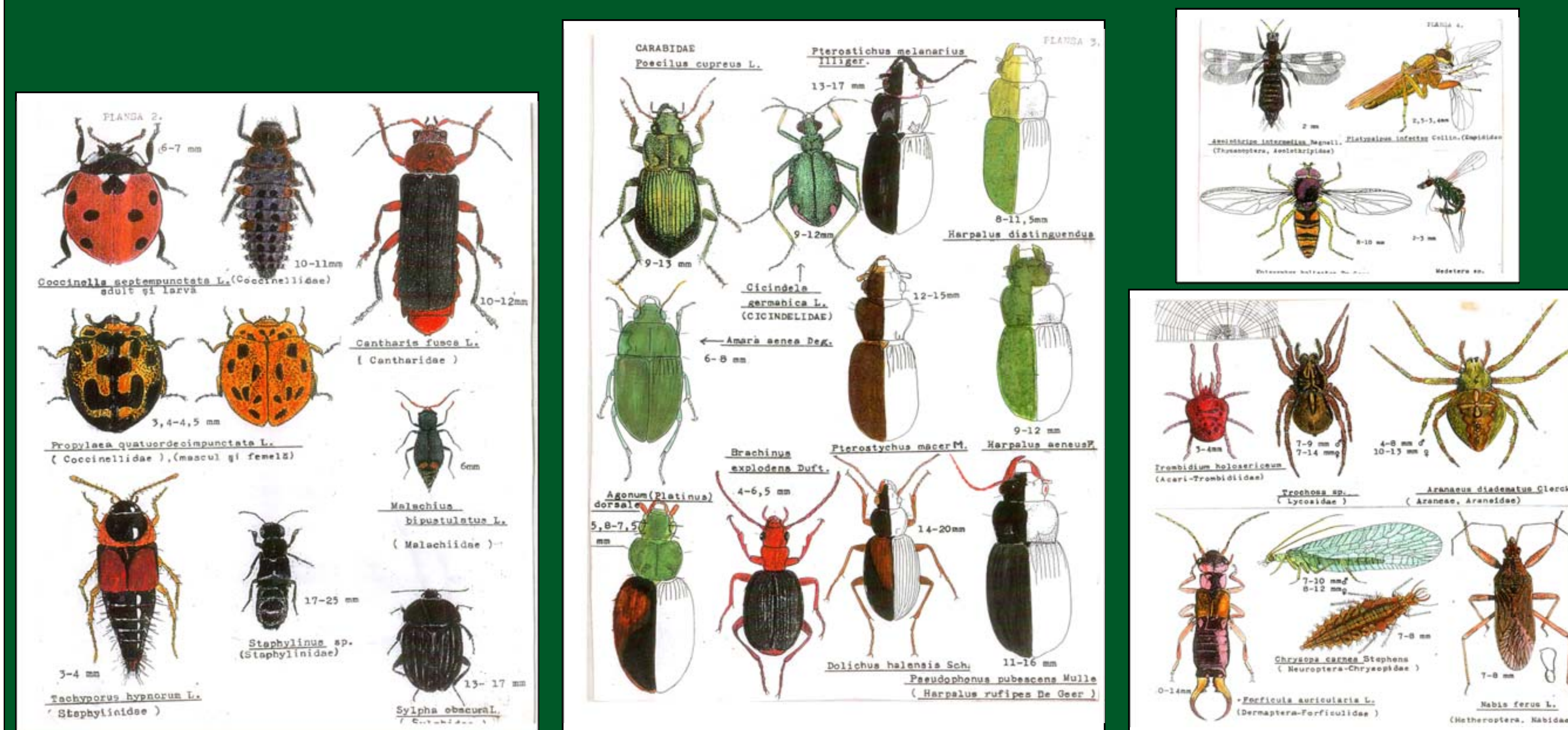

Plate 6. Entomophagous arthropods from cereal agro-biocenoses in the center of Transylvania
(Malschi, 2009, from Cîndea, 1986, Panin, 1951, Reitter,1908, 1911, 2012, Trautner & Geigenmüller, 1987, Wetzel et al., 1995)

The author is known within the specialists community in the field of plant protection as a dedicated scientist showing scientific accuracy in her scientific works, professional dedication in her research presented in over 200 published scientific papers. The elaborated book, entitled "Integrated pest management in relation to environmental sustainability. Part II. Wheat pest management under the dynamics of agroecological changes in Transylvania" is a study continuation of the previous books from 2007, 2008, 2009, with another 10 years research results carried out at Agricultural Researches and Development Station Turda of the Academy of Agricultural and Forestry Sciences. These research results have been obtained with the collaboration of the researchers involved in performing the scientific field experiments from the Agricultural Researches and Development Station Turda.

The book is intended for researchers, students and all those involved and interested in the integrated pest control in field crops, and is a real contribution to the broadening of knowledge regarding the relation between the objectives of agricultural production and environmental sustainable management in the context of agricultural ecological and technological changes.