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CLIMATE WARMING IN RELATION TO WHEAT PEST DYNAMICS AND THEIR INTEGRATED CONTROL IN TRANSYLVANIAN CROP MANAGEMENT SYSTEMS WITH NO TILLAGE AND WITH AGROFORESTRY BELTS

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ABSTRACT

The paper presents new research on pest population abundance and integrated pest management (IPM) in winter wheat crops in relation to the climate warming in Transylvania. In 2007-2013, entomological study has been carried out under different cultural soil crop management practices: classical (by ploughing) and conservative no tillage (successive no ploughing), in open field agro-ecosystems and in agro-forestry belts farming system. Major outbreaks of abundance of thrips (*Haplothrips tritici)*; wheat flies (Chloropidae: *Oscinella frit, Meromyza nigriventris, Elachiptera cornuta* etc. and Anthomyiidae: *Delia coarctata, Phorbia securis, Ph. penicillifera);* stem flea beetles *(Chaetocnema aridula);* leafhoppers (*Javesella pellucida, Psammotettix alienus, Macrosteles laevis*), aphids (*Sitobion avenae, Schizaphis graminum, Rhopalosiphum padi, Metopolophium dirhodum*); bugs *(Eurygaster maura, Aelia acuminata*), etc. were observed.

The paper mentions the importance of adjusting the technology of IPM to the structural changes of harmful entomofauna, which is highlighted, in relation to climatic warming and increased aridity, by higher abundance of wheat thrips (as eudominant species), of Chloropidae wheat flies, leafhoppers, aphids, wheat fleas (as dominant groups), cereals bugs, etc.

IPM recommends special attention to preventing measures for zone specific pests which still show a high biological potential: cereal flies, leafhoppers, aphids, etc., by respecting the optimal sowing time, agro-technical methods, seed treatment with systemic insecticides and complex plant protection measures. Due to increased aridity and climate warming, the critical attack moments were recorded 3-4 weeks earlier and overlapped. The research results proved the importance of insecticide applications at two different moments: at the end of tillering phase and at ear emergence, in open field area. At the first treatment, the pest groups that focus on spring crops (cereal flies, fleas, leafhoppers, thrips, bugs, etc.) are controlled simultaneously, by recommending the shock and systemic insecticides (pyrethroids, neonicotinoid, etc.), no later than the herbicides are applied. At the second treatment, the ear pests (thrips, aphids, bugs, etc.) are controlled simultaneously and shock insecticides (pyrethroids etc.) with a low negative effect on the entomophag arthropod fauna, are strongly recommeded. The IPM is a major section of successive soil no tillage technologies, comprising a special pest control strategy, with insecticides application as seed treatment and in 2-3 successive treatments in vegetation.

Entomophagous populations are very active and efficient on the pest natural limitation. They are particularly abundant and present an important species diversity on the agro-ecosystems in open field area, both in the classic technological system-by plowing, but also in soil no tillage conservative system.

The research pointed out the efficiency of biological control, using only the entomophagous natural resources, without insecticides application, in the farming system with protective agro-forestry belts – favourable for increasing of useful fauna.

Key words: wheat pests, integrated pest control, no tillage, agro-forestry belts, climate change.

INTRODUCTION

Integrated pest management (IPM) is an agro-ecological system approach to crop protection that uses several practices to control the pest and minimize the pesticide applications (Baicu, 1996; Bărbulescu and Popov, 2001; Malschi, 2009; Popov et al., 2009; 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.
- Crop management control methods: soil preparation, using certified seeds.

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- Biological control: entomophagous predators and parasites, biological products and natural resources.
- Chemical control: using insecticides, only recommended if the biological methods fail and the threshold limit has been surpassed.
- Record keeping: used to predict the attack and future investments (FAO, www.fao.org/agriculture/crops/core-themes/ theme/pests/ipm/; Bărbulescu et al., 2001, 2002; Malschi, 2007, 2008; Popov, 1979; Popov et al., 2000, 2001, 2007, 2010).

Common Agricultural Policy specifying 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; Guş and Rusu, 2008; Malschi, 2009).

Long-term research on sanitary state of the field crops underlying the development of pest control technologies suitable of climate change and increased aridity (Popov et al., 2003, 2006; Popov and Barbulescu, 2007; Malschi, 2007, 2008, 2009).

Studies performed from 1980 showed the evolution of main cereal pest such as: *Diptera, Homoptera, Thysanoptera, Coleoptera,* etc. at the Agricultural Research & Development Station Turda, in Central Transylvania (Malschi, 2007, 2008, 2009). During 2007-2013 period, especially under the conditions of profound agro-ecological changes caused by climate warming and also under the new crop management conditions in regional agricultural exploitations, the integrated control strategy of wheat pests was elaborated (Malschi et al., 2012, 2013 a, b, c).

MATERIAL AND METHODS

Based on the entomological research at the Agricultural Research&Development Station Turda the paper presents an agro-ecological study on the population dynamics of wheat pests and the adequate integrated pest control methods under different soil crop management systems: 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, under the current agro-ecological changes, in Transylvania.

During 2007-2013, the study revealed data on species composition and dynamics in wheat crops. Species determination was achieved based on the abundant samples, performed every 10 days**.** The analysed samples were obtained by the method of captures in 100 double sweep-net catches, for the arthropod fauna at the plant level. The structure and dynamics of the pest species populations interacting with predatory arthropod fauna were studied in wheat crops.

The research objectives 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 crop management factors: selective, efficient insecticides, agro-technical methods; biotic factors, natural entomophags and environment protection factors.

RESULTS AND DISCUSSION

The changes in the level of regional climate, represented by warming and excessive drought, especially in spring have caused the burst of pest populations, which may cause important damages to wheat crops. In the last years of climate warming, changes in the pest structure were recorded. 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, Ph. penicillifera)*; stem flea beetles *(Chaetocnema aridula),* as dominant species; bugs (*Eurygaster maura, Aelia acuminata*) etc were observed (Figure 1).

During 2007-2012, eudominant wheat thrips, dominant wheat flies, wheat fleas, aphids and leafhoppers were highlighted. The average of pest structure showed: 72.2% for thrips, 10.4% for aphids and 2% for leafhoppers, 3.4% for Diptera, only 0.5% for cereal leaf beetles and 9% for cereal fleas, 2% for cereal bugs and up to 0.5% for wire worms and other pests. Compared to the structure of wheat pests in the previous period, there was an increase of the percentage share of thrips and wheat fleas, which frequently recorded population explosions. Besides these, cereal bugs in some years reached dangerous densities in the crop. 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 remarkable. But the attack potential of Diptera, leafhoppers and aphids is still important (Figure 1).

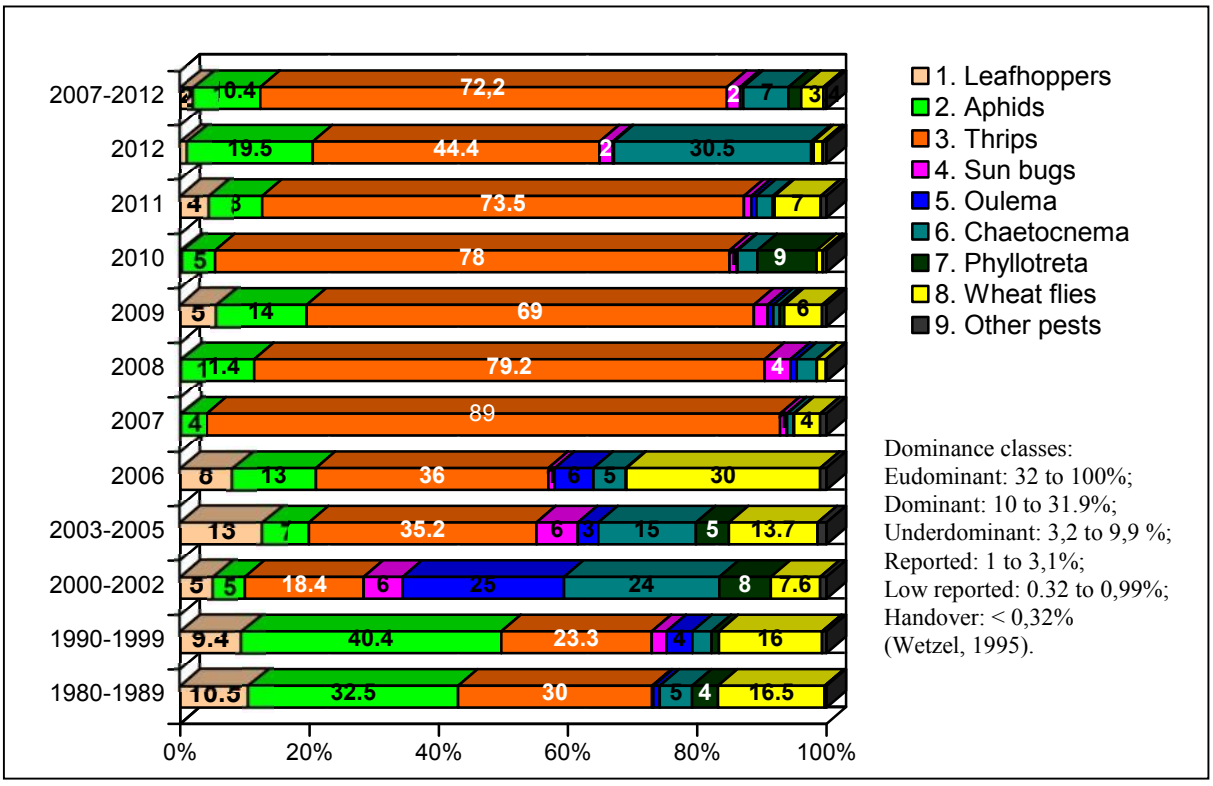

Figure 1. Dynamics of wheat pests structure (% dominance), at ARDS Turda during 1980-2012

Biological potential and the attack of the main pests of wheat were related to climate change (Figure 2), to species biology and to phenological development of crops in the current crop management change. In open field area, these changes on the structure and populations abundance of referred pest species is a dangerous risk situation to wheat crops. A reduction in the species range and an increase of the population abundance were 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 was 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 increased aridity and climate warming, the critical attack moments were 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.

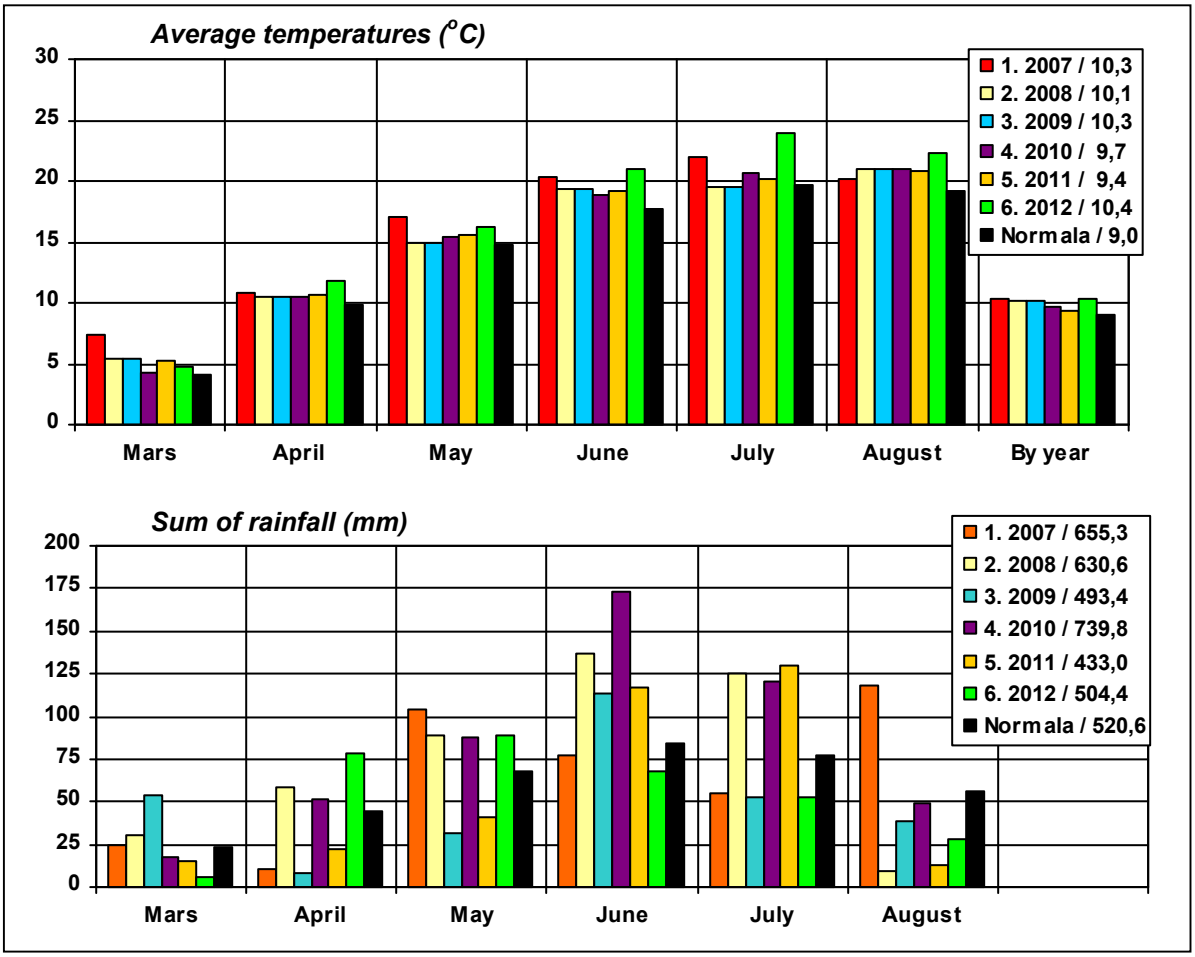

Figure 2. Average temperatures and sum of rainfall at Turda conditions by month, from March to August and by year, at ARDS Turda during 2007-2012

In open field agricultural system, comparative research on the abundance and structure of wheat pests in classical and conservative soil technologies proved a greater abundance and importance of the populations of thrips, flies, aphids, leafhoppers, wireworms under conservative no tillage technology (Figures 3 and 4). *Haplothrips tritici* was the most abundant and important pest of wheat in classical (by ploughing) and conservative (by minimum soil tillage and no tillage) technologies. Thrips, as well as aphids and leafhoppers, are the dangerous vectors for viruses and other pathogens, favouring their attack.

By practicing successive no tillage conservative soil technologies, recommended for the current conditions of climate aridity in Transylvania, the main pest populations were increased and higher biological reserve of thrips, Chloropidae, leafhoppers, aphids and soil pests (wire worms *Agriotes* sp., etc.) were accumulated. So, in recent years 2009-2012 (Figure 3), *Haplothrips tritici* – reached at 71%; flies: 6.3%; aphids: 10%; leafhoppers 6.3%, wheat fleas 4.8% in the pest structure, showing an important attack potential. The pests have achieved 84.35% and entomophagous 15.65% in the structure of entomofauna of no tillage crops in open field area.

In wheat fields with classical ploughing system cereal flies achieved 8.58 % more then in no tillage system, also the sun bugs reached at 2.66%. The entomophagous achieved 17.65% more then in no tillage system (Figure 4).

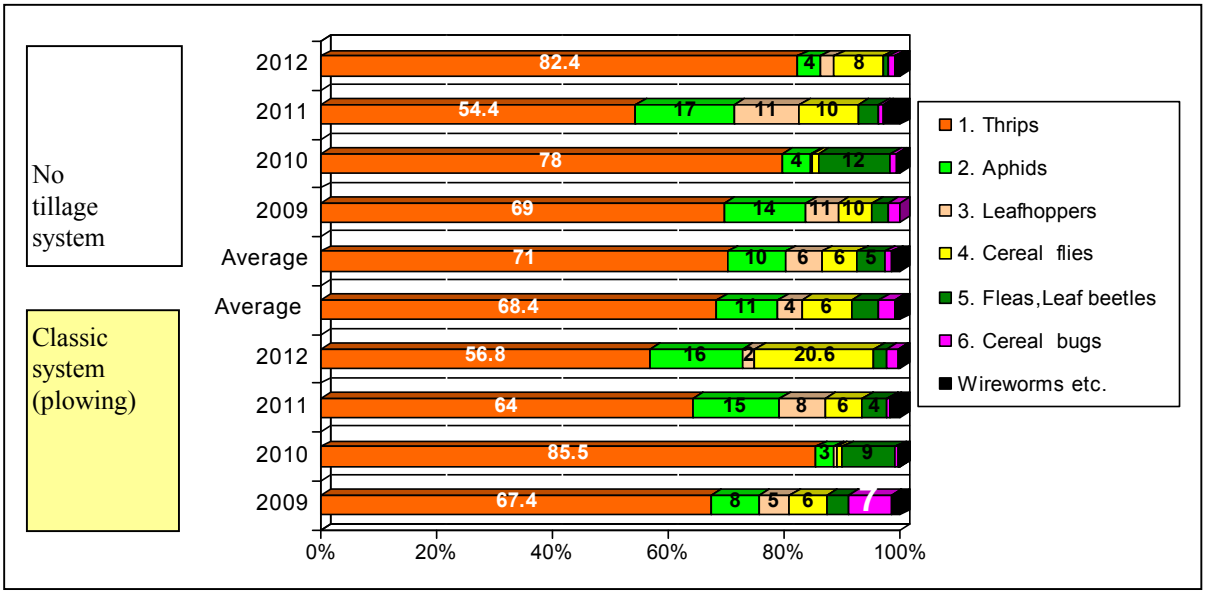

Figure 3. Dynamics of wheat pests structure (% dominance), at ARDS Turda

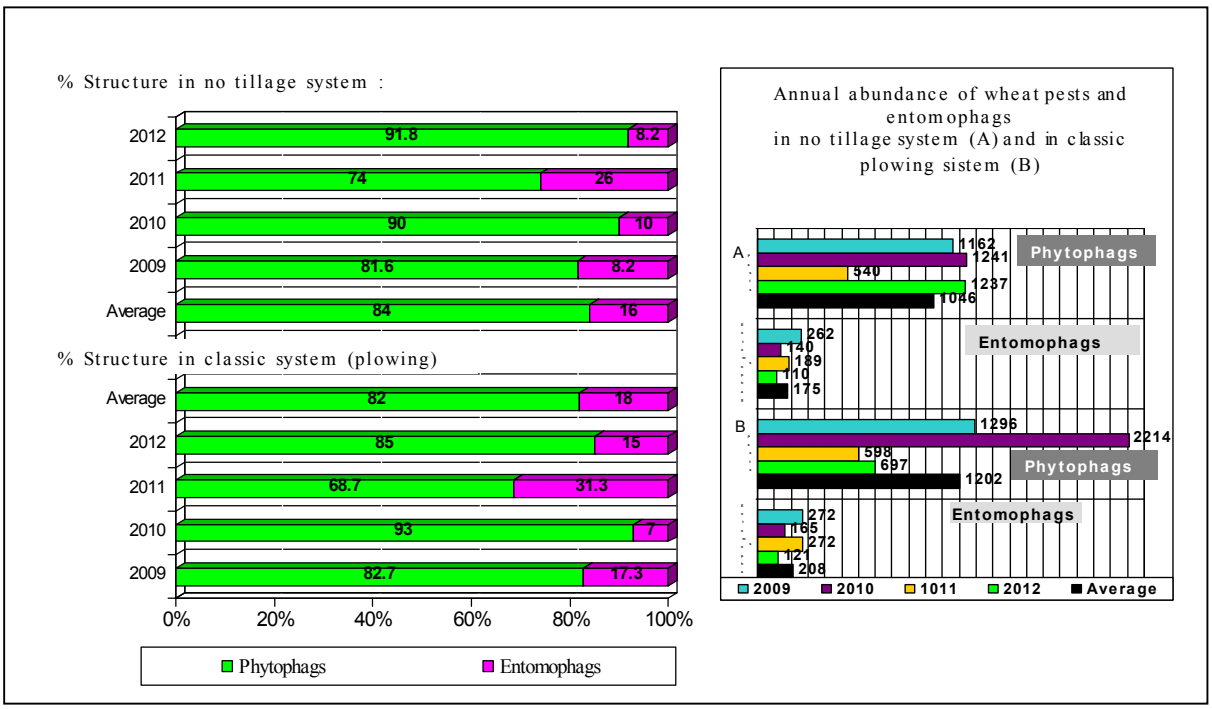

Figure 4. Dynamics of structure (%) and abundance of wheat pests and entomophags, in classic and in no tillage system, at ARDS Turda during 2009-2012

An entomocenotic balance was maintained **in agroforestry belts farming system** of Cean Bolduţ, similar to the values in the last three decades (1980-2010) (Figure 1). The wheat pests had a structural share of 69% and the entomophagous achieved 31%, on the favourable conditions due to the forestry belts. Thrips showed only 32% and flies 27.5%, aphids 12.7%, leafhoppers 5.1% in the pest structure (Figures 5 and 6).

In 2010-2012, the abundance of pests in the open system was 2.8 times higher than in the farm with protective forestry belts (Figures 7 and 8). The ratio of phytophagus/entomophagous was 5.75/1 in the open field system and only 2.35/1 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.

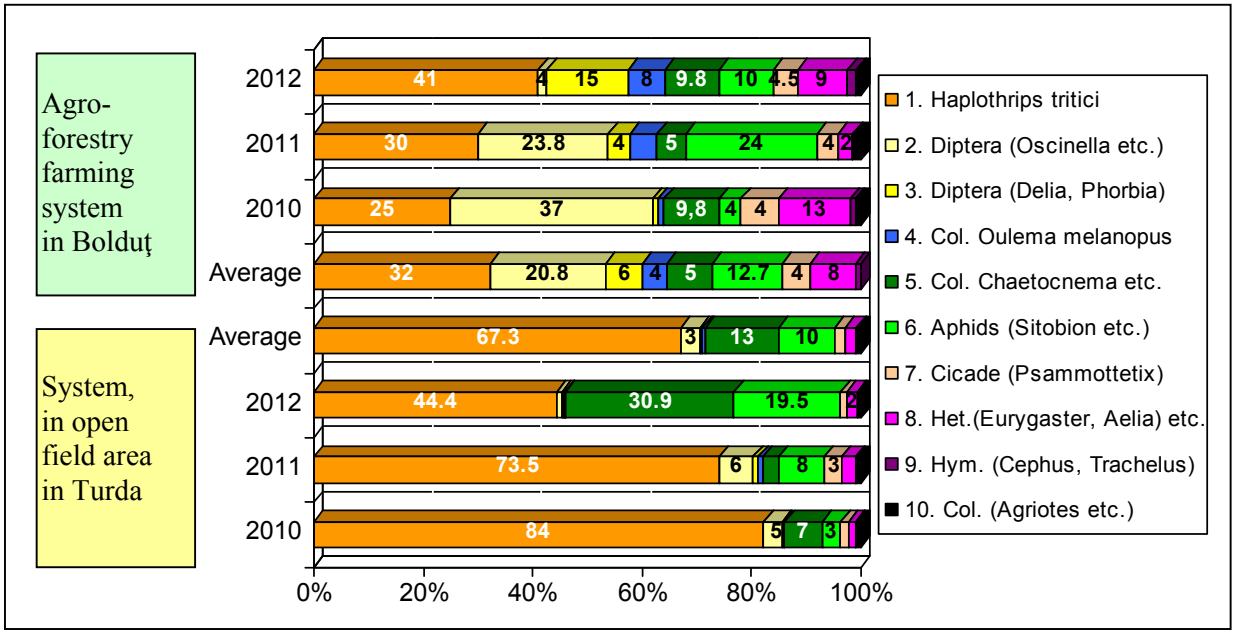

Figure 5. Dynamics of % structure of pests in wheat crops in open field area in Turda and in the agro-forestry farm in Cean – Bolduţ, at ARDS Turda during 2010-2012

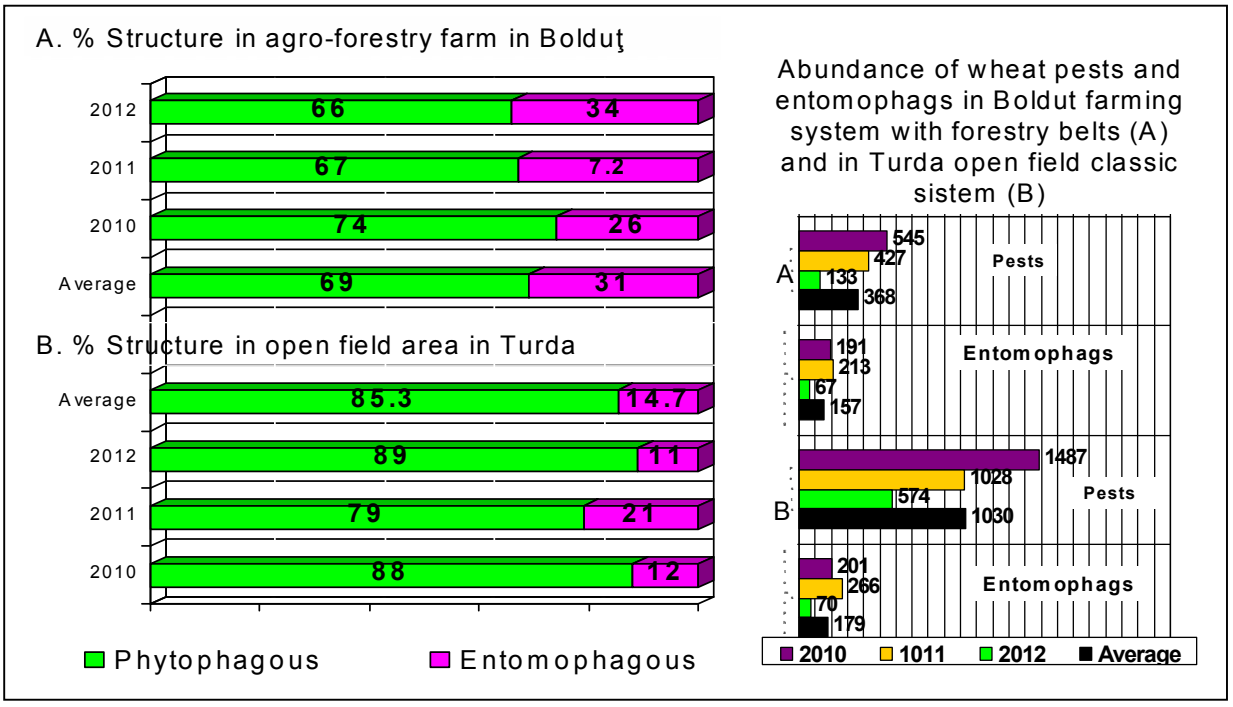

Figure 6. Dynamics of structure (%) of wheat pests and entomophagous in open field area in Turda and in the agro-forestry farm in Cean – Bolduţ, at, ARDS Turda, during 2010-2012

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 7) (Table 1).

The applied integrated pest management on favourable agroecological conditions in the farm with protective forestry belts, in Cean-Bolduţ (Figure 8), shows the efficiency of biological control (Table 1), using the entomophagous natural resources, without insecticides (Malschi, 2009; Malschi et al., 2010).

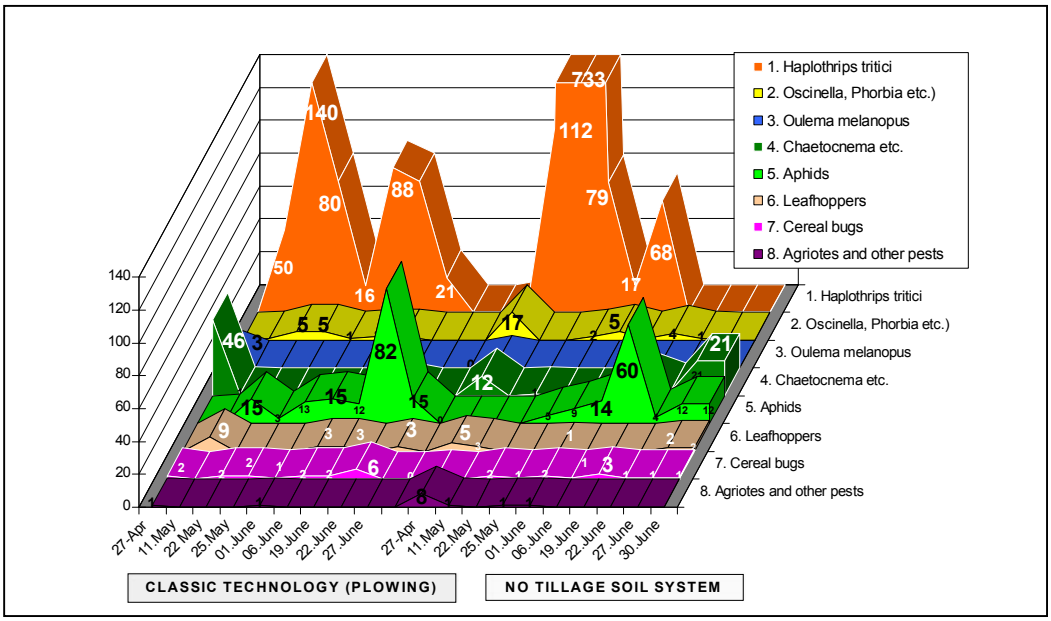

Figure 7. Occurrence and dynamics of wheat pests, in classic plowing and conservative no tillage soil technology, in 2012, at ARDS Turda (No./100 sweepnet catches)

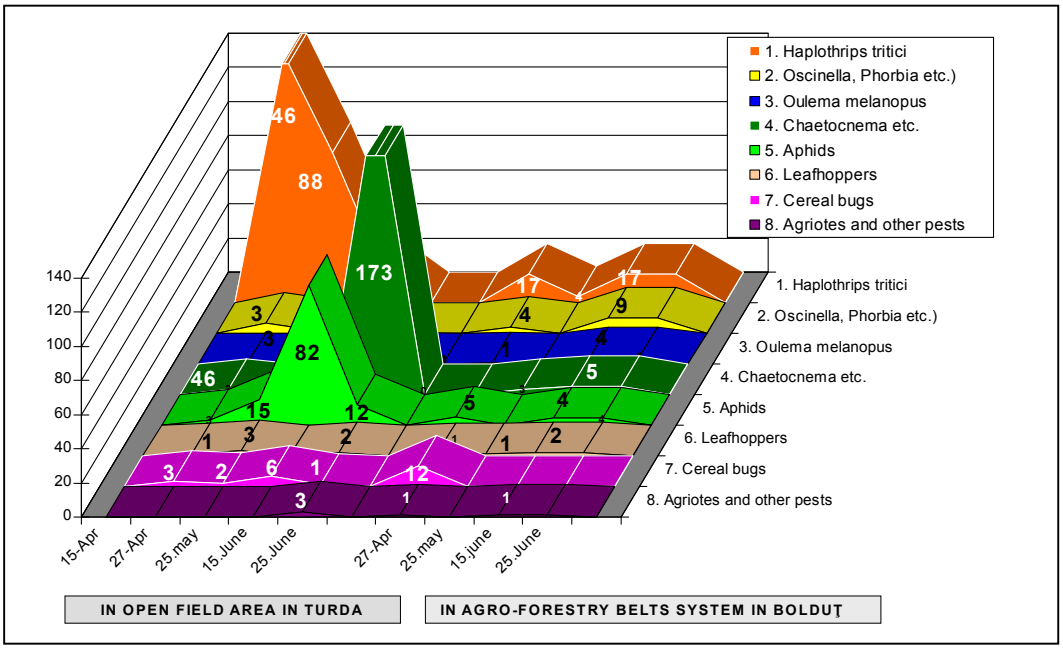

Figure 8. Occurrence and dynamics of wheat pests in open field area in Turda and in the agro-forestry farm in Cean – Bolduţ, in 2012, ARDS Turda. (No./100 sweepnet catches)

In order to provide a sustainable development of winter wheat crop, adequate prevention and control measures were required, specifying the correct times for the application of insecticide treatments.

Favoured by the warmer years, wheat thrips population explosions were manifested especially in the years with more abundant precipitation in May and June. The optimal time of insecticide treatment for thrips control is between 10 to 20 May.

The aphids and leafhoppers manifested a population increases particularly related to their favourable development in May and in summer on volunteer plants, grasses and other crops, becoming dangerous as vectors of wheat yellow dwarf, especially for the early sowed crops. Wheat flies of the genus

Phorbia, Delia, Opomyza were disadvantaged by aridity, warm and drought periods in the spring months. The same conditions, related with delayed phenological development of wheat, were favourable, however, to the Chloropidae species. They can become dangerous for early autumn sowing crops.

Wheat fleas (*Chaetocnema, Crepidodera*) showed an increase in abundance of populations, very dangerous in early spring and in April, damaging as Diptera larvae. It appears that the high temperatures from April to May decreased cereal leaf beetles (*Oulema* sp.) larvae populations.

The efficiency of integrated pest control methods was studied under different crop crop management systems: in open field area (in classical ploughing and in conservative no tillage system) and in the agro-forestry belts farming system (Table 1). Within the testing experiments, of efficient insecticides and optimal application time, an integrated pest management was studied, including herbicides, fungicides, fertilizers applications, etc.

Table 1. Effect of insecticide treatments in wheat crops (Ariesan variety). ARSD Turda, 2013

Insecticide treatments	Grain yield (kg / ha)			Thrips (larvae/ear)
	Average	%	Differ.	Average
1. Lot ST + Untreated on vegetation	7763	100.0	-	1.5
2. Lot ST + T1	7710	99.3	- 53	0.0
3. Lot ST + T1+T2	7922	102.0	159	0.5
4. Plowing lot without treatments)	4376	56.4	- 3387 ooo	21.1
5. No tillage lot without treatments)	4590	59.1	- 3173 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	
LDS p 1%		10.79	837.66	
LDS p 0.5%		15.23	1182.58	
Testul F	69.97 (4.82)			
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 100 ml/ha; T2 = field treatment at the ear emergence / 17.05. 2013/ with Faster 10 CE 100 ml/ha				

In open field agricultural system, the integrated pest control needs special attention on:

- analysis of zone and crop climate in interrelation with the periodical observation of attack potential (at crop emergence, in the spring at tillering and in the 2nd decade of May, at flag-leaf appearance and ear emergence);
- the use of agro-technological measures (sowing in the second half of October, volunteers wheat destruction, balanced fertilization, herbicide treatment and others);
- periodical multi-annual observation of the pests interactions with auxiliary entomophags;
- insecticide treatment on seeds and on vegetation;
- predator populations enrichment and protection by careful treatment application on vegetation, by protection of entomophag refuge sites (by the development of flowering plants from the crop borders, protection of marginal flora biodiversity, protective agroforestry belts, etc.).

Insecticide application should be carried out when the economic damage threshold values of pest are 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. The well known 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)* were represented in the structure of arthropod fauna

in wheat crops of Transylvania (Malschi, 2007, 2008, 2009).

The integrated pest management research on the cereal agroecosystems with conservative no tillage soil technology, recommended the insecticides chimical control, using insectofungicide seed treatment and 2-3 successive insecticides field treatments (Malschi et al., 2012). The application of special insecticide treatments is required especially under unfavourable agroecological conditions of excessive heat and drought 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., 2013 c).

In the last years, two critical attack moments and risk situations (Figures 7 and 8) were reported, which required treatment application (Malschi, 2009; Malschi et al., 2013 b):

1. In April, at the end of tillering in the 25-33 DC stage (at latest of herbicidal treatment), or earlier in some years; insecticide treatment for Diptera and wheat fleas (*Chaetocnema)*, bug and *Oulema* adults, and also to reduce thrips and leafhoppers attack potential, was carried out by using systemic insecticides: neonicotinoids – tiacloprid, thiametoxam; organophosphorous, etc. At this moment, entomophagous were at the beginning of field occurrence and less exposed to insecticides.

2. The treatment at the flag-leaf appearance and ear emergence, in the 45-59 DC stage, in May 10-20, was 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, resulting in yield increases.

CONCLUSIONS

The paper presents new research on pest population abundance and integrated pest management (IPM) in winter wheat crops in relation to the climate warming in Transylvania, under different cultural soil technologies: classical (ploughing) and conservative (no tillage), in open field agro ecosystems and in agro-forestry belts system, in experimental lots, during the vegetation years 2007-2013. Major outbreaks of abundance of thrips (*Haplothrips tritici*); wheat flies (Chloropidae: *Oscinella frit, Meromyza nigriventris, Elachiptera cornuta* etc. and Anthomyidae: *Delia coarctata, Phorbia securis, Ph. penicillifera*); stem flea beetles (*Chaetocnema aridula*); leafhoppers (*Javesella pellucida, Psammotettix alienus, Macrosteles laevis*), aphids (*Sitobion avenae, Schizaphis graminum, Rhopalosiphum padi, Metopolophium dirhodum*); cereal bugs (*Eurygaster maura, Aelia acuminata*), etc. were observed.

The paper mentions the importance of adjusting the IPM technology on the pests structural changes, which is highlighted in relation to climatic warming and increased aridity by higher abundance of wheat thrips (as eudominant species), of wheat flies Chloropidae, leafhoppers, aphids, wheat fleas (as dominant groups), cereals bugs, etc.

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, crop management methods, cultural hygiene, seed treatment with systemic insecticide and by complex plant protection measures.

Due to increased aridity and climate warming, the critical attack moments were recorded 3-4 weeks earlier and overlapped. 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. At the first treatment, the pest groups that focus on spring crops (cereal flies, fleas, leafhoppers, thrips, bugs, etc.) are controlled simultaneously, by recommending the shock and systemic insecticides (pyrethroids, neonicotinoid, etc.), no later than

the herbicide application moment. At the second treatment, the ear pests (thrips, aphids, bugs, etc.) are controlled simultaneously and the shock insecticides (pyrethroids, etc.) with reduced effects on the entomophagous arthropod fauna are strongly recommended.

The IPM is a major section in 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.

Entomophagous populations are very active and efficient on the pest natural limitation in Transylvania. They are particularly abundant and present an important species diversity on the agro-ecosystems in open field areas, both in the classic technological system, but also in soil no tillage conservative system.

In the farming system with protective agro-forestry belts – favourable for increasing of useful fauna, the research pointed out the efficiency of biological control, using only the entomophagous natural resources, without insecticides application.

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, attaining economic and ecological efficiency; the protection of environment and food quality; the preservation and use of biodiversity.

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