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WHEAT PEST DYNAMICS, FORECASTING AND CURRENT IMPORTANCE OF THE ATTACK, TO DEVELOP INTEGRATED CONTROL SYSTEM IN THE CENTER OF TRANSYLVANIA (ARDS TURDA, 2006-2016)

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ABSTRACT

The paper presents data about wheat pest attack in Transylvania in the last 10 years, under the different climatic, phenological and technological conditions, with details of the correlations of the climatic factors with the bio-ecology of the 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. In the years 2006-2015, the eudominance of thrips (58%), the dominance of aphids (14%) and of wheat flies (12%), the subdominant species of Chrysomelidae and the increase of entomophagus abundance were revealed. In the year 2016, the weight of the dominant groups of wheat flies (25%), aphids (21%), leafhoppers (18%), thrips (17%), of the subdominant group of Chrysomelidae (10.6%) and cereal bugs (4.5%) increased. 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 optimum of the interactions at values of 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 in the spring, no later than the end of tillering, for wheat flies, leafhoppers, Chrysomelidae etc.; the second treatment at the phenophase of flag leaf stage and ear appearance, for thrips, aphids, bugs etc.; and other treatments 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.

Key words: wheat pests, auxiliary entomophagus, structural entomocenoses interactions, integrated pest control.

INTRODUCTION

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 work brings important clarifications, checked year after

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year, in experimental lots at The Agricultural Research and Development Station Turda.

Knowledge about wheat pests and their integrated control is an important direction in the phytosanitary practice of wheat crop (Baicu and Săvescu; 1978, Baicu, 1989; Bărbulescu et al., 1973, 2002; Mustea, 1973; Munteanu et al., 1973, 1983; Malschi et al., 1980, 2005, 2006, 2010, 2013, 2015; Malschi and Mustea, 1992, 1995, 1997, 1998; Malschi, 1980, 1982, 1993, 1995, 1998, 2000, 2001, 2003, 2004, 2005; Paulian et al., 1974; Popov et al., 1983, 1984, 2007a; Perju, 1968, 1999; Perju et al., 1989; Perju and Peterfy, 1968; Rogojanu and Perju, 1979; Roman et al., 1982, mentioned by Malschi et al., 2016.)

The integrated management systems of wheat pest have been extensively studied in Romania (Baicu, 1996; Bărbulescu, 1984; Bărbulescu, Popov and Mateiaş, 2002; Hulea et al., 1975; Malschi, 2007, 2008, 2009, 2014; Malschi et al., 2012, 2016; Mărgărit et al., 1984; Paulian et al., 1974; Perju, 1983; Popov, 1979, 1983, 2003; Popov and Bărbulescu, 2001, 2007; Popov et al., 2001, 2003, 2006; Roșca et al., 2011). Comprehensive studies of great importance were performed on cereal sun bugs (Popov, 1983, 1984, 1999, 2003 b., 2003 c.), on wheat thrips (Baniţă, 1976; Malschi and Mustea, 1992; Malschi, 2001, 2009); 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 (Baniţăet al., 1971; Petcu and Popov, 1978; Popov et al., 1989), on aphids (Bărbulescu, 1965, 1972, 1975, 1982; Malschi et al., 2003, 2006, 2013 a; Malschi, 2008, 2009); on leafhoppers (Munteanu, 1973); on wheat flies (Bărbulescu et al., 1973, 1984; Malschi, 1980, 1982, 1993, 1998, 2001, 2007; Malschi and Mustea, 1992; Malschi et al., 1980; Malschi, 1980, 1982, 1993, 1998, 2001, 2007, 2008, 2009; Popov et al., 1983, 2003 b) or on the pests from soil and on the seed preventive treatments for *Zabrus* corn ground beetles**,** wireworms, aphids etc. (Popov et al., 1996, 1997, 2001 a, b, 2007 d, 2010), mentioned by Malschi et al., 2016. Also 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, 1999; Popov et al., 2009; Roşca et al., 2008 etc.).

During the last four decades (1974-2016), more than 50 insect species of pests have been highlighted in the structure of enthomocenoses of the wheat crops at the Agricultural Research and Development Station Turda, in central Transylvania. A specific complex of pests has been observed consisting of Diptera species (wheat flies)*:* *Opomyza florum* F., *Delia coarctata* Fll*.*, *Phorbia securis* Tiensuu*, Ph. penicillifera* Jerm*y, 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*.* (Malschi et al., 1980, 2003, 2005, 2013 a, b, c, 2015, 2016; Malschi and Mustea, 1992, 1997, 1998 a, b; Malschi, 1980, 1993, 1998, 2003, 2007, 2008, 2009, 2014).

The research has also revealed the presence of a useful natural entomophagous arthropods fauna characterized by the species richness and the efficiency in limiting activity of phytophagous insects. Parasites and especially predators were signalled (*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 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 1). 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).

Table 1. Composition of prey and feed ratio of the main predators of cereal pests in laboratory tests (Malschi, 2007, 2009)

Phytophagous: / Entomophagus predators:	Number of phytophagous consumed / day / individual predator										
	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	-	-	-	-	-	-

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).

MATERIAL AND METHODS

During 2006-2016 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 investigations were conducted in wheat crop on large experimental lots: in different cultural systems (the agro-forestry system with curtains, the open field system with traditional ploughing or conservative-no tillage). In the no-intervention research lots all zone recommendations of technology and phytosanitary complex were 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 included an untreated plot and an integrated pests control plot with insecticides application for two different treatment moments: the first - at the end of tillering in the 25-33 DC stage, at herbicides application time, and the second - at flag leaf stage and ear appearance in the 45-59 DC stage.

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, entomophagus biological limiters) were carried out. 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 species dominance (%), by correlations and quadratic regressions in order to study wheat pest evolution, depending on climatic conditions, abundance of entomophages etc.

RESULTS AND DISCUSSION

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 agro-ecosystems. 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 the last 10 years (Figures 2, 3):
- 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 for Chrysomelidae and increasing the 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-ecoclimatic 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 2, 3) (Malschi et al., 2016).

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 2), (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.

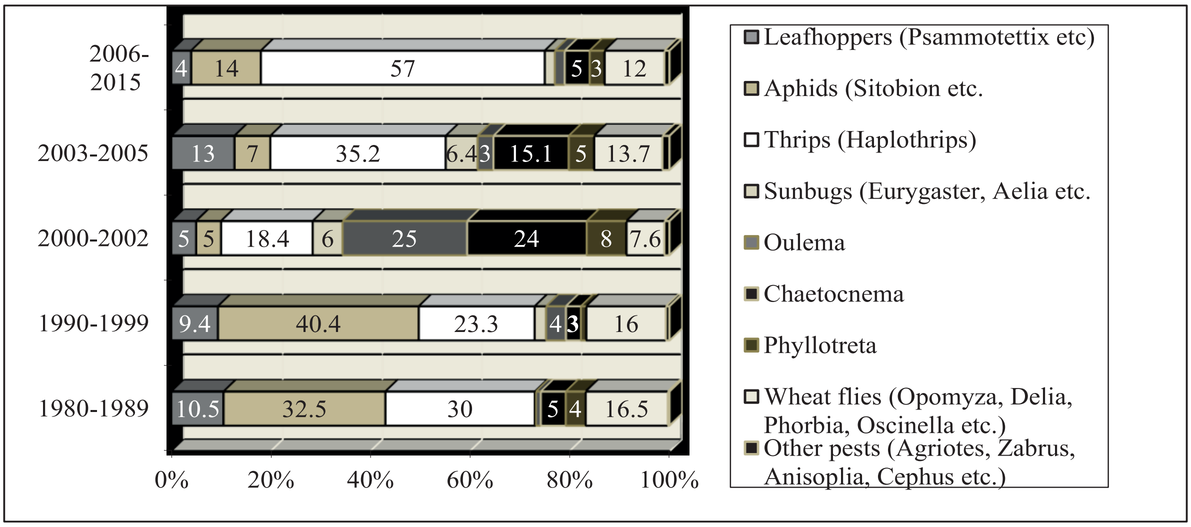

Figure 1. Structure of wheat pests (ARDS Turda, 1980-2015)

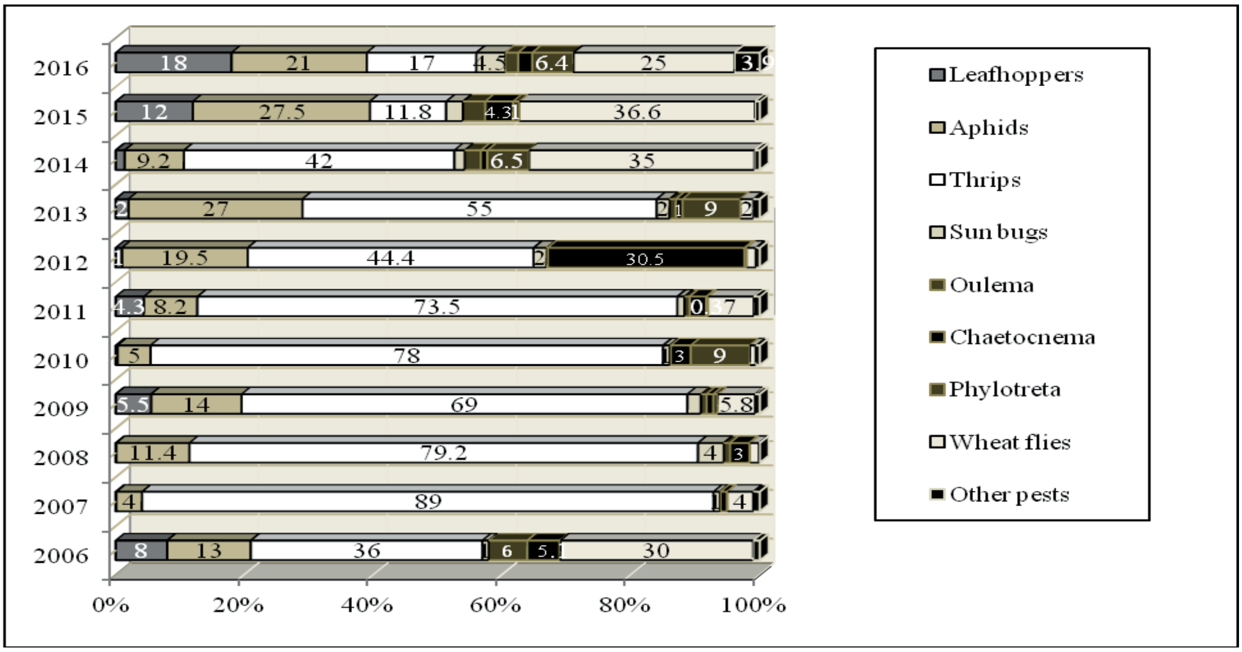

Figure 2. Annual structure of wheat pests (ARDS Turda, 2006-2016)

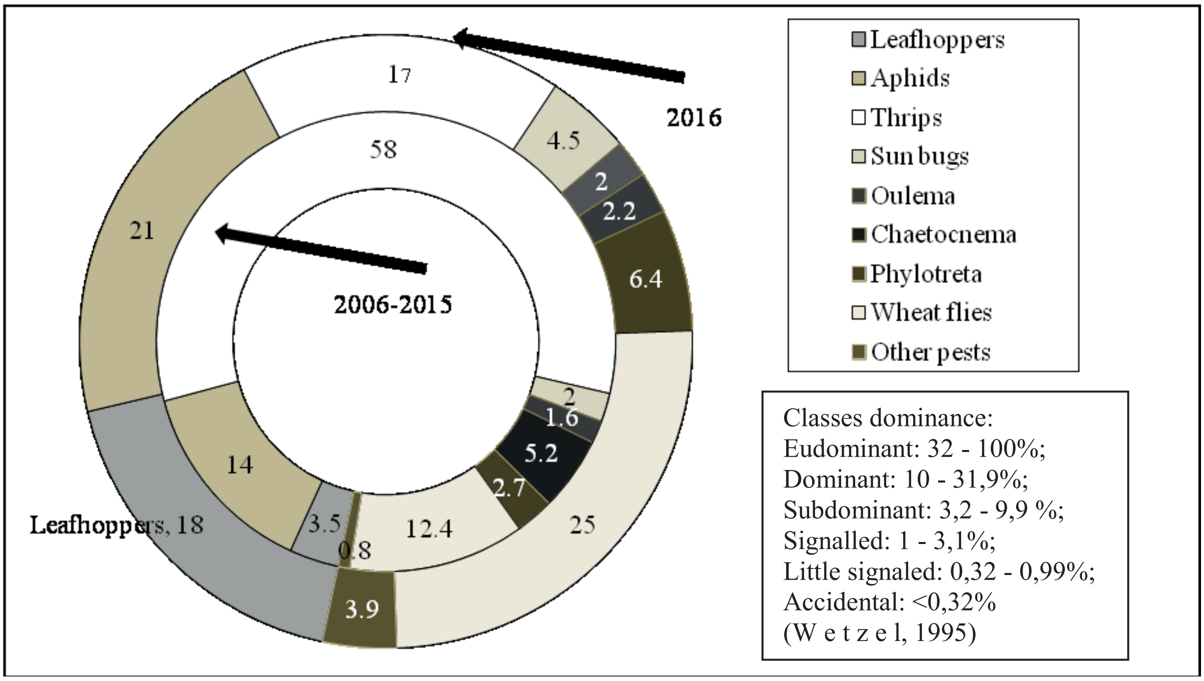

Figure 3. Structure of wheat pests in 2006-2015 period and in 2016 (ARDS Turda)

The wheat thrips structural weight was reduced to only 17% in the structure of the wheat pest (Figure 3). Entomophagus had a high weight of 29% in the structure of arthropod fauna collected from wheat.

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 the climatic and technological conditions (Figures 4, 5, 6). The years 2012-2015, characterized by increasing warming, 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) were still favourable 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 favourable to eudominant Diptera populations and to the further development of those of thrips, aphids, leafhoppers, cereal leaf beetles and sunbugs.

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: 4, 5, 6) (Malschi et al., 2016).

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 = 0.36). 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 4).

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 arthropods 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 5) (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 6) (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 (Malschi et al., 2016).

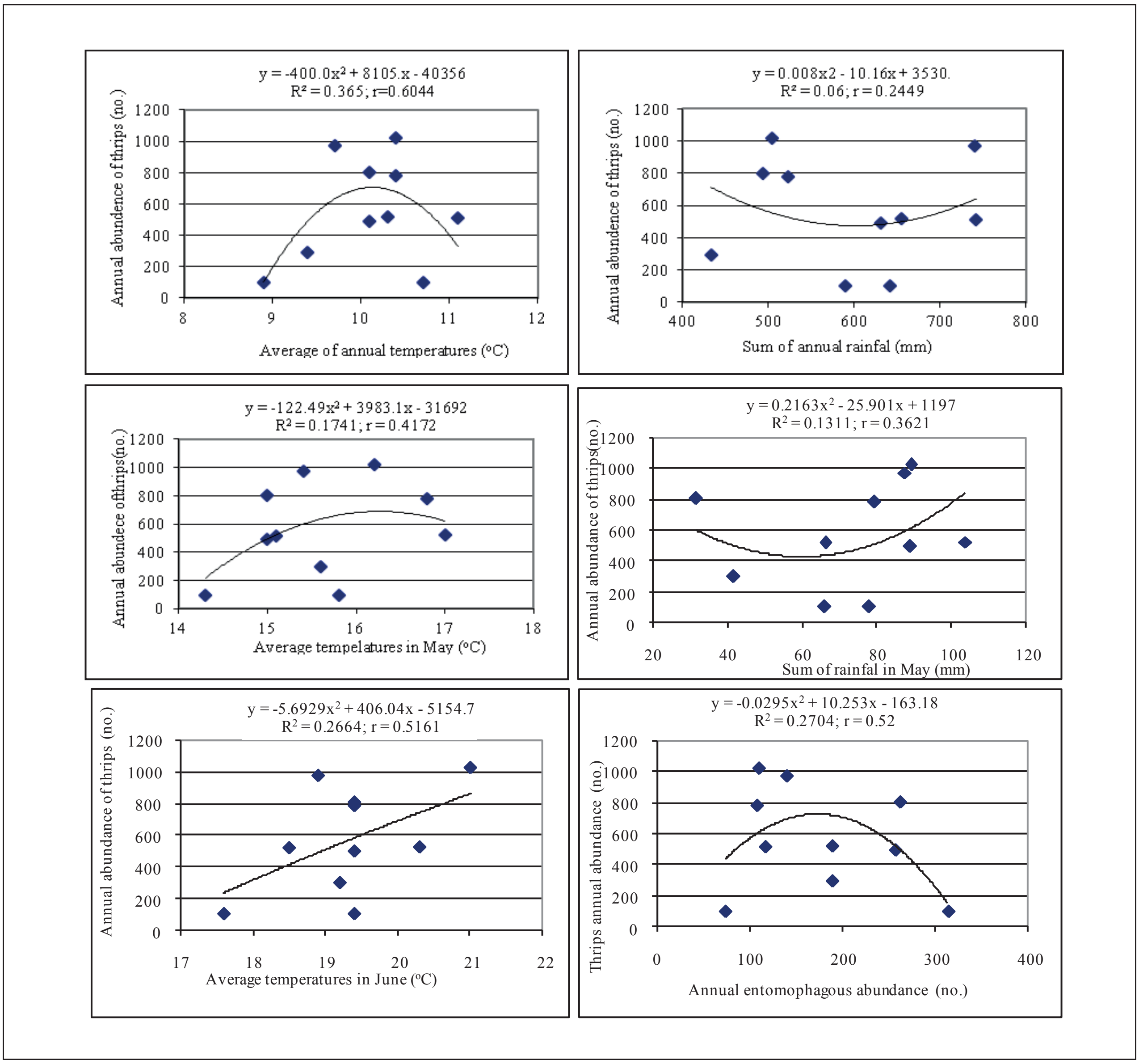

Figure 4. Dynamics of wheat thrips depending on climate and entomophagus during 2006-2015, ARDS Turda (Malschi et al., 2016)

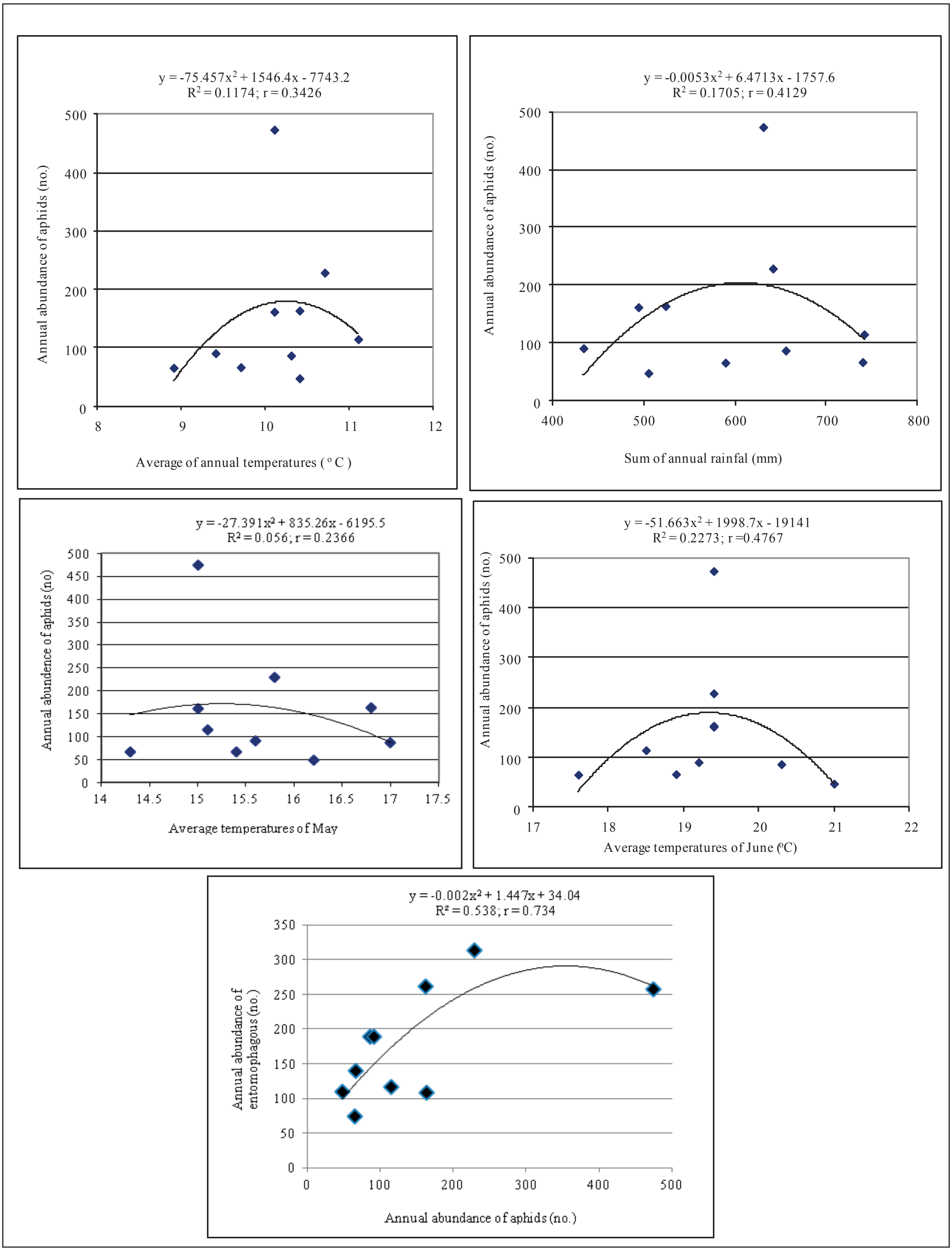

Figure 5. Dynamics of wheat aphids depending on climate and entomophagus during 2006-2015, ARDS Turda (Malschi et al., 2016)

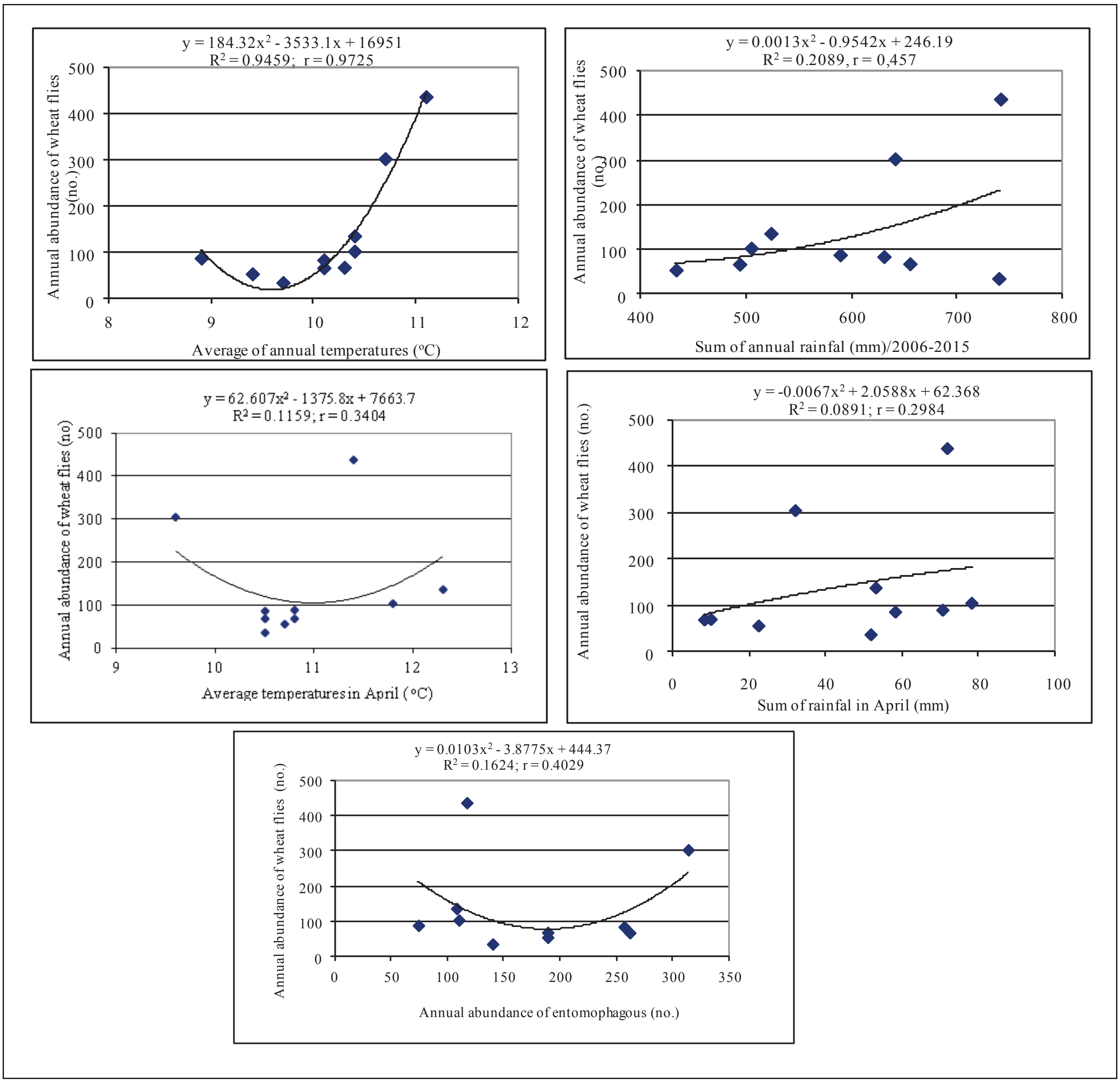

Figure 6. Dynamics of wheat flies depending on climate and entomophagus during 2006-2015 at ARDS Turda (Malschi et al., 2016)

The dynamics of the annual biological potentials of the pests was studied according to annual climate conditions and structural interactions with entomophagus (Figures 7, 8, 9, 10).

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 thrips - 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.

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 7) 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 8). 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). 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 9) and less well correlated with the annual rainfall (Figure 10).

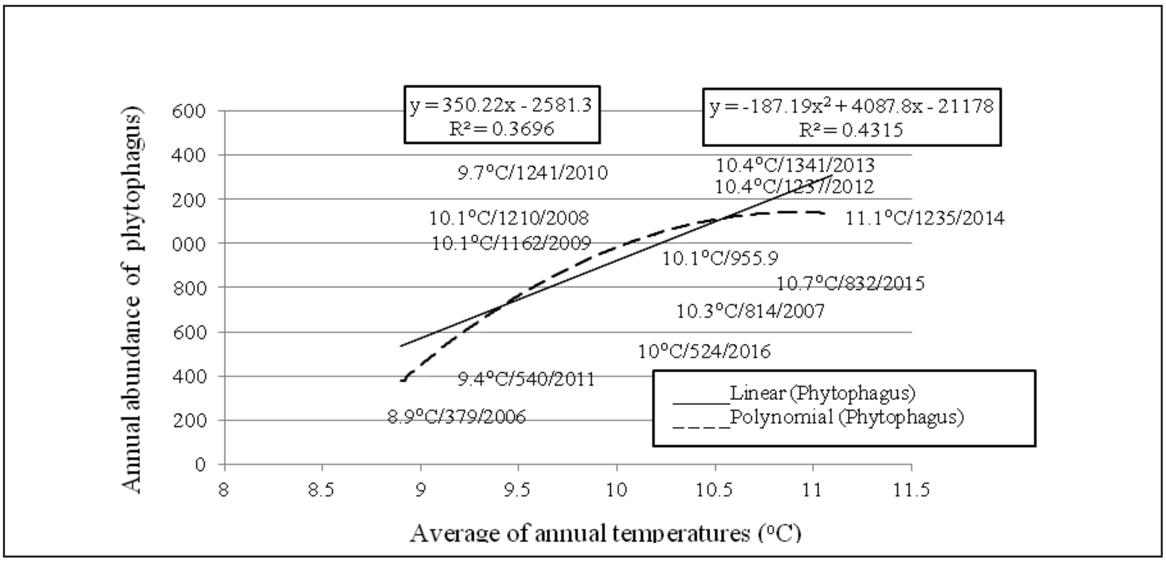

Figure 7. The correlation of the annual abundance of wheat pests and the average annual temperature during the period 2006-2016, at ARDS Turda (collected by decadal 100 double, sweep-net catches)

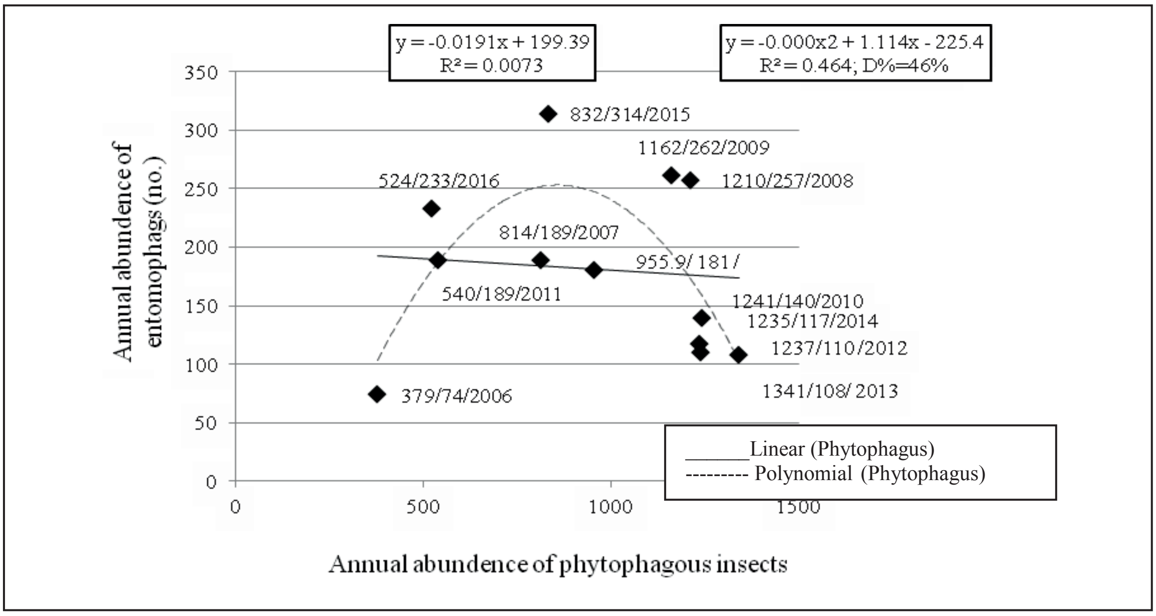

Figure 8. The annual abundance of entomophagus according to the abundance of wheat pest insects, during 2006-2016, at ARDS Turda (collected by decadal 100 double, sweep-net catches)

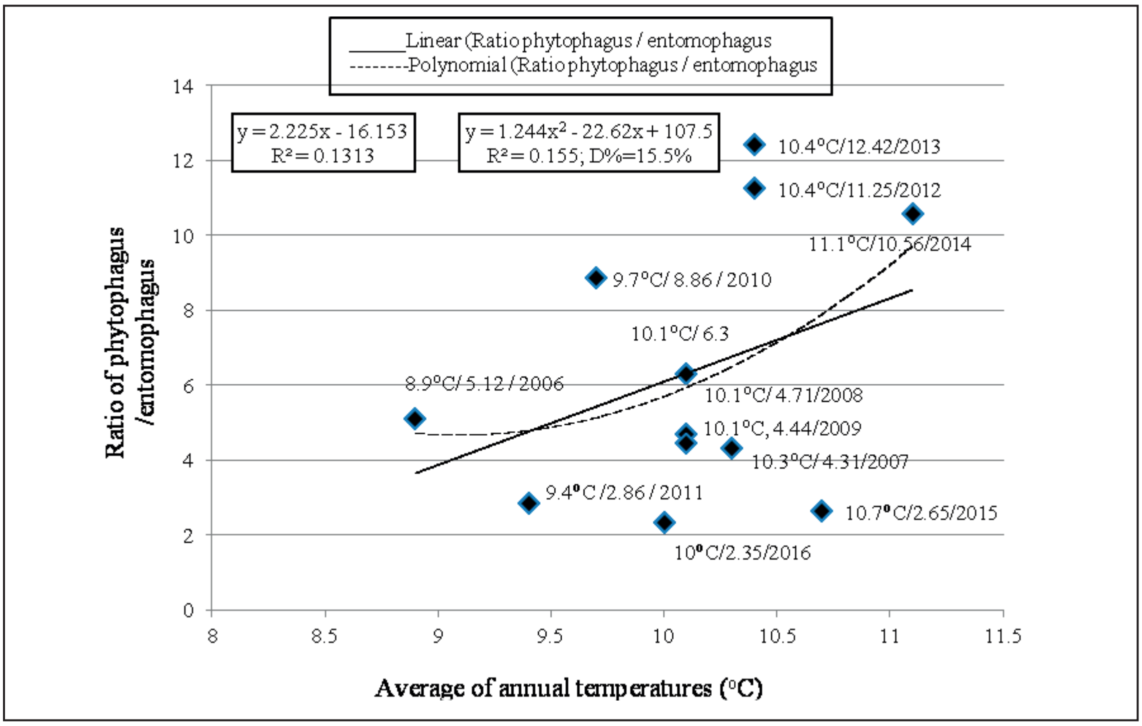

Figure 9. Ratio of annual number of pests of wheat and entomophagus according to average of annual temperatures, under the impact of climate warming in 2006-2016, at ARDS Turda (collected by decadal 100 double, sweep-net catches)

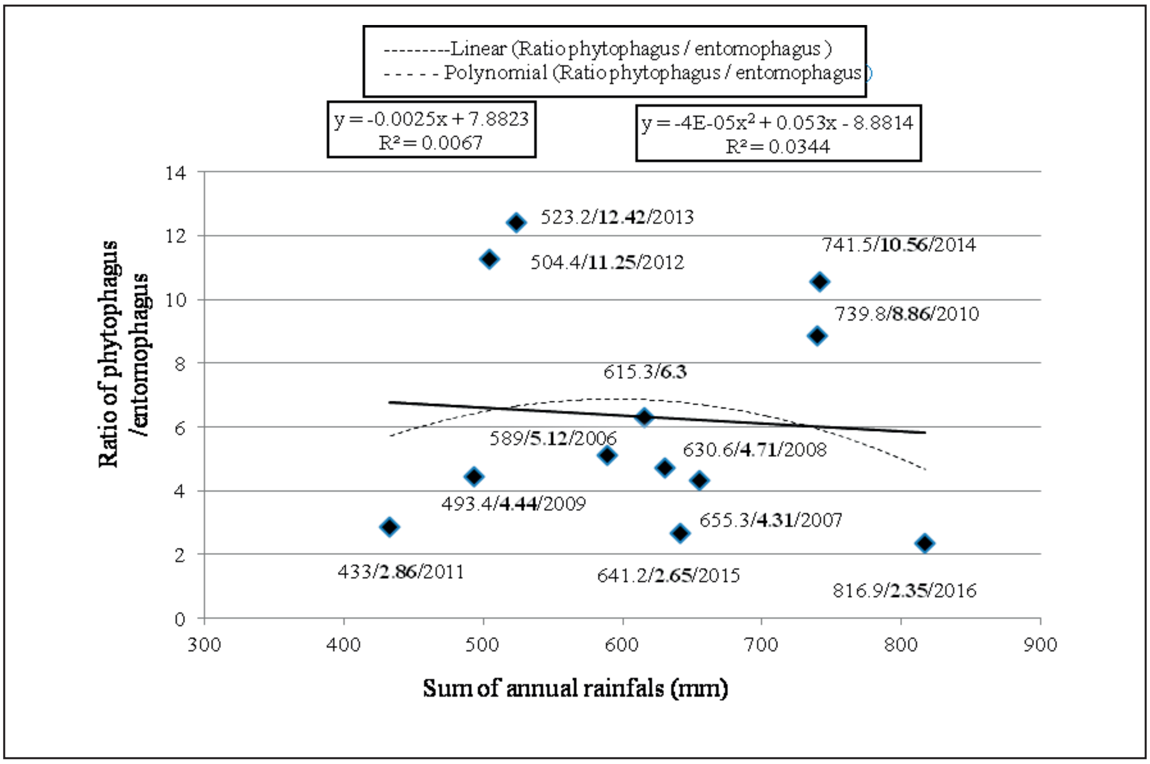

Figure 10. Annual numerical ratio between wheat pests and auxiliary entomophages according to annual rainfall (mm) between 2006-2016 at ARDS Turda (collected by decadal 100 double, sweep-net catches)

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 (Figure 11). 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.

In the agro-forestry curtain system, for the last 10 years, the entomocenotic balance gained in the 65 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 the conditions of global warming, in some years, there are also some disturbances, massive concentrations of pests in the crop (flies Chloropidae, aphids, cereal sun bugs), 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.

Figure A. Abundance of pest populations to 2015

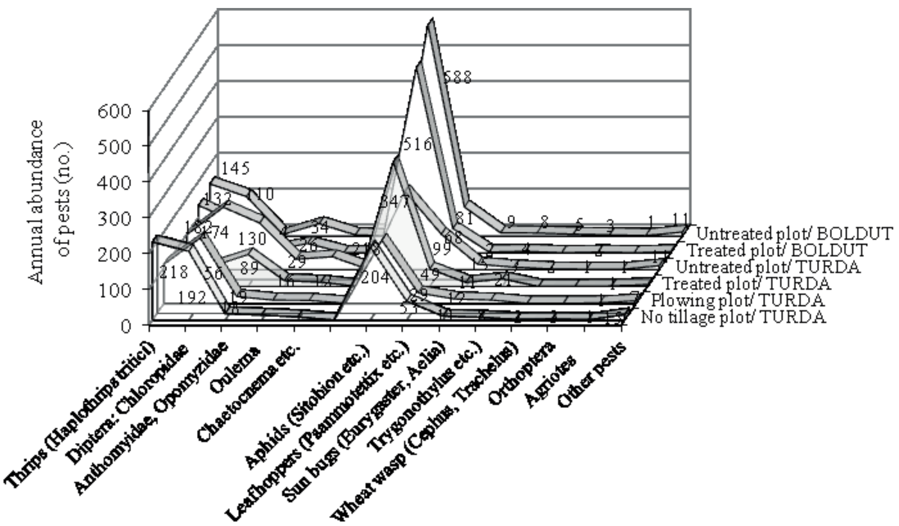

Figure B. Abundance of entomophagus arthropod fauna to 2015

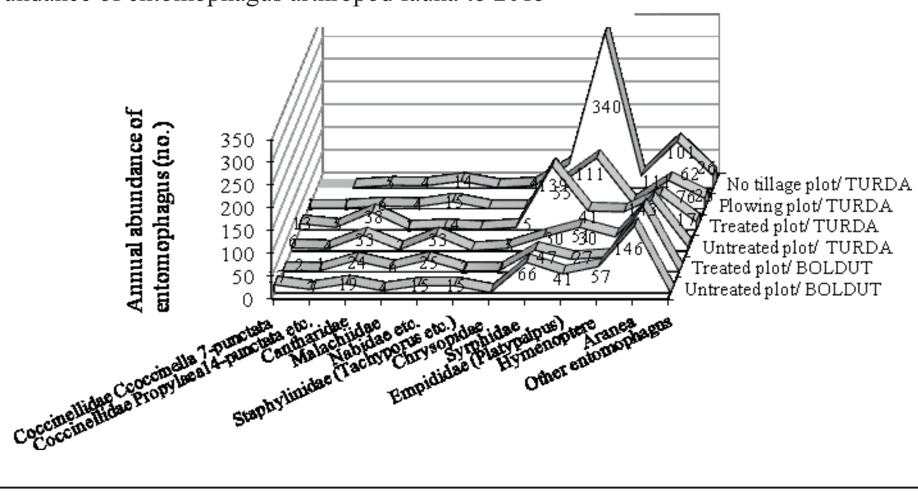

Figure 11. The annual abundance of pest populations (A) and entomophagus arthropods (B) from wheat crops at ARDS Turda in 2015 in different technological systems (the farm with the agroforesty curtains of Bolduţ, the Turda open field farm, the conservative technology with minimal soil tillage, with plowing and no tillage variants)
(No. of arthropods collected annually by decadal 100 double sweep-net catches)

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) (Figure 12).

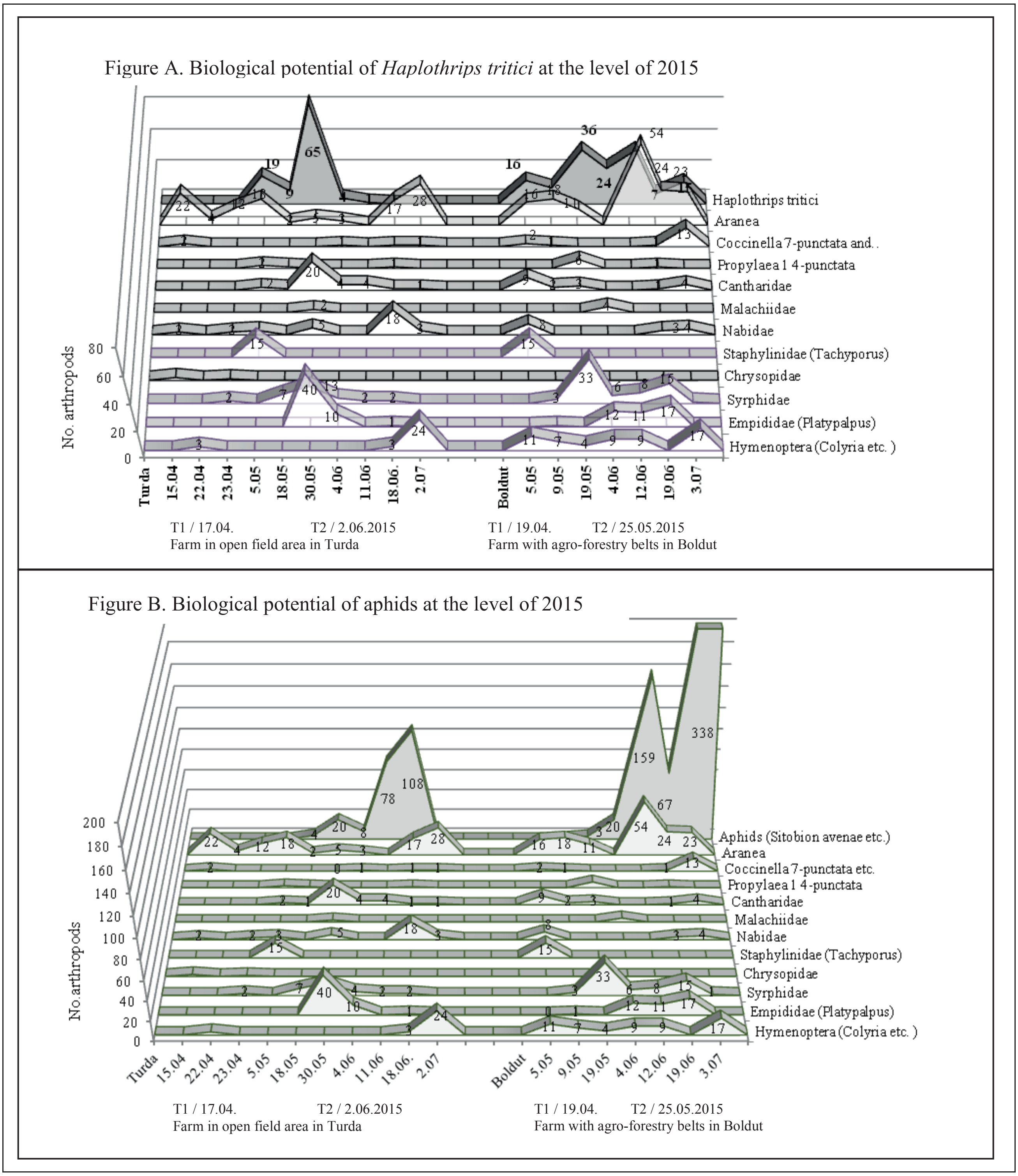

Figure 12. Structural interactions on the abundance and dynamics of thrips populations (*Haplothrips tritici*) (A) and aphids (*Sitobion avenae* etc.) (B) in relation to the natural active entomphagus arthropods, indicating the moments of insecticide treatments (T1, T2) from wheat crops in open field conditions at Turda and in the farm with agroforestry courtains at Boldut (ARDS Turda, 2015) (No. arthropods collected by decadal 100 double sweep-net catches/sample)

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 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) (Figures 13).

Figure 13 A. Biological potential of *Haplothrips tritici* at the level of 2015 in no tillage and plowing fields

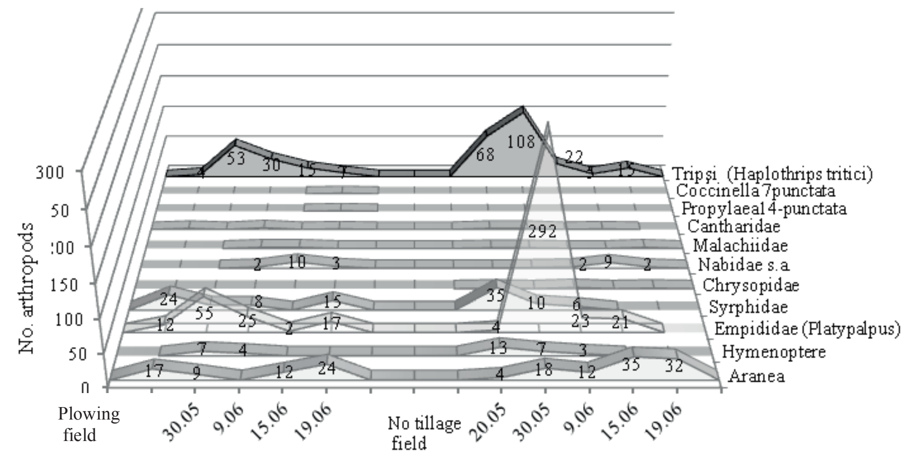

Figure 13 B. Biological potential of aphids and leafhoppers in 2015 in no tillage and plowing fields

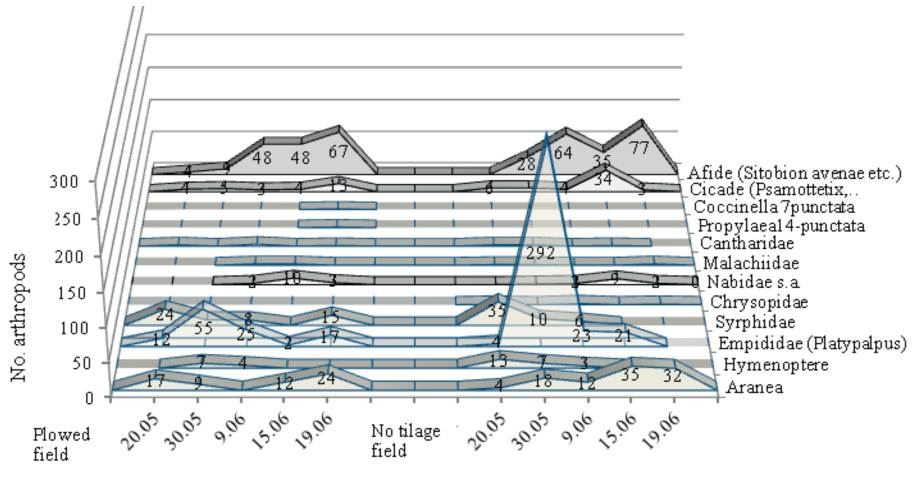

Figure 13. Structural interactions on the abundance and dynamics of *Haplothrips tritici* (A), of aphids (*Sitobion avenae* etc.) and leafhoppers (*Psammotettix alienus* etc.) (B) in relation to the entomofage arthropods from wheat, indicating the moments of insecticide treatments (T1, T2), in the technology with plowing and no tillage, at ARDS Turda, 2015) (No. arthropods collected by decadal 100 double sweep-net catches / sample)

These changes in wheat entomocenoses, the biological potential accumulated over the last 10 years and in 2015 (Figure 11) 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 12, 13). It is necessary to protect and use entomophagus and flora biodiversity.

The data on the abundance of wheat pests and the abundance of entomophagus (Figure 11), 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 11).

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 12, 13). 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. 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 12, 13), 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. 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 pests (*Oulema*, thrips larvae, aphids, cereal bugs etc.), special treatments at warning may be required.

CONCLUSIONS

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.

1. The paper 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).

2. 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.

3. 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.

4. The following methods of control are recommended:

Preventive 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.

Treatments with insecticides on vegetation:

- For groups of pests whose attacks overlap as a result of climatic warming: the first optimal moment of application / in April, at the end of tillering, the second optimal moment of application / in May, in the flag leaf to the ear apparition phenophase.
- Other special treatments at warning for *Oulema*, thrips larvae, aphids, sun bugs etc., with the protection of the auxiliary entomophagus present in the culture.

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