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UTILIZAREA PROGRAMELOR EXPERT ŞI A CAPCANELOR CU FEROMONI PENTRU MONITORIZAREA STRESS-ULUI BIOCENOTIC ŞI AVERTIZAREA TIMPURIE A TRATAMENTELOR CU INSECTICIDE ÎN PLANTAŢIILE POMICOLE

USE OF EXPERT SOFTWARE AND PHEROMONES TRAPS FOR BIOCENOTIC STRESS MONITORING AND EARLY WARNING OF TREATMENTS AGAINST INSECTS IN ORCHARDS

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Abstract

This paper presents our results in use of the specialized software and specific modules for microclimate monitoring and pest biological cycle assessment, to evaluate and quantify the attack risk for microclimate monitoring, combined with 6 type specific pheromones produced in Romania, in order to determine their efficacy in detecting the targeted micro *Lepidoptera*, assess their population flight pattern, as well and the biocenotic stress, both tools categories aiming to the precise positioning of the treatments to achieve integrated pests management and reduce the overall impact of the treatments with insecticides on the environment. According the fruit species, several strategies have been defined and followed by several insecticide applications into the bearing orchards, to achieve a better control of damaging micro *Lepidoptera*. Use of the mixed monitoring systems in tandem with specific pheromones contributed to a more efficient use of the insecticides and increased performances, both for pome and stone fruit species as well.

Cuvinte cheie:, micro-Lepidoptere, dinamica zborului, insecticide.
Key words: micro-Lepidopterae, flight dynamic, insecticides.

1. Introduction

During the last decade, in the fruit growing sector, many technical and socio-economic changes occurred, which turn this into an intensive and complex activity. As followed, important amounts of fruits and derivate are put on the market to satisfy the increasing demand and very exigent consumers as well.

In Europe, the average mean productions of pome fruits was 8,238,585 t apples and 429,340 t pears/year, harvested from 989,294 respectively 163,815 ha. On the continent, the most important apple producing countries are: Poland, Italy, France, and Germany. Romania is producing in average 488,773 t apples annually, from 54,970 and respectively 51,972 t pears from 3,137 ha.

In the latest years, the plum harvested surface in Europe was 381,602 ha, with a mean production of 2,539,868 t/year. The most important plum producing countries were: Romania, Serbia and Bulgaria, followed by Turkey. Romania is producing in average 558,356 t plums / year, from 65,985 ha.

The average production of apricots in Europe is 1,101,294 t/year, obtained from 101,476 ha. The most important apricot producing countries are: Turkey, Italy, Spain and France. Romania is producing in average 33,839 t apricots/year, from 2,317 ha.

As regard the peach and nectarine production in Europe, this one was about 246,485 t/year, obtained from 21,462 ha. The most important peach and nectarine producing countries are: Greece, Spain, France and Italy. Romania is producing in average 21,462 t peach and nectarines/year, from 1,771 ha. (Faostat 2014-2019)

Even under the climatic changes, a major link in the production chain is orchard and crop phytoprotection.

The fruit moths of *Lepidoptera* Order, mainly from *Tortricidae* and *Gelechiidae* families, are very damaging pests of integrated fruit production chain in most of the fruit growing areas in Europe and Worldwide.

Among orchards micro Lepidoptera the most damaging ones are apple codling moth (*Cydia pomonella*) which affects the apple, pear and quince productions, plum fruit moth (*Cydia funebrana*) which attack plums, the peach twig borer *Anarsia lineatella* which attack especially peach and nectarines shoots, but also the ones of some plum species and *Cydia molesta* which affects peach, nectarines and apricot productions and impacts sometimes over pome fruit production.

Sometimes, under temperate climate, other micro Lepidoptera like marbled tortrix (*Hedya nubiferana*) and summer tortrix (*Adoxophyes reticulana*) can affect the quality of the harvested fruits.

On our opinion, the lack of adequate treatments, or partial control of the specific pests may lead to economic loses estimated, somewhere between 1,278-4,261 Euro/ha/year for pome fruit species, and 1,583-3,652 Euro Euro/ha/year for stone fruit species.

Depending on year microclimate parameters dynamics, each important damaging micro Lepidoptera has two or three generations per year which involve monitoring and two or three applications with insecticides to keep the population and the damages under economic damages threshold (EDT).

Today the goal is to find new solutions in order to improve the crop protection, as well as protect the environment and natural resources. (Sallai et al., 2000; Polesny, 2000; Cravedi, Pollini, 2003; Sumedrea et al., 2010).

The increasing public awareness and changes in social attitude towards exposure to pesticides which are not very cheap control tools, together with the development of resistance against the insecticides used for the key micro *Lepidoptera* moth control (Ioriatti et al., 2000; Ioriatti and Bouvier, 2000; Drosu et al., 2001; Teodorescu et al., 2003; Groening et al., 2003; Bruner et al., 2012), makes necessary to introduce improved strategies and develop improved monitoring methods for micro-*Lepidoptera* (fruit moths), compatible with the aims of precise monitoring of biotic stress induced in the modern orchards, early warning of potential damages, precise positioning of treatments and integrated pests management (LaGasa et al., 2003; Oprean et al., 2006; Molinari and Schiaparelli, 2012; Jones et. al. 2019).

This paper presents our results in use of specialized software for microclimate monitoring in order to determine their effectiveness in targeted micro Lepidoptera detection, assessment of their population flight pattern, as well as the expert software modules for microclimate monitoring and pest biological cycle assessment. The goal was to evaluate and quantify the attack risk as well as specific pheromones produced in Romania, to assess the biocenotic stress, both tools categories aiming to the precise positioning of the treatments to achieve integrated pests management and reduce the overall impact of the treatments with insecticides on the environment.

2. Material and methods

During 2018-2020, field trials were conducted into the two groups of modern orchards plots with different level of micro *Lepidoptera* populations, in order to determine the efficacy of pheromone traps in targeted pest's detection and assess the pest's population flight pattern. We used also the expert Specware Pro software modules specific to the WatchDog semi-automate weather station from Spectrum Inc. USA effectiveness, for microclimate monitoring and pest biological cycle assessment. Both instruments were used to the precise positioning of the treatments in integrated pest's management frames and reduced overall impact of the treatments with insecticides on the environment.

First group of plots were established at RIFG Pitesti and consisted in:

1 plot established in 2009 with apple trees grafted on M9, T337, Pi80 and EMLA rootstocks, planted at 3.50 x 1.25 m (2,285 trees/ha) and trained as slender spindle;

1 plot established in 2016 with apple trees grafted on M9, rootstock, planted at 3.50 x 1.25 m (2,285 trees/ha) and trained as slender spindle;

1 plot established in 2009 with plum trees grafted on Saint Julien rootstock, planted at 4.00 x 2.25 m (1,111 trees/ha) and trained as slender spindle;

1 plot established in 2010 with peach trees grafted on Adaptabil rootstock, planted at 4.00 x 2.5 m (1,000 trees/ha) and trained as slender spindle;

The second group of plots were established at RSFG Constanta (Valu lui Traian) and consisted in:

3 plots established in 2011 with peach trees grafted on Tomis 1 rootstock, planted at 4.00 x 4.00 m (833 trees/ha) and trained as goblet;

3 plots established in 2011 with apricot trees grafted on a local apricot rootstock selection, planted at 4.00 x 4.00 m (833 trees/ha) and trained as goblet.

The Specware Pro software early warning modules were used for microclimate monitoring and pest biological cycle monitoring, to evaluate the attack risk and better choose of the insecticides according their mode of action, aiming to increase the efficacy of their application in the pome and stone fruits orchards.

Six types of pheromones traps were used: atraPOM (*E8, E10-dodecadien-1-ol*), atraRET (*Z9-tetradecen-1-il, Z-11-tetradecen-1-il acetate*), atraFUN (*de Z8-dodecen-1-il acetate, E8-dodecen-1-il acetate*), atraLIN *(E5-decen-1-il, E5-decen-1-01 acetate*), atraMOL (*Z8-dodecen-1-il, E8-1-il, dodecan 1-il acetate*), atraNUB (*E8, E10-dodecadien-1-il, de Z8-dodecen-1-il acetate*).

These were produced and supplied by Chemistry Institute "*Raluca Ripan*" Cluj-Napoca. The biotechnical devices were mounted in the experimental plots randomly, on the northern face of the trees canopies, in groups of three. In order to count the captures, the pheromones traps were visited twice per

week. The number of captures were registered and used to assess the pest population and draw the flight pattern graphs, using MS Excel 2010 facilities.

3. Results and discussions

During the years of studies and in the years before, the data collected indicated that in South-Eastern Romania, the orchard microclimate of last year's was favorable to damaging micro Lepidoptera development and strike.

Assessment of the tables 1-6 reveal that monthly average temperature allowed the complete development of the damaging micro *Lepidoptera*.

At RIFG Pitesti, during the spring and summer, this indicator oscillated between 10.9^{o}C in April and 22.8^{o}C in August, while at RSFG Constanta varied between 10.3^{o}C in April and 25.4^{o}C in August.

These temperature ranges, were in both research centers above the minimum biological threshold of 10^{o}C, necessary for complete development of apple codling moth - *Cydia pomonella*, plum fruit moth - *Cydia funebrana*, and peach twig moth - *Anarsia lineatella* and even more above the minimum biological threshold of 7.2^{o}C necessary for complete development of the oriental fruits moth - *Cydia molesta.*

Also, the maximum temperatures were important because influenced the speed of the pest development, to complete the biological cycles of the generations and to initiate the attack in the orchards.

At RIFG Pitesti, during the spring and summer, this indicator oscillated between 25.3^{o}C in April and 35.1^{o}C in August, due the continental climate while at RSFG Constanta varied between 17.1^{o}C in April and 31.4^{o}C in August, due the continental climate with maritime influences.

cThe use of Specware Pro software warning modules allowed calculation of Degree-Days Sum (DD), which is another indicator which offered information of the moment when a particular development stage was reached for each monitored pest (Table 7).

In this sense, on apple codling moth (*Cydia pomonella)*, first adults butterflies appeared at 100-150 DD and was the moment to install the AtraPOM pheromone traps to initiate the mixt monitoring.

The adult butterflies of the first generation (G1) emerged between 340-350 DD and their first larva between 381-920 DD. However, the massive eggs lying occur between 1,000-1050 DD and massive larva occurrence between 1100-1336 DD. The butterflies of second generation (G2) emerged around 1,500 DD and last around 1,720-1,976 DD and massive larva occurrence around 2100 DD.

Also, on plum fruits moth (*Cydia funebrana)*, first adults butterflies appeared at 100-150 DD and was the moment to install the AtraFUN pheromone traps to initiate the mixt monitoring.

The adult butterflies of the first generation (G1) emerged at 536 DD and eggs laying starts at 135 DD and very soon the larva occurrence at 288 DD. The maximum of G1 flight was reached around 356 DD and the maximum eggs lying and larva occurrence was between 378-387 DD.

The butterflies of second generation (G2) emerged around 1,490 DD and according the year microclimate stretched 1,652 DD, and the massive eggs lying and larva occurrence was between 1,682-1,712 DD.

As regard the oriental fruits moth (*Cydia molesta)* on which minimum biological threshold is 7.2^{o}C, the warning modules display that the biological cycle run very fast.

First adult butterflies appeared at 216-238 DD and was the moment to install the AtraMOL pheromone traps to initiate the mixt monitoring.

The eggs laying and larva occurrence was between 239-280 DD and the maximum of the first generation (G1) was reached at 288 DD, the maximum eggs laying and larva occurrence being reached between 289-324 DD. The butterflies of second generation (G2) maximum flight was reached between 800-920 DD, while the mass eggs lying and larva appearance was between 956-1,050 DD.

In the case of peach twig moth - *Anarsia lineatella*, the biologic cycle run fast. At 300-330 DD and was the moment to install the AtraLIN pheromone traps to initiate the mixt monitoring.

First adult butterflies appeared at 216-238 DD and starts to mate between 400-500 DD. A range of 300-400 DD was necessary for start of the eggs hatch (5-25%) and G1 larva occurrence.

The maximum flight of first generation (G1) was reached when 900-1080 DD were accumulated.

Mass appearance of the G1 larva was registered between 1,200-1,360 D.

The butterflies of second generation (G2) emerged around 1,760 DD and the massive eggs lying and larva occurrence was between 2,014-2,340 DD.

It seems logical that, when the expert software modules are used it is possible to select the registered insecticides for the control of orchard microlepidoptera, according to their active ingredients, registration rate, active ingredient and way of action against different development stages of the pests. (Table 8). In this sense, it can be defined and followed several insecticide application strategies into the bearing orchards, to achieve a good control of damaging micro *Lepidoptera*:

A. For the first generation (G1): A1-Broad spectrum -- ovicide-larvicide, or A2-Adulticide -- ovicide-larvicide.

B. For the second generation (G2), which is more aggressive: B1-Ovicide-larvicide -- Adulticide – Adulticide, or B2-Ovicide-larvicide -- Broad spectrum -- Broad spectrum.

C. In warmer autumn, when the third generation (G3), might occur, a more simple control strategy might be used: C1-Ovicide-larvicide -- Adulticide or C2 Broad spectrum.

If the use of Specware Pro software warning modules offer information on the fulfillment of the different stages of the biological cycle of the damaging micro *Lepidoptera* and support for choosing registered insecticides, the use of pheromone traps, offer data on the pests populations dynamic, the level of stress applied on the fruit species. Both tools are used to establish the period of monitoring, the best moment or interval for insecticide application to achieve the best efficacy, to reduce the number of application the quantities of insecticides applied to protect the crop, with direct implications on the farmer, the consumer and the environment.

Assessment of the figures 1-2 reveal that under Pitesti-Maracineni conditions of 2019-2020, on apple codling moth - *Cydia pomonella*, the monitoring period covered usually the period 4/20--8/30.

The sum of captures ranged 192-244 butterflies/trap/season. The maximum of G1 flight ranged between 22 and 48 butterflies/trap/week, and was registered between 04.05 and 15.05. Also, the maximum of G2 flight ranged between 10 and 23 butterflies/trap/week, and was registered between 04.07 and 15.08. The level of stress applied on the apple crop was high, because the economic damage threshold (EDT) has been exceeded between 7.33-16.00 times for G1 and between 3.33-7.66 times for G2.

Examination of the figures 3-4 highlight that under the same location conditions of 2019-2020, on plum fruit moth - *Cydia funebrana*, the monitoring period covered usually the period 20.04-11.09. The sum of captures ranged 105-166 butterflies/trap/season. The maximum of G1 flight oscillated between 17 and 22 butterflies/trap/week, and was registered between 6-15, May. Also, the maximum of G2 flight ranged between 7 and 22 butterflies/trap/week, and was registered between 04.07 and 15.08. The level of stress applied on the plum crop was medium, because the economic damage threshold (EDT) has been exceeded between 5.66-7.33 times for G1 and between 2.33-7.33 times for G2.

Assessment of the figures 5-6 reveal that under conditions of 2019-2020, on oriental fruit moth - *Cydia molesta*, the monitoring period covered usually the period 01.05-10.09. The sum of captures ranged 68-99 butterflies/trap/season. The maximum of G1 flight ranged between 12 and 22 butterflies/trap/week, and was registered between 01.05 and 09.06. Also, the maximum of G2 flight ranged between 4 and 5 butterflies/trap/week, and was registered between 04.07 and 15.08.

The level of stress applied on the peach crop was medium to low, because the economic damage threshold (EDT) has been exceeded between 4.00-7.33 times for G1 by 1.66 times for G2.

Till now it can be concluded that, under Pitesti-Maracineni conditions the level of stress applied on the apple, plum and peach crops were high or medium, especially in the case of the first generation G1 of the damaging micro *Lepidoptera*, which must be very well controlled.

Examination of the figures 7-16 suggest that under Valu lui Traian specific microclimate conditions favored the complete development and a major strike of many damaging micro Lepidoptera on peach and apricot as well.

Assessment of the figures 7-8 reveal that under Valu lui Traian conditions of 2019-2020, on oriental fruit moth - *Cydia molesta*, the monitoring period covered usually the period May 1 – September 8.

For peach crop, the sum of captures ranged 69-125 butterflies/trap/season. The maximum of G1 flight ranged between 12 and 23.3 butterflies/trap/week, and was registered between 19.05 and 30.06.

Also, the maximum of G2 flight ranged between 4.0 and 9.7 butterflies/trap/week, and was registered between 01.07 and 15.08. The level of stress applied on the peach crop was medium to low, because the economic damage threshold (EDT) has been exceeded between 5.43-7.77 times for G1 and by 3.33 times for G2.

Examination of the figures 9-10 shows that on apricot crop, the sum of captures ranged 83.0-123.3 butterflies/trap/season. The maximum of G1 flight ranged between 10 and 21 butterflies/trap/week, and was registered between 19.05 and 23.06. Also, the maximum of G2 flight ranged between 7.0 and 11.8 butterflies/trap/week, and was registered between 01.07 and 15.08. The level of stress applied on the peach crop was medium to low, because the economic damage threshold (EDT) has been exceeded between 3.33-7.00 times for G1 and between 2.33-3.93 times for G2.

Examination of the figures 11-12 highlight that under Valu lui Traian conditions of 2019-2020, on peach twig moth - *Anarsia lineatella*, the monitoring period covered usually the period 01.05-08.09.

For peach crop, the sum of captures ranged 80.0-116.6 butterflies/trap/season. The maximum of G1 flight ranged between 11.3 and 19.0 butterflies/trap/week, and was registered between 26.05-23.06. Also, the maximum of G2 flight ranged between 14.3 and 16.3 butterflies/trap/week, and was registered between 01.07 and 15.08. The level of stress applied on the peach crop was medium to low, because the

economic damage threshold (EDT) has been exceeded between 3.77-6.33 times for G1 and between 4.77-5.43 times for G2.

From the figures 13-14 it can be seen that, on apricot crop, the sum of captures ranged 66.0-73.1 butterflies/trap/season. The maximum of G1 flight ranged between 12.0 and 19.5 butterflies/trap/week, and was registered between 26.05-16.06. Also, the maximum of G2 flight ranged between 6.0 and 7.3 butterflies/trap/week, and was registered between 14.07 and 31.08. The level of stress applied on the peach crop was medium to low, because the economic damage threshold (EDT) has been exceeded between 4.00-6.50 times for G1 and between 2.00-2.43 times for G2.

Under Valu lui Traian conditions of 2020, marbled orchard tortrix - *Hedya nubiferana* was present in the peach experimental plots, on 2 valuable cultivars and was monitored together with the other damaging micro Lepidoptera between 01.05 and 08.09.2021.

The sum of captures ranged 66.0-71.0 butterflies/trap/season. The maximum of G1 flight ranged between 6 and 17.0 butterflies/trap/week, and was registered between 20.05-16.06. Also, the maximum of G2 flight ranged between 3.0 and 6.0 butterflies/trap/week, and was registered between 01.07 and 25.08. The level of stress applied on the peach crop was medium to low, because the economic damage threshold (EDT) has been exceeded between 2.00-5.67 times for G1 and by 2.00 times for G2.

4. Conclusions

In South-Eastern Romania, the orchard microclimate of last year's was favorable to damaging micro *Lepidoptera* development and strike. According the location the average and maximum air temperature influenced the speed of the pest development, to complete the biological cycles of the generations and to initiate the attack in the orchards.

The use of Specware Pro software warning modules, allowed calculation of Degree-Days Sum (DD), which is another indicator which offers information one the moment when a particular development stage was achieved for each monitored pest.

The Degree-Days Sums for each pest and development stage are accumulated in different periods, according to thermic resources of each year, earlier in warmer years and later in colder years.

When the expert software modules are used, it is possible to select the registered insecticides for the control of orchard micro *Lepidoptera* according their active ingredients, registration rate, active ingredient and way of action against different development stages of the pests.

When the economic damages threshold (EDT) is exceeded by 3 or 4 times in a week, the treatments against damaging micro *Lepidoptera* became mandatory.

The use of pheromone traps offer data of the pests populations dynamic, the level of stress applied on the fruit species, and it is used to establish the period of monitoring, the best moment or interval for insecticide application to achieve the best efficacy, to reduce the number of application, the quantities of insecticides used to protect the crop, with direct implications on the farmer, the consumer and the environment.

The mixed monitoring system contribute to a more efficient use of the insecticides and achievement of a better orchard and crop protection and increase of performances, both for pome and stone fruit species as well.

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Tables and Figures

Table 1. Dynamic of some meteorological parameters in 2018 vegetation period RIFG Pitesti Lat. N 44.513; Long. E 24.52; Alt 287m

Year 2018 / Month	Maximum temperature (*C)	Minimum temperature (*C)	Average Temperature (*C)	Leaf wetness (h)	Days with wetness (n)	Precipitations (l/m2)	Days with precipitations (n)	Wind speed (km/h)	Wind gust (km/h)
April	29.4	-1.1	15.3	67.5	17.0	5.0	7	2.6	21.6
May	30.8	7.4	17.5	130.8	25.0	112.5	15	1.7	18.8
June	32.0	7.7	20.2	172.8	26.0	198.5	20	1.2	18.1
July	31.3	9.7	21.0	198.5	28.0	90.9	16	1.0	16.1
August	33.9	12.1	22.2	184.5	30.0	36.2	8	0.9	15.9
September	32.6	-1.5	17.1	78.5	23.0	14.3	7	1.1	16.0
Average	***31.67***	***5.72***	***18.88***	***138.77***	***24.83***	***76.23***	***12.17***	***1.42***	***17.75***
Std. deviation	*1.5488*	*5.6908*	*2.6514*	*55.8433*	*4.5350*	*73.4740*	*5.5648*	*0.6432*	*2.2474*
Variance	*4.8908*	*99.5482*	*14.0407*	*40.2426*	*18.2619*	*96.3804*	*45.7378*	*45.4002*	*12.6617*

Table 2. Dynamic of some meteorological parameters in 2019 vegetation period RIFG Pitesti Lat. N 44.513; Long. E 24.52; Alt 287 m

Year 2019 / Month	Maximum temperature (*C)	Minimum temperature (*C)	Average Temperature (*C)	Leaf wetness (h)	Days with wetness (n)	Precipitations (l/m2)	Days with precipitations (n)	Wind speed (km/h)	Wind gust (km/h)
April	26.3	-0.1	10.8	54.8	22	35.6	11	2.5	22.5
May	28.2	2.4	15.7	107.0	27	46.3	19	1.9	20.1
June	32.2	11.2	21.2	188.3	30	197.1	19	1.0	20.9
July	34.9	7.9	21.1	135.8	26	93.4	10	1.0	17.2
August	35.1	10.2	22.8	32.8	12	9.7	3	1.0	17.7
September	33.0	1.3	17.5	41.3	13	11.9	5	1.4	18.4
Average	**31.62**	**5.48**	**18.18**	**93.33**	**21.67**	**65.67**	**11.17**	**1.47**	**18.47**
Std. deviation	*3.60.86*	*4.8775*	*4.4737*	*61.42.55*	*7.5542*	*71.1984*	*6.7651*	*0.6186*	*2.0520*
Variance	*11.4135*	*88.9507*	*24.6031*	*65.8130*	*34.8658*	*108.4239*	*60.5830*	*42.1773*	*10.5410*

Table 3. Dynamic of some meteorological parameters in 2020 vegetation period RIFG Pitesti Lat. N 44.513; Long. E 24.52; Alt 287 m

Year 2020 / Month	Maximum temperature (*C)	Minimum temperature (*C)	Average Temperature (*C)	Leaf wetness (h)	Days with wetness (n)	Precipitations (l/m2)	Days with precipitations (n)	Wind speed (km/h)	Wind gust (km/h)
April	25.3	-3.9	10.9	11.3	6	21.1	6	2.3	20.8
May	30.13	4.3	15.0	79.0	21	104.1	14	2.6	18.6
June	32.8	4.3	19.6	168.8	27	166.2	14	4.0	18.8
July	35.3	11.6	22.0	98.3	21	52.0	11	2.5	15.0
August	33.9	11.0	22.0	94.0	17	29.0	10	3.8	18.4
September	33.8	6.2	18.9	81.0	19	68.2	6	1.3	17.2
Average	**31.87**	**5.58**	**18.07**	**88.73**	**18.5**	**73.43**	**10.17**	**2.75**	**18.13**
Std. deviation	*3.6515*	*5.6418*	*4.3532*	*50.3595*	*6.9785*	*54.3065*	*3.6009*	*1.0055*	*1.9253*
Variance	*11.4570*	*101.0468*	*24.0954*	*56.7538*	*37.7218*	*73.9535*	*35.4189*	*36.5631*	*10.6173*

Table 4. Dynamic of some meteorological parameters in 2018 vegetation period RSFG Constanţa Lat. 44.095, Long. 28.28, Alt. 80 m

Year 2018 / Month	Maximum temperature (*C)	Minimum temperature (*C)	Average Temperature (*C)	Leaf wetness (h)	Days with wetness (n)	Precipitations (l/m2)	Days with precipitations (n)	Wind speed (km/h)	Wind gust (km/h)
April	18.5	3.3	10.4	62.6	20.5	18.2	10.5	5.1	24.1
May	23.1	10.8	16.7	12.9	25	23.2	18	1.2	21.3
June	30.8	16.5	23.4	161.6	28	20.45	18	3.7	20.6
July	31.3	16.1	23.8	185.6	24	9.5	9	3.5	18.6
August	31.8	17.2	24.5	172.5	11	5.8	3	3.4	18.4
September	27.1	13.6	20.4	73.7	12	39.8	5	3.6	18.5
Average	***27.1***	***12.9***	***19.9***	***111.5***	***20.1***	***19.5***	***10.5***	***3.9***	***20.0***
Std. deviation	*5.3550*	*5.2678*	*4.4654*	*71.0744*	*7.0740*	*11.9671*	*6.3482*	*0.6432*	*2.2474*
Variance	*19.7601*	*40.7829*	*27.5104*	*63.7535*	*35.2233*	*61.3962*	*60.4593*	*16.6337*	*11.0985*

Table 5. Dynamic of some meteorological parameters in 2019 vegetation period SCDP Constanţa Lat. 44.095, Long. 28.28, Alt. 80 m

Year 2019 / Month	Maximum temperature (*C)	Minimum temperature (*C)	Average Temperature (*C)	Leaf wetness (h)	Days with wetness (n)	Precipitations (l/m2)	Days with precipitations (n)	Wind speed (km/h)	Wind gust (km/h)
April	17.1	3.6	10.3	48	19	29.3	10	5.0	34.5
May	23.5	11.6	17.5	94	24	27.0	17	4.4	22.6
June	33.4	17.8	25.6	166	26	1.1	17	3.5	23.4
July	31.5	16.4	24.0	120	23	38.1	9	3.6	19.7
August	33.4	17.4	25.4	29	10	9.4	3	3.5	20.2
September	27.6	13.5	20.6	36	11	46.8	4	3.9	20.9
Average	***27.8***	***13.4***	***20.6***	***82.2***	***18.8***	***25.3***	***10.0***	***3.98***	***23.6***
Std. deviation	*6.4717*	*5.3600*	*5.9210*	*54.2675*	*6.8532*	*17.2246*	*6.0663*	*0.6047*	*5.5479*
Variance	*23.3215*	*40.0499*	*27.7895*	*66.0457*	*36.3888*	*68.1262*	*60.6630*	*15.1808*	*23.5579*

Table 6. Dynamic of some meteorological parameters in 2020 vegetation period SCDP Constanţa Lat. 44.095, Long. 28.28, Alt. 80 m

Year 2020 / Month	Maximum temperature (*C)	Minimum temperature (*C)	Average Temperature (*C)	Leaf wetness (h)	Days with wetness (n)	Precipitations (l/m2)	Days with precipitations (n)	Wind speed (km/h)	Wind gust (km/h)
April	17.9	2.9	10.3	10	5	7.2	5	4.8	23.3
May	22.7	10.0	16.0	70	18	19.4	12	5.1	21.1
June	28.2	15.2	21.2	149	24	39.8	12	6.5	21.3
July	31.2	15.8	23.7	87	18	9.6	10	5.0	17.5
August	30.3	16.7	23.6	87	15	2.2	9	6.3	20.9
September	26.7	13.6	20.2	83	17	32.8	5	3.8	19.7
Average	***26.2***	***12.4***	***19.2***	***81***	***16.2***	***18.5***	***8.8***	***5.25***	***20.6***
Std. deviation	*5.0437*	*5.2026*	*5.1779*	*44.2858*	*6.2423*	*15.0438*	*3.6009*	*1.0055*	*1.9253*
Variance	*19.2752*	*42.0692*	*27.0151*	*54.9451*	*38.6123*	*81.3179*	*35.4189*	*19.1521*	*9.3309*

Table 7. Relationship between the Degree-Day sum accumulated on microclimate monitoring system and development stage of the studied microlepidoptera (synthesis)

Damaging insect	Minimum treshold [^{0}C]	Degree-Day Sum (Tmax+Tmin)/ 2	Development stages	Events / Monitoring or control activity
Apple codling - *Cydia pomonella*	10	100-150	pre-emergence	pre-emergence / **AtraPOM** traps installation
	10	**175-220**	adult	first adults occurrence / monitoring
		post-biofix	post-biofix	post-biofix
	10	250-290	larva	beginning of eggs hatch / orchard control
	10	**340-350**	adult	maximum flight of G1 / monitoring
	10	381-640	larva	mass appearance of G1 larva / monitoring
	10	920	larva	end of appearance of G1 larva / monitoring
	10	**1000-1050**	eggs	G1 adults mass eggs laying / orchard control
	10	1100	larva	eggs hatch and G2 larva occurrence / orchard control
	10	1320-1336	larva	mass appearance of G2 larva / monitoring
	10	**1720-1976**	adult	maximum flight of G2 / monitoring
	10	2100	larva	end of appearance of G2 larva / monitoring
	10	2160	larva	appearance of G3 larva / monitoring
Plum fruit moth - *Cydia funebrana*	10	100-150	pre-emergence	pre-emergence / **AtraFUN** traps installation
	10	**536**	adult	first adults occurrence, matting / monitoring
		post-biofix	post-biofix	post-biofix
	10	135	eggs	G1 adults mass eggs laying / orchard control
	10	288	larva	eggs hatch and G1 larva occurrence / orchard control
	10	315	nimph	nimph occurrence / orchard control
	10	**356**	adult	maximum flight of G1 / monitoring
	10	**378**	eggs	G1 adults mass eggs laying / orchard control
	10	**387**	larva	mass appearance of G2 larva / orchard control
	10	**1490-1652**	adult	maximum flight of G2 / monitoring
	10	1682	larva	end of appearance of G2 larva / orchard control
	10	1712	larva	appearance of G3 larva / orchard control
Oriental fruit moth - *Cydia molesta*	7,2	**216-238**	adult	first adults occurrence, matting / **AtraMOL** traps installation
	7,2	239-280	eggs	adults mass eggs laying / monitoring, orchard control
	7,2	281-288	adult	maximum flight of G1 / monitoring
	7,2	289-324	eggs, larva	G1 adults mass eggs laying, larva appearance / orchard control
	7,2	**800-920**	adult	maximum flight of G2 / monitoring
	7,2	956-1000	eggs, larva	G2 adults mass eggs laying, larva appearance / orchard control
Peach twigs moth - *Anarsia lineatella*	10	**300-330**	pre-emergence	pre-emergence / **AtraFUN** traps installation
	10	**400-500**	adult	first adults occurrence, matting / monitoring
	10	post-biofix	post-biofix	post-biofix
	10	300-400	larva	eggs hatch 5-25% G1 larva occurrence / orchard control
	10	**900-1080**	adult	maximum flight of G1 / monitoring
	10	1200-1360	larva	mass appearance of G1 larva / orchard control
	10	**1760**	adult	maximum flight of G2 / monitoring
	10	2014-2340	larva	G2 adults mass eggs laying, larva appearance / orchard control

Table 8. Registered insecticides active ingredients, targets and way of action in Romania
(Sources: PESTICIDE 2020 Database;
https://www.madr.ro/omologare-produse-de-protectie-a-plantelor/lista-produselor-de-protectie-a-plantelor-omologate.html
https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=activesubstance.selection&language=EN **)**

No.	Insecticide active ingredient	Way of action	Pest species
1	abamectin+clorantraniliprol	ovcide-larvicide	Apple codling moth
2	acetamiprid	adulticide; ovcide-larvicide	Apple codling moth, plum fruit moth
3	alpha cipermetrin	larvicide; adulticide	Apple codling moth, plum fruit moth, and peach moths
4	clorantraniliprol	ovcide-larvicide	Apple codling moth, plum fruit moth
5	deltametrin	adulticide; larvicide	Apple codling moth, plum fruit moth
6	diflubenzuron	larvicide	Apple codling moth
7	emamectin benzoat	ovcide-larvicide	Apple codling moth, peach fruit moth
8	esfenvalerat	adulticide	Apple codling moth
9	granulovirus	larvicide	Apple codling moth
10	lambda-cihalotrin	adulticide; larvicide	Apple, plum, peach, apricot moths
11	metoxifenozide	adulticide	Apple codling moth

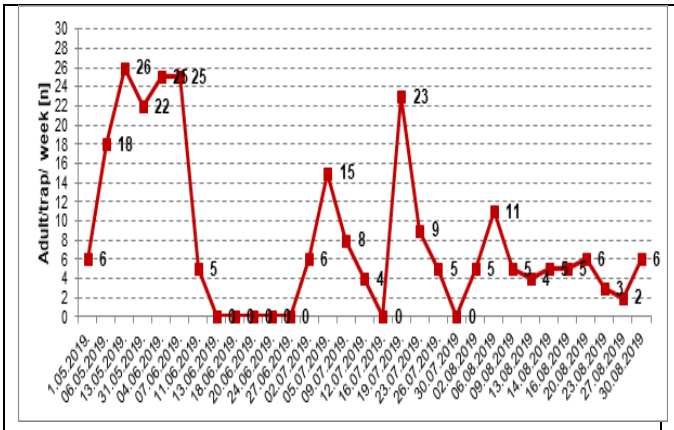

Fig. 1. Dynamic of *Cydia pomonella* L. adults flight on apples, 'Jonagold/M9' cv. RIFG Pitesti 2019, Lat. N 44.513; Long. E 24.52; Alt 287 m

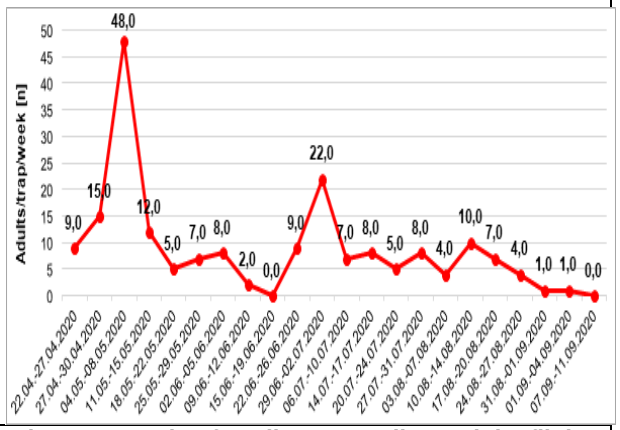

Fig. 2. Dynamic of *Cydia pomonella* L. adults flight on apples 'Topaz/M9' cv. RIFG Pitesti 2020, Lat. N 44.513; Long. E 24.52; Alt 287 m

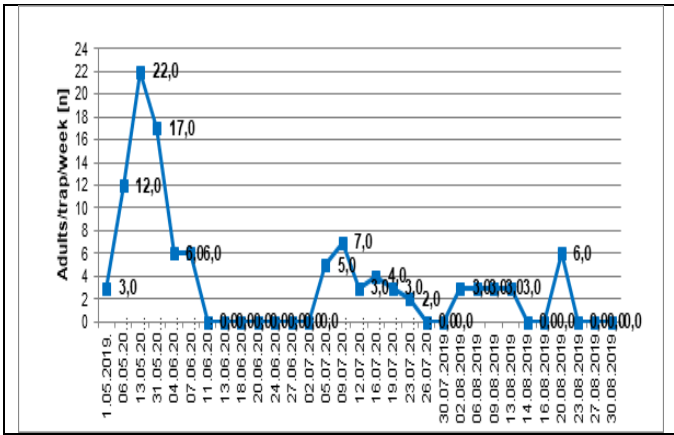

Fig. 3. Dynamic of *Cydia funebrana* L. adults flight on plum 'Centenar/Saint Julien' RIFG Pitesti 2019, Lat. N 44.513; Long. E 24.52; Alt 287 m

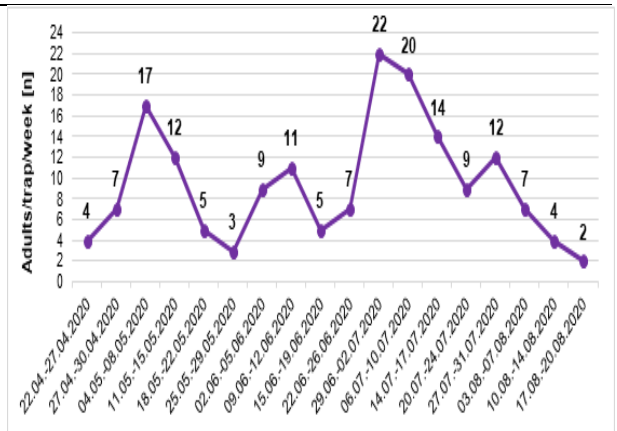

Fig. 4. Dynamic of *Cydia funebrana* L. adults flight on plum 'Stanley/Saint Julien' cv. RIFG Pitesti 2020 Lat. N 44.513; Long. E 24.52; Alt 287 m

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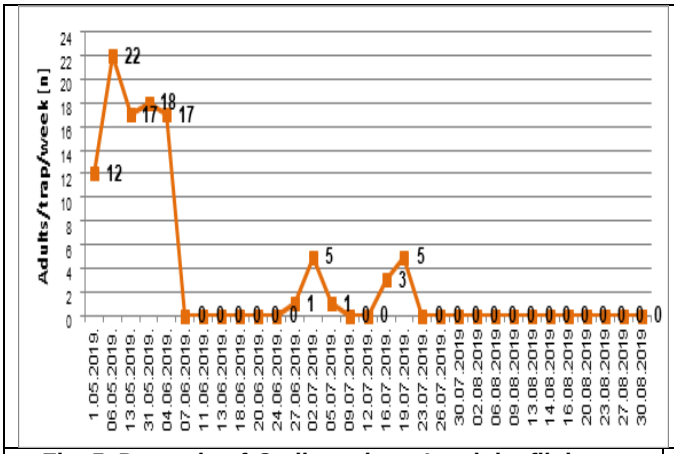

Fig. 5. Dynamic of *Cydia molesta* L. adults flight on peach 'Filip/Adaptabil' cv. RIFG Pitesti 2019 , Lat. N 44.513; Long. E 24.52; Alt 287 m

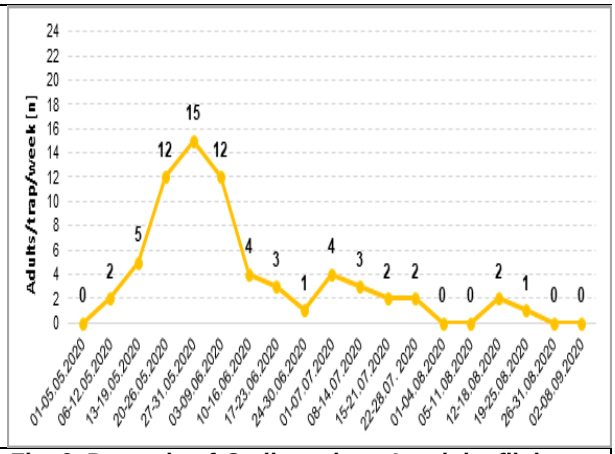

Fig. 6. Dynamic of *Cydia molesta* L. adults flight on peach 'Filip/Adaptabil' cv. RIFG Pitesti 2019, Lat. N 44.513; Long. E 24.52; Alt 287 m

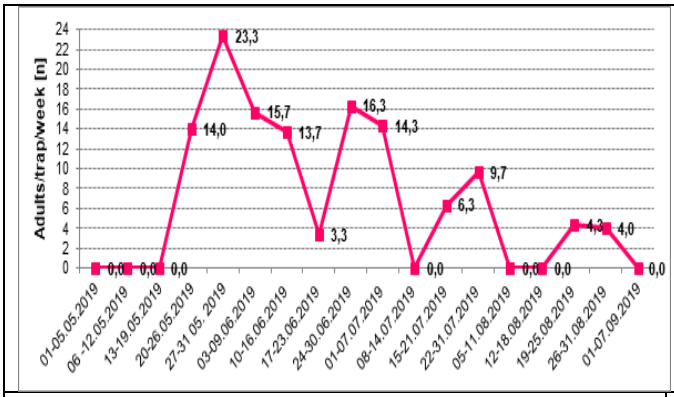

Fig. 7. Dynamic of *Cydia molesta* L. adults flight on peach, RSFG Constanta (Valu lui Traian) 2019, Lat. 44.095, Long. 28.28, Alt. 80 m

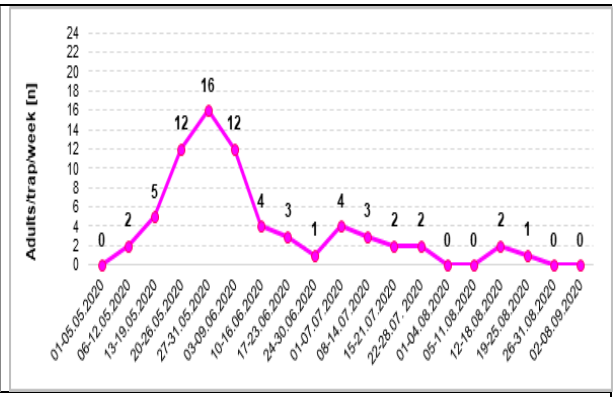

Fig. 8. Dynamic of *Cydia molesta* L. adults flight on peach, 'Southland/Tomis 1', RSFG Constanta (Valu lui Traian) 2019, Lat. 44.095, Long. 28.28, Alt. 80 m

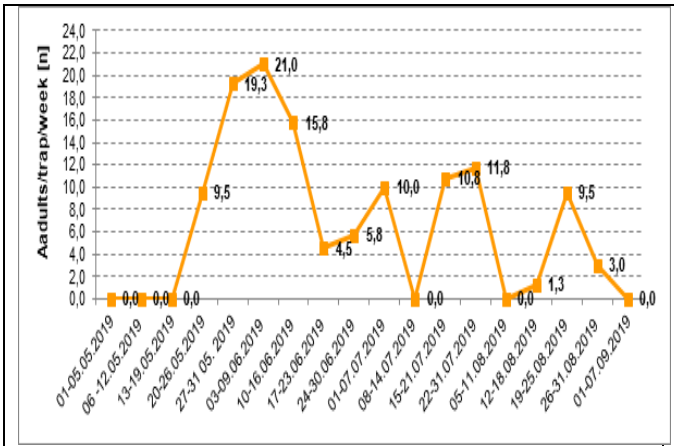

Fig. 9. Dynamic of *Cydia molesta* L. adults flight on apricot, RSFG Constanta (Valu lui Traian) 2019, Lat. 44.095, Long. 28.28, Alt. 80 m

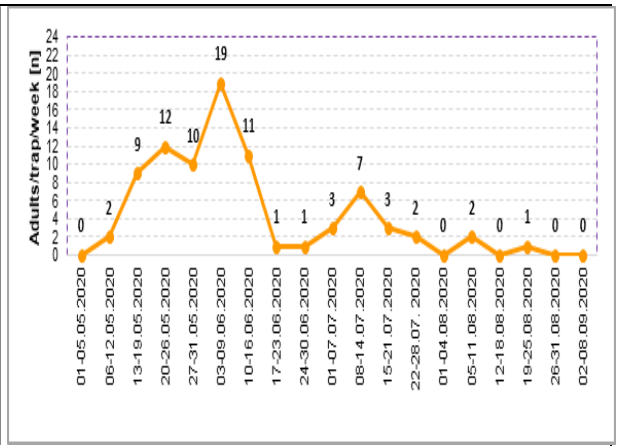

Fig. 10. Dynamic of *Cydia molesta* L. adults flight on apricot, 'Orizont' cv. RSFG Constanta (Valu lui Traian) 2019, Lat. 44.095, Long. 28.28, Alt. 80 m

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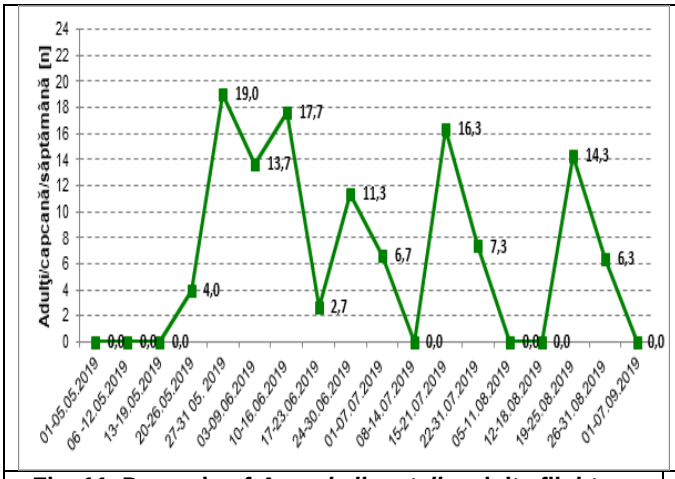

Fig. 11. Dynamic of *Anarsia lineatella* adults flight on peach, 'Catherine' cv. RSFG Constanta (Valu lui Traian) 2019, Lat. 44.095, Long. 28.28, Alt. 80 m

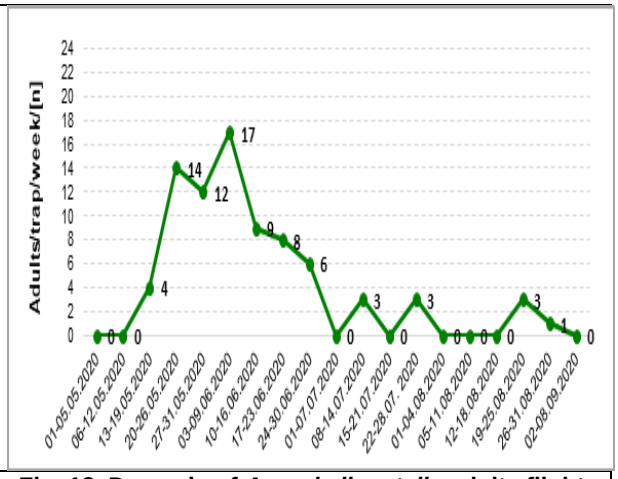

Fig. 12. Dynamic of *Anarsia lineatella* adults flight on peach, 'Filip' cv. RSFG Constanta (Valu lui Traian) 2020, Lat. 44.095, Long. 28.28, Alt. 80 m

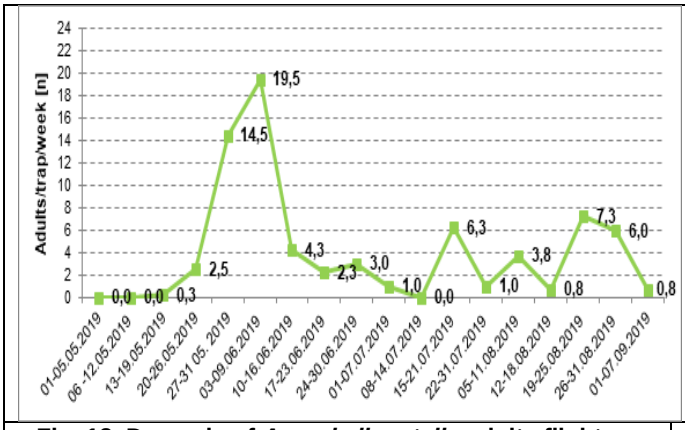

Fig. 13. Dynamic of *Anarsia lineatella* adults flight on apricot, RSFG Constanta (Valu lui Traian) 2019, Lat. 44.095, Long. 28.28, Alt. 80 m

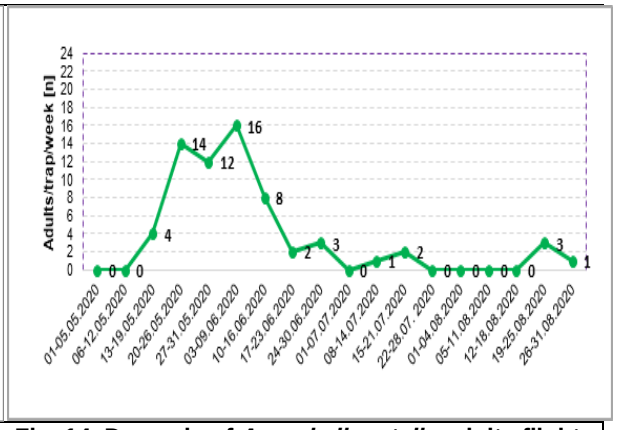

Fig. 14. Dynamic of *Anarsia lineatella* adults flight on apricot, 'Liana' cv. RSFG Constanta (Valu lui Traian) 2019, Lat. 44.095, Long. 28.28, Alt. 80 m

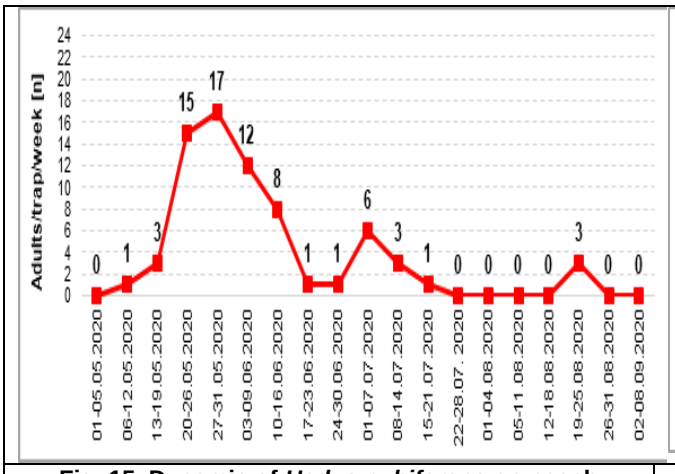

Fig. 15. Dynamic of *Hedya nubiferana* on peach 'Catherine' cv. RSFG Constanta (Valu lui Traian) 2020, Lat. 44.095, Long. 28.28, Alt. 80 m

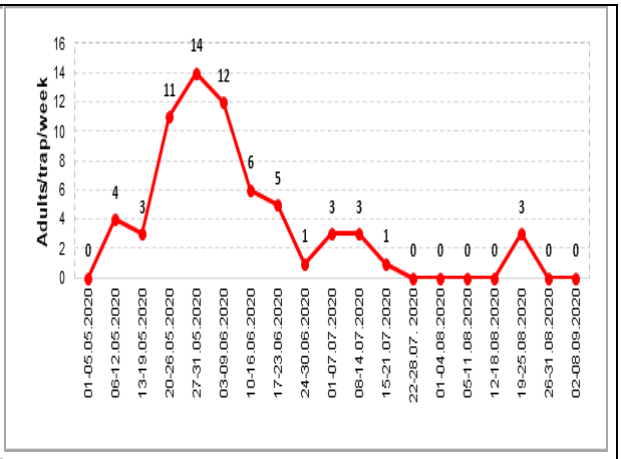

Fig. 16. Dynamic of *Hedya nubiferana* on apricot 'Orizont' cv., RSFG Constanta (Valu lui Traian) 2020, Lat. 44.095, Long. 28.28, Alt. 80 m

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Fig. 17. Pheromones trap AtraPOM

Fig. 18. Pheromones trap AtraFUN

Fig. 19. Pheromones trap AtraLIN

Fig. 20. Pheromones trap AtraMOL