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Environmental public goods associated with agriculture practice of integrated wheat pest management

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Abstract. During 2007-2013 period, 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 paper presents the adequate integrated pest control methods and their benefits 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. Integrated pest management (IPM) is an agro-ecological-environmental system approach to crop protection that uses different practices to control the pest and minimize the pesticide applications. The IPM objectives are the achievement of yield safety, the attaining economic and ecological efficiency; the protection of environment and food quality; the preservation of biodiversity, environmental public goods. Common Agricultural Policy mentions the importance of providing environmental public goods associated with agriculture such as agricultural landscapes, farmland biodiversity, soil, water and air quality, climate stability farming practices. Special environmental public goods are associated with integrated pest management crop technologies such as: the positive impact of biological pest control, using biodiversity of beneficial entomophags and flora, biological agriculture, related to pollution limitation and sustainable development of environmental factors quality; the positive impact of agro-forestry belts farming system and of soil conservative no tillage systems, particularly in water stressed areas, related to climate stability etc.

Key Words: wheat pests, integrated pest control, soil no tillage technology, protective agro-forestry belts, environmental public goods.

Introduction. 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 & Popov 2001; Malschi 2009; Popov et al 2009; Popov & 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; 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; Guş & 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 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 technological conditions in regional agricultural exploitations, the integrated control strategy of wheat pest was elaborated (Malschi et al 2012, 2013 a, b, c).

The paper presents an agro-ecological study 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, efficient insecticides, agro-technical methods; biotic factors: - natural entomophags; environment protection factors and environmental public goods provided and associated with agriculture.

Material and Method. During 2007-2013, the study has revealed data on species composition and dynamics in wheat crops. Species determination has been achieved based on the abundant samples, performed every 10 days, since April to July. The analysed samples have been 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 have been studied in wheat crops.

Results and Discussion. 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). 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 2012, 2013 a, b, c). During 2007-2013, are highlighted: eudominant wheat thrips, dominant wheat flies, wheat fleas, aphids and leafhoppers (Figure 1). The average of pests structure shows: 70% for thrips, 12% for aphids and 2% for leafhoppers, 3% for Diptera, only 1% for cereal leaf beetles and 9% 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.

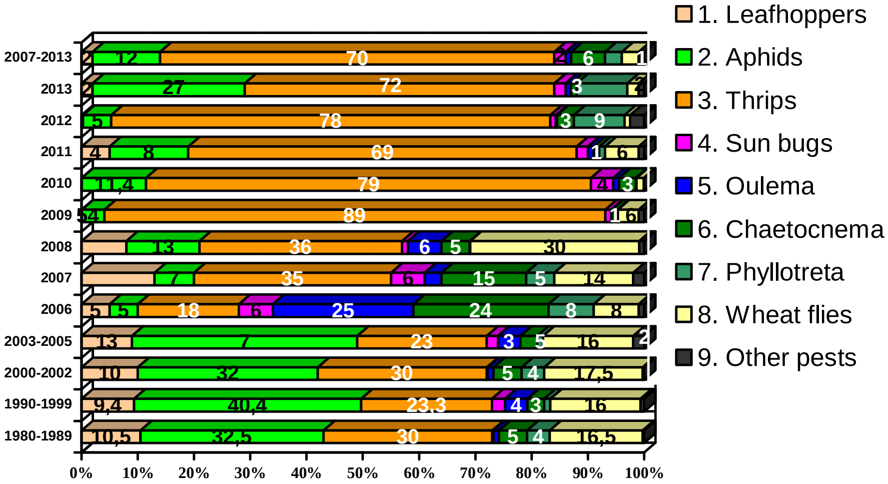

Figure 1. Dynamics of wheat pests structure (% Dominance) in 1980-2013, at ARDS Turda.

Biological potential and the attack of main wheat pests were related to climate change (Figure 2), species biology and phenological development of crops in the current technological change.

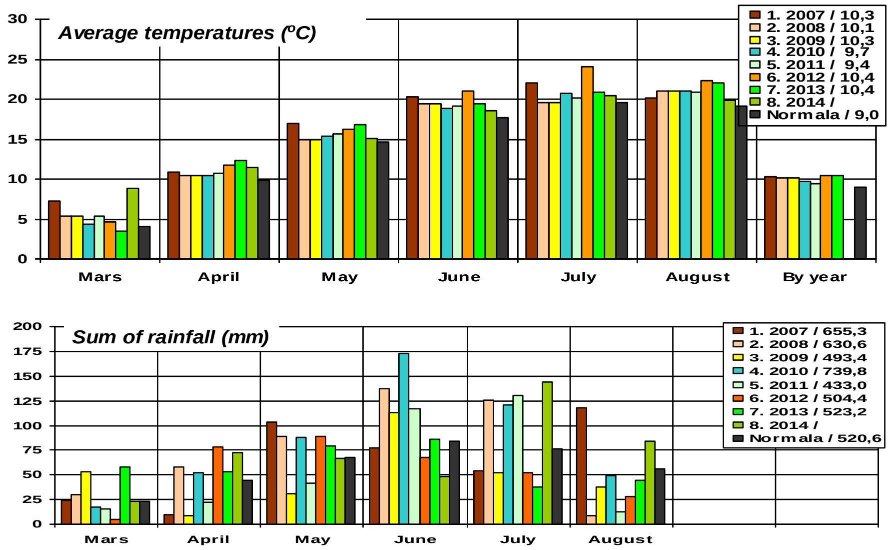

Figure 2. Average temperatures and sum of rainfall at Turda conditions by month, from March to August and by year, in 2007-2014 (ARDS Turda).

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 and conservative soil technologies 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, leafhoppers, aphids and soil pests (wire worms *Agriotes* sp. etc.). In 2009-2013, *Haplothrips tritici* reached at 68%; flies: 6%; aphids: 10%; leafhoppers 4%, wheat fleas 6%, cereal bugs 4% in the pest structure, showing an important attack potential. The pests have achieved 86% and entomophagous 14% in the structure of entomofauna of no tillage crops in open field area (Figure 3).

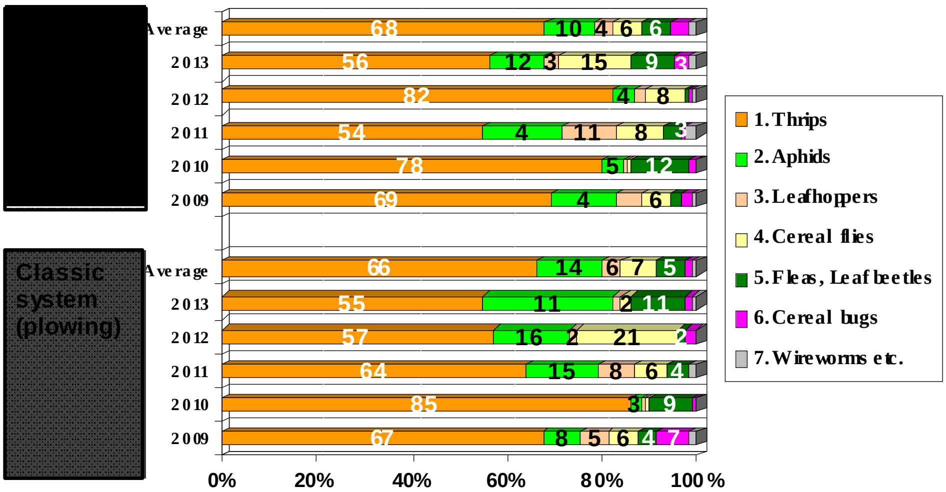

Figure 3. Dynamics of structure (%) of pests in wheat crops, in classic and in no tillage system, at ARDS Turda, in 2009-2013.

In wheat fields with classical plowing system cereal flies achieved 7 %, aphids 14%, leafhoppers 6%, more then in no tillage system, *Haplothrips tritici* reached at 66% and the sun bugs reached at 2%. The entomophagous achieved at 16% more then in no tillage system (Figure 4).

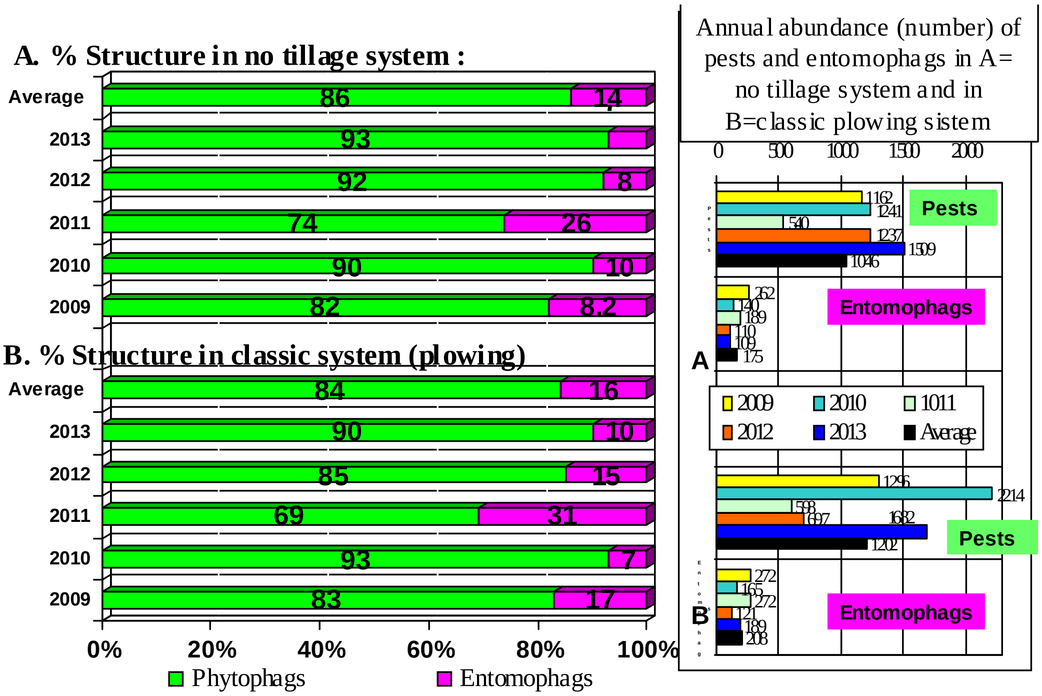

Figure 4. Dynamics of structure (%) and abundance of wheat pests and entomophags, in classic and in no tillage system, ARDS Turda, 2009-2013.

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). The wheat pests had a structural share of 75% and the entomophagous achieved 25%, on the favourable conditions due to the forestry belts. Thrips showed 30% only and flies 25%, aphids 17%, leafhoppers 5% in the pest structure (Figures 5 and 6).

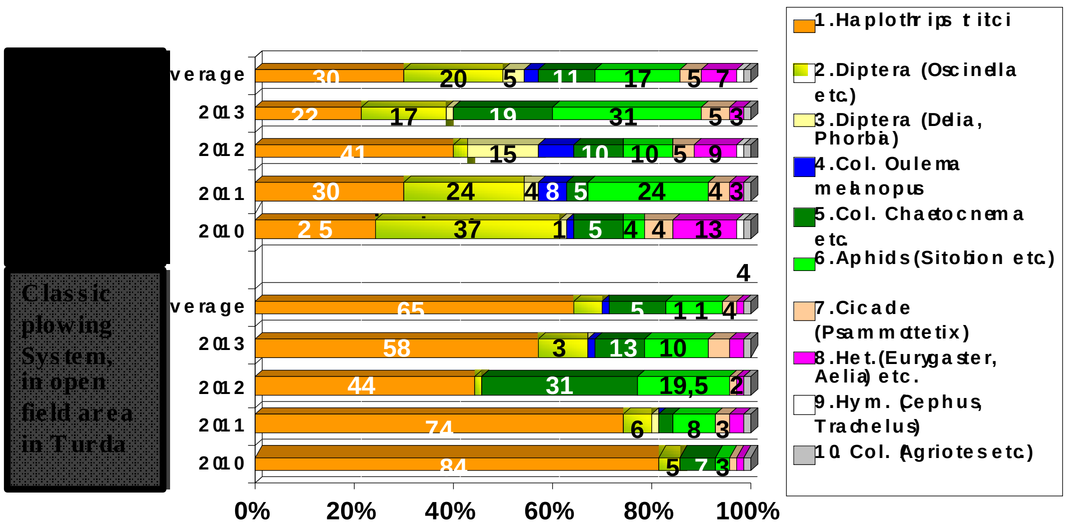

Figure 5. Dynamics of % structure of pests in wheat crops in open field area in Turda and in the agro-forestry farm in Cean–Bolduţ , 2010-2013, ARDS Turda.

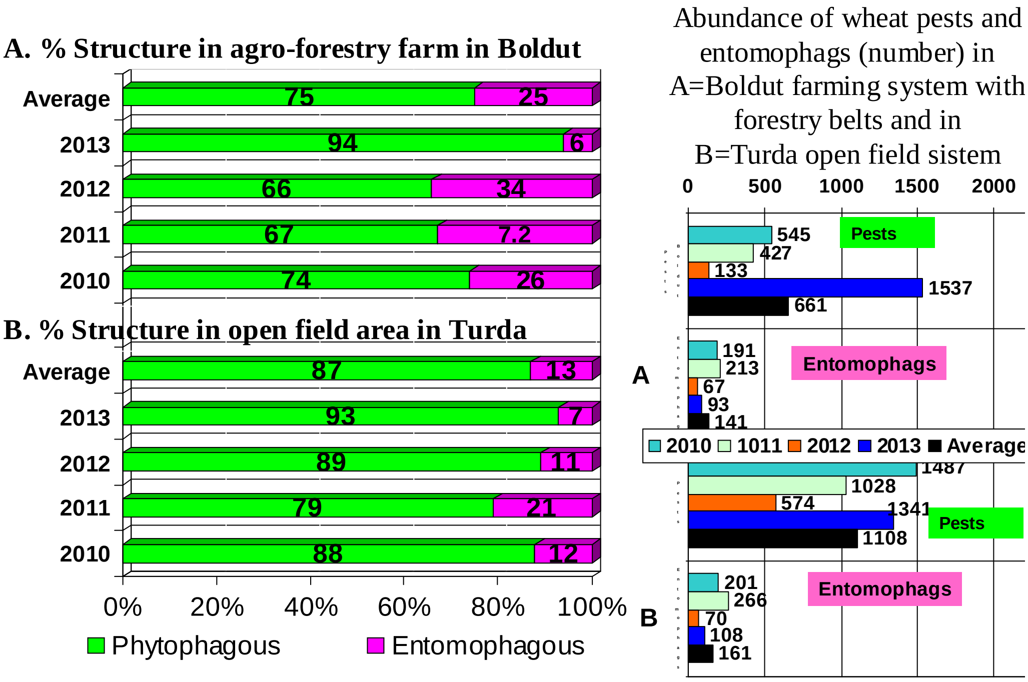

Figure 6. Dynamics of structure (%) of wheat pests and entomophagous in open field area in Turda and in the agro-forestry farm in Cean–Bolduţ , 2010-2013, ARDS Turda.

In 2010-2013, the abundance of pests in the the open system was 1.7 times higher than in the farm with protective forestry belts (Figures 7 and 8). The report on phytophagous/entomophagous was 7/1 in the open field system and only 4.7/1 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. The mentioned species abundance is a risk situation on wheat crops, which requires special measures for pests 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). 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 using the entomophagous natural resources, without insecticides (Malschi 2009; Malschi et al 2010). 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).

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.

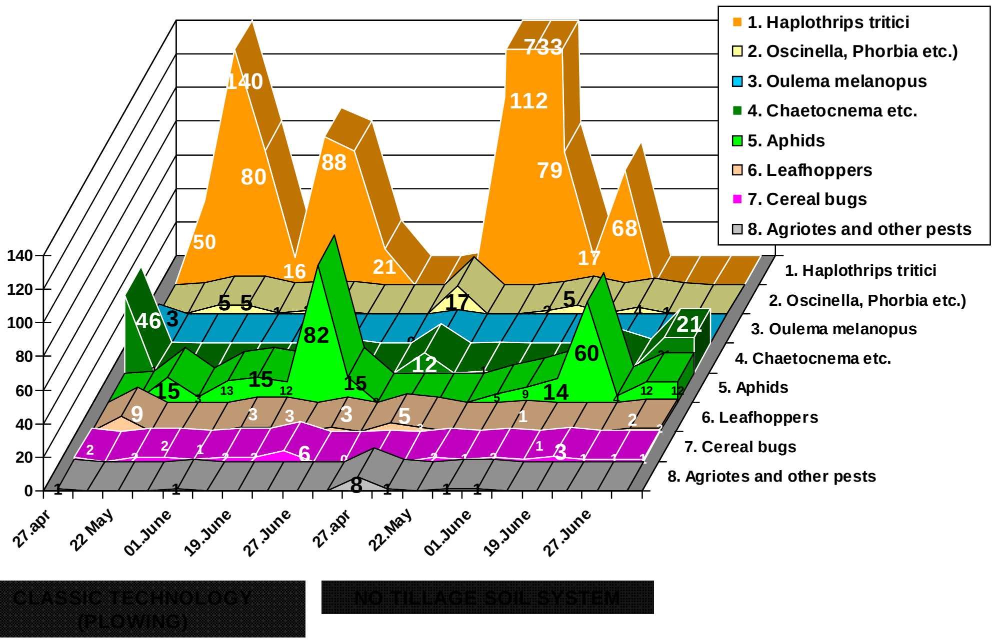

Figure 7. Occurrence and dynamics of wheat pests, in classic plowing and conservative no tillage soil technology, in 2012, at ARDS Turda (No/100 sweep net catches).

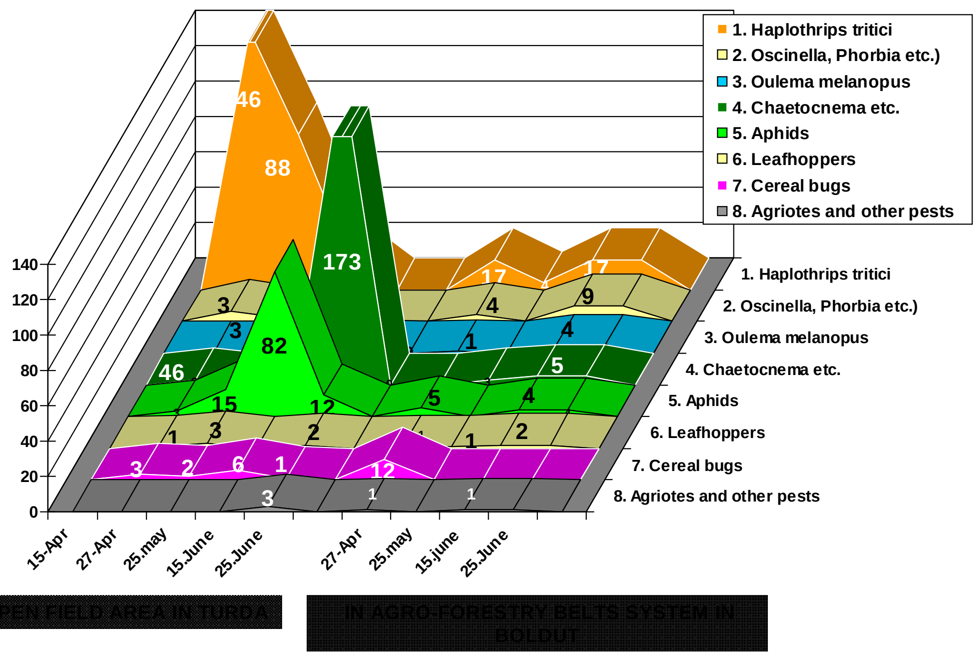

Figure 8. Occurrence and dynamics of wheat pests in open field area in Turda and in the agro-forestry farm in Cean–Bolduţ, in 2012, ARDS Turda (No/100 sweepnet catches).

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 & 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 1).

Table 1

The different types of belts compositions in Cean-Boldut farm with antierosional agroforesty belts (Lupe & 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 2). 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.

Table 2

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

Insecticide treatments	*Grain yield (kg ha^{-1})*			*Thrips (larvae/ear)*
	Average	*%*	*Differ.*	*Average*
Plot ST + Untreated on vegetation	7763	100.0	-	1.5
Plot ST + T1	7710	99.3	- 53	0.0
Plot ST + T1+T2	7922	102.0	159	0.5
Plowing plot without treatments)	4376	56.4	- 3387	21.1
No tillage plot without treatments)	4590	59.1	- 3173	28.8
Plot agro-forestry system (ST+T1+T2)	5200	67.0	- 2563	4.1
Plot in agro-forestry system without treatments	5105	65.7	- 2658	7.7
LDS p 5%		7.68	596.76	
LDS p 1%		10.79	837.66	
LDS p 0.5%		15.23	1182.58	
F test	69.97 (4.82)			

ST = seed treatment with Yunta 246 FS, 2 L t^{-1} TS; T1 = field treatment at the end of tillering/23.04.2013/ with Calypso 480 SC 100 ml ha^{-1}; T2 = field treatment at the ear emergence/17.05. 2013/ with Faster 10 CE 100 ml ha^{-1}.

The integrated pest management researche on the cereal agroecosystems with conservative no tillage soil technology, have recommended the insecticides chimical 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 & Rusu 2008; Haş et al 2008; Malschi et al 2013c).

In the last years, two critical attack moments and risk situations (Figures 7 and 8) have been reported to require treatment application (Malschi 2009; Malschi et al 2013b): 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 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; 2). the treatment in the flag-leaf appearance and ear emergence, in the 45-59 DC stage, in May 10-20, 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.

Conclusions. The paper 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 2007-2013, 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. 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. 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.

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 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 preservation and use of biodiversity; the achievement of environmental public goods associated with agriculture and integrated pests control technology.

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References

Baicu T., 1996 [Principles of integrated pest and disease management]. Ceres Publishing House, Bucharest [in Romanian].

Bărbulescu A., Popov C., 2001 [Elaborating a system of integrated pest and disease of wheat and barley]. Anale ICCPT LXVIII: 373-384 [in Romanian].

Bărbulescu A., Popov C., Mateiaş C. M., Voinescu I., Guran M., Raranciuc S., Spiridon C., Vasilescu S., Valsan D., 2001 [The evolution of diseases and pests of cereals, industrial crops and fodder in our country in 2000]. Probleme de Protectia Plantelor XXIX(1):1-17 [in Romanian].

Bărbulescu A., Popov C., Mateiaş M. C., 2002 Bolile şi dãunãtorii culturilor de câmp. Ceres Publishing House, Bucharest, 376 pp. [in Romanian]

Carlier L., Vlahova M., Rotar I., 2006 Reduction of soil erosion and soil carbon and nutrient losses by “reduced tillage” cultivation in arable land. Bulletin USAMV - Cluj-Napoca 62:14-20.

Cooper T., Hart K., Baldock D., 2009 The provision of public goods through agriculture in the European Union. Report prepared for DG Agriculture and Rural Development, contract no. 30-CE-0233091/00-28, Institute for European Environmental Policy: London.

Guş P., Rusu T., 2008 [The minimum tillage systems, alternatives for environmental protection]. In: [Soil tillage systems: the Vth International Symposium]. Risoprint Publishing House, Cluj-Napoca, pp. 9-18 [in Romanian].

Haş I., Nagy C., Haş V., Moldovan V., Mureşan E., Nagy E., Ignea M., 2008 [Varieties and hybrids of wheat, soybeans and corn for conservative technologies with minimal tillage conditions SCDA Turda]. In: [Soil tillage systems: the Vth International Symposium]. Risoprint Publishing House, Cluj-Napoca, pp. 162-170 [in Romanian].

Lupe I. Z., Spîrchez Z., 1955 [Research on the technique of creating protective curtains in Transylvania Plain]. Analele ICAS 16:411-449 [in Romanian].

Malschi D., 2007 [Environment, agriculture, sustainable development and integrated pest management of cereal agroecosystems]. Argonaut Publishing House, Cluj-Napoca, 186 pp. [in Romanian].
Malschi D., 2008 [Environment-agriculture-sustainable development. Optimization of integrated wheat pest management technologies under the dynamics of agroecological changes in Transylvania]. Argonaut Publishing House, Cluj-Napoca, 315 pp. [in Romanian]
Malschi D., 2009 Integrated pest management in relation to environmental sustainability. Part I. Ecological management of wheat pests. Bioflux Publishing House, Cluj-Napoca, 200 pp. Available at: http://www.editura.bioflux.com.ro/docs/malschi.I.pdf.
Malschi D., Tritean N., Şerbănescu R., 2010 Protective agroforestry belts and their environmental importance for sustainable agriculture development in Transylvania. Romanian Agricultural Research 27:103-114.
Malschi D., Ivaş A., Pacurar A. N., Ignea M., Tritean N., Cheţan C., 2012 Integrated wheat pests control in relation with agro-ecological changes and agriculture sustainable development. In : Agri-environment: perspectives on sustainable development. Petrescu D. C., Burny P., Petrescu-Mag R. M. (eds), Les Presses Agronomiques de Gembloux & Bioflux Publishing House Cluj-Napoca, pp. 141-168.
Malschi D., Ivaş A. D., Kadar R., 2013a Integrated management of wheat aphids and leafhoppers – suitable control methods in Transylvania. Romanian Agricultural Research 30:317-328.
Malschi D., Mureşanu F., Ivaş A., 2013b [Evaluation of pests potential of field crops in the Transylvanian Plain]. Anale INCDA Fundulea LXXXI(1):167-183. [in Romanian]
Malschi D., Ivaş A., Ignea M., Cheţan F., Cheţan C., 2013c Adequate integrated control of wheat pests in no-tillage conservative system. Proenvironment 6:332-341.
Popov C., 1979 [General considerations regarding ecological factors involved in regulating insect populations numeric level harmful cereal crops]. Probleme de Protectia Plantelor 7(4):401-423 [in Romanian].
Popov C., Bărbulescu A., 2007 [50 years of scientific activity in the field crops protection against pests and diseases]. Anale INCDA Fundulea LXXV: 371-404 [in Romanian].
Popov C., Cană L., Georgescu E., 2009 [Role of biodiversity indicators to estimate pest management in wheat crops]. Anale INCDA Fundulea LXXVII:199-210 [in Romanian].
Popov C., Bărbulescu A., Vilău F., Trotuş E., Malschi D., Vasilescu S., Traşca G., 2003 [Effect of drought on the development of pest insects populations in the field crops]. Probleme de Protectia Plantelor 31(1):49-66 [in Romanian].
Popov C., Trotuş E., Vasilescu S., Bărbulescu A., Râşnoveanu L., 2006 Drought effect on pest attack in field crops. Romanian Agricultural Research 23:43–52.
Wetzel T., 1995 Integrierter Pflanzenschutz und Agroökosyteme. Steinbeis–Transferzuntrum (STZ). Integrierter Pflanzenschutz und Ökosysteme. Ed. Druckhaus Naumburg GmbH, Halle/Saale und Pausa Vogtl. Bundesrepublik Deutschland.
*** www.fao.org/agriculture/crops/core-themes/theme/pests/ipm/.

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