# RESEARCHES CONCERNING CONTROLLING OF THE MAIZE LEAF WEEVIL (*TANYMECUS DILATICOLLIS* GYLL) IN LABORATORY CONDITIONS, USING HIGH PEST PRESSURE, AT NARDI FUNDULEA

***GEORGESCU EMIL[1), LIDIA CANA[1), CARMEN MINCEA[2)***

*[1)National Agricultural Research Development Institute (NARDI) Fundulea, 1 Nicolae Titulescu, 915200, Fundulea, Calarasi County, Romania, emilgeorgescu2013@gmail.com*

*[2)Institute of Research-Development for Plant Protection, 8 Ion Ionescu de la Brad, 013811, district 1, Bucharest, Romania*

***Keywords: maize, seed treatment, pest, control***

## ABSTRACT

*Maize leaf weevil (Tanymecus dilaticollis) is main pest of the maize crops in south and south-east of Romania. Every year there were attacked approximate one million of hectares cultivated with maize, with different attack intensity degrees. In many cases pest attack is high, as result maize plants were destroyed and farmers must sow again. The attack is dangerous when plants are in first vegetation stages (BBCH 10-14). In this paper, there were presented results of insecticides testing, used for maize seeds treatment against T. dilaticollis attack, in laboratory conditions, using high pest pressure (4 insects/plant). It has used imidacloprid, clothianidin and thiamethoxam active ingredients from neonicotinoid insecticides class. Maize plants were sowed in plastic pots and insects were added in pots, after plants emergence (BBCH 10). It has recorded daily weevils mortality until 8 days from the starting of the experiment. Also it has recorded attack intensity of the weevils at maize plants, using a scale from 1 (plants not attacked) to 9 (total damages). In laboratory conditions, in case of high pest pressure, at control (untreated) variant the attack intensity of T. dilaticollis weevils at maize plants, on a scale from 1 to 9 was 8.63. At the end of the experiment, all plants from untreated variant were destroyed. In case of seeds treated with imidacloprid, clothianidin or thiamethoxam active ingredients pest attack ranged from 4.58 to 4.65. At these variants, weevils mortality ranged from 67.50 to 71.25 %. All maize plants from treated variants survive of the attack.*

## INTRODUCTION

According MADR data (2017) and INS data (2018), in the last years, Romanian maize area was higher then 2.4 million hectares, with a grains production higher then 10 million tones (except year 2015), even higher then 14 million tones, in 2017. That means maize is one of the main crops from our country. Data from Eurostat (2017) ascertained that in the last years, Romania occupy first place in EU on maize area, but average production per hectare is still low, comparative with countries from West Europe. Lup et al. (2013) mentioned that high numbers of small farmers that practice subsistence agriculture is a possible reason for average low maize yield per hectare in Romania. Pests attack represents another cause for maize yield losses (Popov *et* al., 2001; Popov *et* Barbulescu, 2007; Rosca *et* Istrate, 2009; Goga *et* Rosca., 2011; Trotus *et* al., 2011, 2013). In south and south east of the Romania, maize leaf weevil (*Tanymecus dilaticollis* Gyll) represent the most important pest for the maize crops (Paulian *et* al., 1969, Voinescu, 1985; Barbulescu *et* al., 1993, 2001; Cristea *et* al., 2004; Popov *et* al., 2007a). Data from the literature demonstrate that, every year, in Romania there were attacked approximate one million hectares with maize by this pest (Barbulescu, 2001; Popov, 2002; Popov *et* al., 2003; 2005; 2006a; 2007a). According Paulian *et* al. (1972) the attack of *T. dilaticollis* is dangerous when maize plants are in first vegetation stages, from plants emergence (BBCH 10) until four leafs stage (BBCH 14). In case of higher attack, maize plants can be destroyed and farmers must sow again (Barbulescu *et* al., 2001). Same author mentioned that in some cases the attack of the weevils can occurred even before plants emergence. In the advanced stages of the maize, weevils attack is less economically important, they consume only leaf margins and plants survive (Rosca *et* Istrate, 2009). Researches made in Romania and neighborhood countries demonstrate that seed treatment with systemic insecticides represents the most effective method to protect maize plants during first vegetation stages (BBCH 10-14) against *Tanymecus dilaticollis* attack (Paulian *et* al., 1980; Voinescu, 1985; Barbulescu *et* al., 2001; Vasilescu *et* al., 2005; Krusteva *et* al., 2006; Popov *et* Barbulescu, 2007; Popov *et* al., 2007b; Keszthelyi *et* al., 2008; Čamprag, 2011; Trotus *et* al., 2011; Georgescu *et* al., 2014; 2015). From beginning of the 2014 the use of neonicotinoid insecticides for seed treatment of the spring crops, including maize, was restricted in EU countries (Official Journal of the European Union, 2013). As result of the EU directive 485/2013 no insecticides remain available for maize seed treatment against *Tanymecus dilaticollis* in Romania. However, between 2014 and 2018, Romania obtained temporary authorizations for use of the neonicotinoid insecticides for seed treatment at maize and sunflower crops during spring. As result of the European Commission Regulations 218/783, 218/784 and 218/785, the use of imidacloprid, clothianidin and thiamethoxam active ingredients for all field crops, both like seed treatment and foliar application will be total banned in EU countries, starting from 2019. Because of high pest pressure, especially in favorable areas of the maize leaf weevil from south and south-east of the Romania, lack of seed treatment alternatives of the spring crops can have negative impact on Romanian agriculture, in next years (Ionel I.I., 2014).

Seed treatment effectiveness it can be assessed in field conditions after a methodology developed by Paulian (1972). The experiments were placed in monoculture system (maize sowed after maize) to have high pest pressure. However climate conditions from the spring period were different from one year to another. According Popov *et* al. (2006b) *Tanymecus dilaticollis* weevils are very active at high air temperatures and low humidity registered in period when maize plants are the most susceptible for the pest attack (BBCH 10-BBCH 14). Same author mentioned that low air temperatures and high rainfall amount from spring period represent unfavorable conditions for weevils activity. Researches made in last 10 years make in evidence that climate changes from Central and South-East of the Europe countries can have negative impact on local agriculture and, in the same time, can favor pests attack (Olesen *et* al., 2011; Bebber *et* al., 2014). In last years, in south-east of the Romania it has observed atypically weather during spring period (Georgescu *et* al., 2015). Because of atypically evaluation of the climatic conditions from spring period in the favorable area of *T. dilaticollis* the attack of this pest was different from one year to another. As result, at NARDI Fundulea, Paulian (1972) has developed a laboratory method for testing of the maize seed treatment effectiveness against maize leaf weevil. The advantage of this method is that experiment is carried out in controlled conditions using high pest pressure for simulating real field situations. Using this method it has tested cloro-derivate insecticides (DDT, HCH) effectiveness concerning maize leaf weevil control (Paulian, 1972), carbofuran insecticides effectiveness (Paulian et al,, 1980) or neonicotinoid insecticides effectiveness used for maize and sunflower seed treatment (Barbulescu *et* al., 2001; Vasilescu *et* al., 2005). In laboratory conditions it has studding insects behavior (Paulian *et* Popov, 1973) or role of the nutrition in maize leaf weevil life cycle (Paulian *et* al., 1979). After 2010, at Plant Protection Institute, Manole *et* al. (2013) has studied mass rearing of *Tanymecus dilaticollis* weevils, successive generations, in controlled conditions. According this author, after a few generations, at insects reared in laboratory controlled conditions can appear physiological disturbances such as female sterility.

Data from the literature make in evidence that laboratory experiments it has made in neighborhood countries, too. In Bulgaria, Keszthelyi *et* al. (2008) studied effectiveness of seed treatment and soil disinfection, on three soils type, using isolators previously sown with corn (1-2 leaf stage). In Bulgaria, Draganova *et* al. (2012) makes bioassays of *Tanymecus dilaticollis* weevils with some *Beauveria bassiana* isolates, for biological control of this pest.

Most of the cited authors use for laboratory assessments insects collected from the open field, from places where maize plants or soil was untreated.

The laboratory testing of different active ingredients used for maize seed treatment continues at NARDI Fundulea too (Georgescu *et* al., 2014; 2016). In this paper there were presented results of laboratory experiment concerning maize seed treatment effectiveness for controlling of the *Tanymecus dilaticollis* attack using high pest pressure (4 insects/plant). It has tested three active ingredients from neonicotinoid class (imidacloprid, clothianidin and thiamethoxam), used in Romanian agriculture for maize seed treatment.

## MATERIALS AND METHODS

The researches have been carried out in 2018 at Plant and Environmental Protection Collective in frame of National Agricultural Research Development Institute (NARDI) Fundulea, Calarasi County, Romania.

The insects were collected from the maize untreated crops, located both at the Plant and Environmental Protection Collective and Ecological Agriculture Laboratory experimental fields (44°30′ N, 24°10′ E). Insects were collected at the end of April or beginning of May. This period coincides with maximum activity of these weevils at the soil surface. Optimum time for collecting insects from the open field is between 11:00 AM and 15:00 PM. Also it is recommended to collect the insects in warm days with clear sky and low wind. These conditions are favorable for weevils activity at the soil surface (Popov *et* al., 2006b).

*Fig. 1-Plastic pots, sowed with maize, used at laboratory experiment, for evaluating seed treatment effectiveness against T. dilaticollis Gyll*

Until starting of the laboratory experiment, weevils collected from the field were maintaining in climatic chambers, for a few days, at 15±2 °C air temperature and 80-85 % relative air humidity. At this temperature the insects remain inactive.

For laboratory experiment it has used plastic pots (12x12x10 cm). Before sowing, pots were filing ¾ with soil, harvested from the areas without chemical treatments (preferably from the edge of the forest). In each plastic pot it has sowed five maize seeds (*Fig*. 1).

For this experiment it has used Olt maize hybrid. After sowing, pots were complete filled with soil, then soil from each pot was slight compressed and soaking with water for ensure uniform emergence of maize plants. All pots receive same water quantity. It is very important to have uniform emergence of the maize plants from all plastic pots. For this reason the experiment was carried out in laboratory room with uniform light for all pots.

*Fig.* 2-*Pots covered with isolators, bonnet with bolter (NARDI Fundulea)*

After beginning of the plants emergence, when maize seedlings arrive above soil surface (BBCH 10), the insects collected from the open field were added in plastic pots. For ensure higher pest pressure, in each pot it has added 20 insects to have a pest density of 4 adults per plant (Barbulescu *et* al., 2001). Insects must manipulated carefully for not hurt then. After insects were added, the pots were covered with isolators, bonnet with bolter (*Fig*. 2). Each variant have four replications, each pot represent one replication. Active ingredients used in this experiment were imidacloprid, clothianidin and thiamethoxam (*Tab*. 1).

**Insects mortality** was assessed daily after pots infestations. After each assessment, dead insects from all pots were removed. Results of these assessments were evaluated as average insects mortality percent, at the end of the assessments period (8 days from pots infestations).

*Tab. 1*

Active ingredients used in the laboratory experiment concerning maize seed treatment effectiveness against *Tanymecus diladicollis* Gyll

| **Variant** | **Active ingredient** | **Commercial product** | **Dose** (mg a.i./grain) |
|---|---|---|---|
| 1 | control (untreated) | — | — |
| 2 | imidacloprid (600 g/l) | Nuprid 600 FS | 1.30 |
| 3 | clothianidin (600 g/l) | Poncho 600 FS | 0.50 |
| 4 | thiamethoxam (350 g/l) | Cruiser 350 FS | 0.83 |

**Attack intensity** of *Tanymecus dilaticollis* adults was rated when maize plants from plastic pots arrive at four leafs stage (BBCH 14). Attacked plants were rated on a scale from 1 to 9, elaborated and improved by Paulian (1972), as follows:

**note 1**-plant not attacked;

**note 2**-plant with 2-3 simple bites on the leaf edge;

**note 3**-plants with bites or clips on all four leafs edge;
**note 4**-plants with leafs chaffed in proportion of 25 %;
**note 5**-plants with leafs chaffed in proportion of 50 %;
**note 6**-plants with leafs chaffed in proportion of 75 %;
**note 7**-plants with leafs chaffed almost at the level of the stem;
**note 8**-plants with leafs completely chaffed and beginning of the stem destroyed;
**note 9**-plants destroyed, with stem chaffed close to soil level.

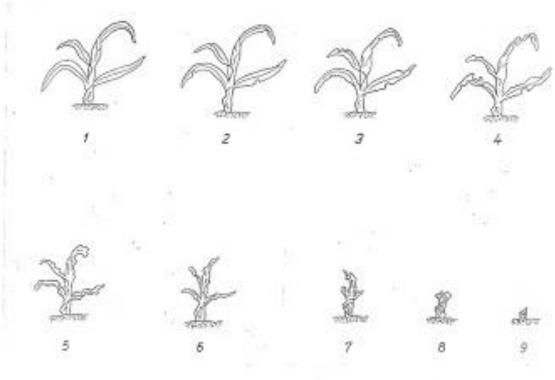


*Fig*. 3-*Attack intensity scale (1-9), elaborated and improved by Paulian (1972), NARDI Fundulea*

Plants with higher attack intensity (note 8 or 9) have all leafs damaged and stem partial or total destroyed (*Fig*. 3). These attacked plants couldn't recovery and will die (Rosca *et* Istrate, 2009). Same authors mentioned that in case of lower attack of the pest (plants with damaged leafs but stem less affected) maize seedlings will not be destroyed but the yield can be reduced.

During the laboratory experiment air temperature and relative air humidity were recorded with Klimalogg..pro data logger. This climatic data were recorded one time at each 15 minutes.

The data from laboratory assessments were **statistical analyzed** through Student Newman-Keuls test.

## RESULTS AND DISCUSSIONS

Air temperature registered in laboratory room where experiment was placed ranged between 20.8 and 28.5 °C. Paulian (1972) mentioned that when average air temperature registered during day time is higher then 20 °C insects have maximum activity on soil surface. In this experiment, temperatures registered during day time, in laboratory room, were higher then 24.0 °C (*Fig*. 4). Relative air humidity registered during this experiment ranged between 37.1 and 65.8 % (*Fig*. 5). Overall climatic conditions from the laboratory, during experiment, were favorable for both *T. dilaticollis* weevils mating and feeding process.

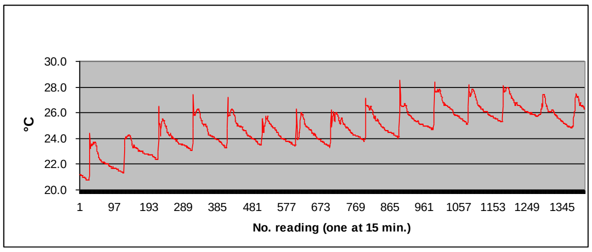


Fig. 4-*Air temperature (°C) registered during laboratory experiment*

After insects were added in plastic pots, immediately they start feeding with maize young plants. Also it has observed starting of weevils mating process. This observations concerning insects behavior in laboratory conditions was in accordance with those mentioned by Paulian *et* Popov (1973) and Paulian *et* al. (1979).

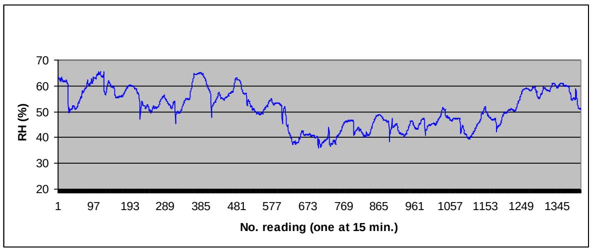


Fig. 5-*Relative air humidity (%) registered during laboratory experiment*

At treated variants the effects of the active ingredients it was starting to be observed after 10-15 minutes from the moment when insects start feeding. Weevils start to have uncontrolled movements and couldn't continue feeding and mating processes.

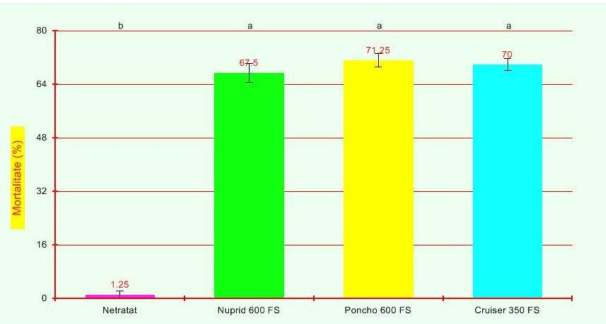


Fig*. 6*-T. dilaticollis adults mortality (%), in laboratory conditions, at NARDI Fundulea

However weevils don't die immediately. A possible explication for this is because of different ways of insecticides action on target pests including maize leaf weevil (*Tanymecus dilaticollis* Gyll). The insecticides from neonicotinoid class affect nervous system of the insects (Chao *et* Casida., 1997; Jeschke *et* al., 2011; Adak *et* al., 2012). At the end of the observations period, at treated variants, insects mortality ranged from 67.50 %, in case of variant treated with imidacloprid active ingredient and 71.25 %, in case of variant treated with clothianidin (*Tab*. 2). At variant treated with thiamethoxam active ingredient it has registered a mortality of 70.00 %. There weren't statistical differences between treated variants (*Fig*. 6). However, higher statistical differences it has registered between all treated variants and control (untreated) variant (P<.05).

*Tab. 2*

The effectiveness of seeds treatment at maize crop against *Tanymecus dilaticollis* Gyll, in laboratory conditions, at NARDI Fundulea

| Nr. crt. | Active ingredient | Insects mortality (%) | Attack incidence (%) | Attack intensity (1-9) |
|---|---|---|---|---|
| 1 | control | 1.25b | 100a | 8.63a |
| 2 | Imidacloprid | 67.50a | 100a | 4.65a |
| 3 | clothianidin | 71.25a | 100a | 4.60a |
| 4 | thiamethoxam | 70.00a | 100a | 4.58a |
| LSD (P=.05) | | 7.05 | 0 | 0.41 |
| Standard Deviation | | 4.41 | 0 | 0.26 |
| CV | | 8.40 | 0 | 4.57 |

Means followed by same letter do not significantly differ (P=.05, Student-Newman-Keuls)

Analyzing data from table 2 it has ascertained that attack intensity of *T. dilaticollis* at maize untreated plants, in conditions of high pest pressure (4 insects/plant), on a scale from 1 to 9, were almost maximum (I=8.63). At eight days after pots infestation, maize plants were destroyed because of high insects attack and can't recover (*Fig.* 7). At treated variants, attack intensity of *T. dilaticollis* at maize plants ranged from 4.58 in case of variant treated with thiamethoxam and 4.65 in case of variant treated with imidacloprid. At variant treated with clothianidin, on a scale from 1 to 9, attack intensity was 4.60. In this laboratory experiment, in conditions of high pest pressure (4 insects/plant), at treated variants, plants have leafs chaffed in proportion of 25-50 %. However maize plants survive of the attack and have normal later development.


*Fig*. 7-*Untreated maize plants destroyed by T. dilaticollis weevils at 8 days from the start of the experiment*

Regard as attack intensity there weren't statistical differences between treated variants (P<.05). However higher statistical differences it was registered between untreated (control) variant and all treated variants (*Fig*. 8).

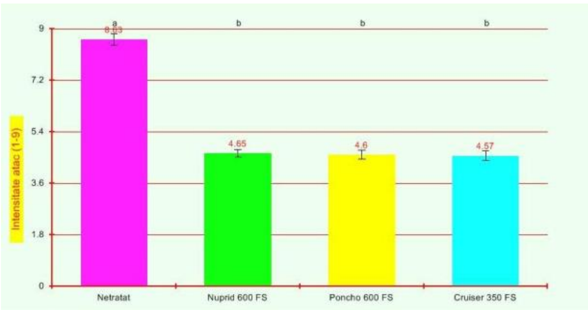


*Fig*. 8-*T. dilaticollis attack intensity, at maize plants in laboratory conditions, at NARDI Fundulea*

Between insects mortality and attack intensity there were negative correlation (*Fig*. 9).

In controlled conditions, using high pest pressure (4 insects/plant) seed treatment with imidacloprid, clothianidin and thiamethoxam active ingredients provide effective protection of the maize plants, in first vegetation stages (BBCH 10-14) against maize leaf weevil (*T. dilaticollis* Gyll) attack (*Fig*. 10). At same conclusion arrive Barbulescu *et* al. (2001), Vasilescu *et* al. (2005), Keszthelyi *et* al. (2008), Georgescu *et* al. (2014, 2015, 2016).

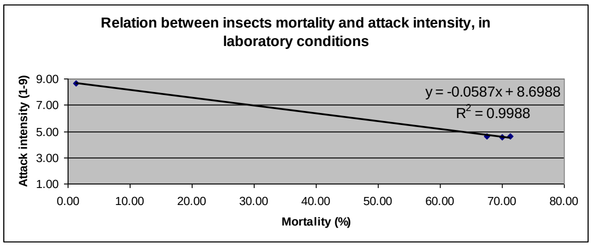


*Fig*. 9- *Relation between insects mortality and attack intensity, in laboratory conditions at NARDI Fundulea*

Laboratory experiment, in conditions oh high pest pressure is a good method to evaluate the effectiveness of the insecticides used for maize seed treatment. This method couldn't replace field assessments but is a good way to observe insecticides mode of action on target pest. Also this method is a good simulation for field situations with heavy weevils infestation (25-30 insects/m$^2$ or higher densities).


*Fig*. 10-*Laboratory experiment, at 8 days from the adding of the insects in the plastic pots. Left-untreated variant.*

On base of the laboratory assessments results, it can be elaborated mathematic models for better understanding of *T. dilaticollis* weevils attack at maize plants.

## CONCLUSIONS

In the conditions of high pest pressure (4 insects/plant), maize plants from untreated variant were destroyed after eight days from pots infestation, by *T. dilaticollis* weevils. Attack of this pest at maize untreated plants, on a scale from 1 to 9 was 8.63.

In this laboratory experiment at variants treated with imidacloprid, clothianidin and thiamethoxam active ingredients weevils mortality ranged from 67.50 to 71.25 %. There weren't statistical differences between treated variants.

In this laboratory experiment at variants treated with imidacloprid, clothianidin and thiamethoxam active ingredients the attack of *T. dilaticollis* at maize plants, on a scale from 1 to 9, ranged from 4.58 to 4.65. There weren't statistical differences between these variants.

In conditions of high pest pressure (4 insects/plant) seed treatment with imidacloprid, clothianidin and thiamethoxam active ingredients provide effective protection of the maize plants, in first vegetation stages (BBCH 10-14) against maize leaf weevil attack.

Laboratory assessments represent a complementary method with field assessments concerning maize leaf weevil control.

Further researches are necessary to evaluate different active ingredients effectiveness for controlling of *T. dilaticollis* weevils, in eventuality of neonicotionids permanent ban.
Also it is necessary new researches concerning rearing of *T. dilaticollis* in laboratory conditions.

## ACKNOWLEDGEMENTS

This research work was carried out with the financial support of the Ministry of Agriculture and Rural Development, in frame of the national project ADER 4.1.5.

## REFERENCES

**1. Adak, T.K., Shakil J., N.,A. and Walia, S.**, 2012 - *Development of controlled release formulations of imidacloprid employing novel nano-ranged amphiphilic polymers. Journal of Environmental Science and Health, Part* B 47 (3):217.

**2. Barbulescu, A.,** 2001 - *Results obtained in year 2000, in frame of the researches concerning cereals, industrial and forages plants pest and diseases. Problems of Plant Protection*, 29 (2):123-178.

**3. Barbulescu, A., Voinescu, I., Sadagorschi, D., Penescu, A., Popov, C. and Vasilescu, S.,** 2001 - *Cruieser 350 FS-A new product for maize and sunflower seed treatment against Tanymecus dilaticollis Gyll. Romanian Agricultural Research*, 15:77-87.

**4. Barbulescu, A., Mateias, M.C., Popov, C., Voinescu, I., Guran, M., Raranciuc, S., Mincu, M., Spiridon, C. and Stanciu, M.,** 1997 - *Evolution of some diseases and pests of cereal, industrial and forage crops in our country during 1997. Problems of Plant Protection*, 25(1):51-72.

**5. Bebber, D.P., Holmes, T. and Gurr, S.J.,** 2014 - *The global spread of crop pests and pathogens. Global Ecology and Biogeography*, 23(12):1398-1407.

**6. Čamprag.,** 2011 - *Impact of climate to appearance of field crop pests in Vojvodina [Serbia] during 2001-2020 [i.e. 2010]. Biljni lekar*, 39(4):434-446.

**7. Chao, S.L. and Casida, J.E.,** 1997 - *Interaction of Imidacloprid Metabolites and Analogs with the Nicotinic Acetylcholine Receptor of Mouse Brain in Relation to Toxicity*. Pesticide Biochemistry and Physiology, 58:77.

**8. Cristea, M., Cabulea, I. and Sarca, T.,** 2004 - *Maize. Monograph study, Vol. 1,* *Romanian Academy Publishing house*, Cap. 14:589-626.

**9. Draganova, S.A., Toshova, T.B. and Takov, D.I.,** 2012 - *Fungal pathogen of grey corn weevil Tanymecus dilaticollis (Coleoptera: Curculionidae) and Bioassay with some Beauveria bassiana isolates. Acta zoological Bulgarica*, 64(3): 289-294.

**10. Georgescu, E., Cana, L., Popov, C., Gargarita, R., Rasnoveanu, L. and Voinea, L.,** 2014 - *Maize leaf weevil (Tanymecus dilaticollis Gyll) in the context of neonicotinoid seed treatment restriction. Annals of N.A.R.D.I. Fundulea*, 82:251-277.

**11. Georgescu, E., Cana, L., Gargarita R., Voinea, L. and Rasnoveanu, L.,** 2015 - *Atypically Behavior of the Maize Leaf Weevil (Tanymecus Dilaticollis Gyll) on Maize and Sunflower Crops, in Climatic Conditions of the Year 2014, in South-East of Romania*. *Agriculture and Agricultural Science Procedia*, 6:9-16.

**12. Georgescu, E., Toader, M., Ionescu, A.M., Cana, L. and Rasnoveanu L.,** 2016 - *Testing of the new insecticides formulation for maize seeds treatment against Tanymecus dilaticollis Gyll in laboratory conditions. AgroLife Scientific Journal*, 5(1):83-90.

**13. Goga, N. and Rosca, I**., 2011 - *Research regarding biology of Western Maize Rootworm (Diabrotica virgifera virgifera Le Conte) in Satu Mare County*. *Scientific Papers-Series A, Agronomy*, 54:382-385.

**14. Ionel, I.I.,** 2014 - *Regulation implications on banning the treatment of seeds with neonicotinoid insecticides on the seed market in Romania. Scientific Papers Agricultural Management*, 16(2):223-228.

**15. Jeschke, P., Nauen, R., Schindler M. and Elbert A.,** 2011 - *Overview of the Status and Global Strategy for Neonicotinoids. Journals of Agricultural and Food Chemistry*, 59:2897-2908.

**16. Keszthelyi, S., Kurucsai, P., Szabó, T. and Pál-Fám, F.,** 2008 - *Food choice studies and control trials carried out with maize leaf and beet leaf weevil*. *Növényvédelem*, 44:391–396.

**17. Krusteva, H., Panajotova, M., Tonev, T., Karadzhova, Y., Milanova, S., Nikolov, P., Dimitrova, A., Stefcheva, M., Ventsislavov, V., Chavdarov, L. and Velichkov, A.,** 2006 - *Good plant protection practice in maize crops*. *Ministry of Agriculture and Food, Sofia*, 2, 015(1):69–77.

**18. Lup, A., Miron, L. and Roman, B.,** 2013 - *Influence of market economy on arable crop structure*. *Annals of N.A.R.D.I. Fundulea*, 81:185-191.

**19. Manole, T., Ionescu-Malancus, I., Antonie, I. and Rebega, L.C.,** - 2013, *New contribution concerning the mass rearing of Tanymecus dilaticollis Gyll (Coleoptera: Curculionidae) under controlled conditions. Scientific Papers, Series Management, Economic Engineering in Agriculture and Rural Development*, 13(4):195-200.

**20. Olesen, J.E., Tmka, M., Kersebaumc, K.C., Skjelvågd, A.O., Seguine, B., Peltonen-Sainiof, P., Rossig, F., Kozyrah, J. and Micalei, F.,** 2011 - *Impacts and adaptation of European crop production systems to climate change. European Journal of Agronomy*, 34 (2):96-112.

**21. Paulian, F., Popov, C. and Dinu-Pana, M.,** 1969 - *The corn leaf weevil (Tanymecus dillaticolis Gyll.) in Romania and its control. Contemporary Agriculture, Yugoslavia, Novi Sad*, 5-6:643-652.

**22. Paulian, F**., 1972 - *Contribution at knowledge of the development, ecology and control of the Tanymecus dilaticollis specie (Contribuţii la cunoaşterea dezvoltării, ecologiei şi combaterii speciei Tanymecus dilaticollis)*. *Doctoral thesis, I.A.N.B. Bucharest*, pp. 300.

**23. Paulian, F. and Popov, C.,** 1973 - *Aspects of the behavior of Tanymecus dillaticolis Gyll, reared under green house conditions*. *Annals of I.C.P.P. Bucharest*, 10:245-252.

**24. Paulian, F., Popov, C. and Grigorescu, R.,** 1979 - *The role of the nutrition regime in the adults life of Tanymecus dilaticollis Gyll. (Curculionidae-Coleoptera) specie*.

*Problems of Plant Protection*, 7(4):363-376.

**25. Paulian, F., Banita, E., Barbulescu, A., Burdea, V., Bunescu, S., Ciurdarescu, G., Craiciu, D., Csep, N., Doncila, A., Enica, D., Ignatescu, I., Iliescu, H., Mateias, M.C., Munteanu, I., Nagy, E., Peteanu, S., Petcu, L., Popov, C., Romascanu, C., Sapunaru, T., Sin., M., Tanase, V., Tusa, C., Vernescu, I., Voicu, M. and Voinescu, I.,** 1980 - *Results obtained in 1979 in the studies on the diseases and pests of field crops, Problems of Plant Protection*, 8(4):203-246.

**26. Popov, C.,** 2002 - *Researches concerning the protection of the cereals, leguminous for grains, technical and forage plants against pathogen agents and pests, year 2001*. Problems of Plant Protection, 30 (2):109-190.

**27. Popov, C., Barbulescu, A., Trotus, E., Vasilescu, S. and Bucurean, E.,** 2001 - *Control of wireworms by seed treatment in Romania. Romanian Agricultural Research*, 15:1-12.

**28. Popov, C., Guran, M., Raranciuc, S., Rotarescu, M., Spiridon, C., Vasilescu and S. and Gogu, F.,** 2003 - *Phytosanitary state of the cereals, leguminous for grains, forage and technical crops from Romania, year 2002*. *Problems of Plant Protection*, 31(1):1-22.

**29. Popov, C., Guran, M., Raranciuc, S., Rotarescu, M., Spiridon, C., Vasilescu, S. and Gogu, F.,** 2005 - *Phytosanitary state of the cereals, leguminous for grains, forage and technical crops from Romania, year 2004*. *Problems of Plant Protection*, 33(1-2):7-30.

**30. Popov, C., Guran, M., Raranciuc, S., Rotarescu, M., Spiridon, C., Vasilescu, S. and Gogu, F.,** 2006a - *Phytosanitary state of the cereals, leguminous for grains, forage and technical crops from Romania, year 2005*. *Problems of Plant Protection*, 34(1-2):15-37.

**31. Popov, C., Trotus, E., Vasilescu, S., Barbulescu, A. and Rasnoveanu, L.,** 2006b - *Drought effect on pest attack in field crops*. *Romanian Agricultural Research*, (23):43-52.

**32. Popov, C., Raranciuc, S., Spiridon, C., Vasilescu, S. and Cana**, **L.,** 2007a - *Phytosanitary state of the cereals, leguminous for grains, forage and technical crops from Romania, year 2006*. *Problems of Plant Protection*, 35(1):1-24.

**33. Popov, C., Barbulescu, A., Raranciuc, S.,** 2007b - *Seed treatment a modern, efficient and less pollutant method for field crops protection*. *Annals of N.A.R.D.I. Fundulea*, 75:133-139.

**34. Popov, C. and Barbulescu, A.,** 2007 - *50 years of scientific activity in field protection domain against diseases and pests*. *Annals of N.A.R.D.I. Fundulea*, 75:371-404.

**35. Rosca, I. and Rada, I.,** 2009 - *Entomology (Agriculture, Horticulture, Forest)*. *Alpha MDN Publishing house*, 699 pp. (Cap. 2:115-143).

**36.** *Trotus, E., Buburuz, A.A. and Zaharia, P*., 2011 - *Researches on the protection of maize crops against soil pests. Agronomical Researches in Moldavia*, 4: 45-51.

**37. Trotus, E., Zaharia, P., Nae, M., Buburuz, A.A. and Pochiscanu, S.F.,** 2013 - *Research on the evolution of Agrotis segetum Den. et Schiff. species under conditions of central Moldavia*. *Annals of N.A.R.D.I. Fundulea*, 81:141-153.

**38. Vasilescu, S., Popov, C., Stoica, V., Negrila, M. and Procopovici, E.,** 2005 - *Results regarding control of maize leaf weevil (Tanymecus dilaticollis Gyll) by chemical seed treatment during 2000-2004*. *Scientific Papers, USAMV, series A*, 68:343-350.

**39. Voinescu**, **I.,** 1985 – *Maize seed treatment with carbamic insecticides, effective method of T. dilaticollis Gyll control*. *Problems of Plant Protection*, 13 (2):151-156.

******INS,** 2018 - *Vegetal agricultural production increasing at all crops in 2017 comparative with 2016 (Producţia agricolă vegetală a crescut în anul 2017 faţă de anul 2016, la toate culturile)*, *Press communicate*, 77:1-4.

http://www.insse.ro/old/sites/default/files/com_presa/com_pdf/prod_veg_r17_1.pdf

***EUROSTAT database, 2017 - http://ec.europa.eu/eurostat/data/database

***MADR data, 2016 - http://www.madr.ro/culturi-de-camp/cereale/porumb.html

***Official Journal of the European Union, 2013 - http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:139:0012:0026:EN:PDF

***Official Journal of the European Union, 2018a - *Commission implementing regulation (EU) 2018/783 of 29 May 2018 amending Implementing Regulation (EU) No 540/2011 as regards the conditions of approval of the active substance imidacloprid*. 61(L132):31-34, ISSN 1977-0677. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.132.01.0031.01.ENG&toc=OJ:L:2018:132:FULL

***Official Journal of the European Union, 2018b - *Commission implementing regulation (EU) 2018/784 of 29 May 2018 amending Implementing Regulation (EU) No 540/2011 as regards the conditions of approval of the active substance clothianidin*. 61(L132):35-39, ISSN 1977-0677. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.132.01.0035.01.ENG&toc=OJ:L:2018:132:FULL

***Official Journal of the European Union, 2018c - *Commission implementing regulation (EU) 2018/785 of 29 May 2018 amending Implementing Regulation (EU) No 540/2011 as regards the conditions of approval of the active substance thiamethoxam*. 61(L132):40-44, ISSN 1977-0677. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.132.01.0040.01.ENG&toc=OJ:L:2018:132:FUL