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# THE RESEARCH ON THE CHEMICAL CONTROL OF THE *OSTRINIA NUBILALIS*, IN NATURAL AND ARTIFICIAL INFESTATION CONDITIONS, IMPORTANT LINK IN INTEGRATED PEST MANAGEMENT

**Adina TĂRĂU[1], Ana-Maria PĂCURAR[1,2], Felicia MUREȘANU[2], Laura ȘOPTEREAN[2], Felicia CHEȚAN[2], Andrei VARGA[2], Ioana PORUMB[2], Florin RUSSU[2], Loredana SUCIU[1,2]**

[1]Agricultural Research-Development Station Turda, 27 Agriculturii Str, Turda City, Cluj County, Emails: tarauadina@yahoo.com, pacurar.anamaria@yahoo.com, diabrotica22@yahoo.com, ticulaura@yahoo.com, felice_fely@yahoo.com, andrei_varga06@yahoo.com, rusuuflorin@yahoo.com, ioanaporumb18@yahoo.com, suciualexandra1@yahoo.com
[2]University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca, Faculty of Agriculture, 3-5 Calea Mănăștur, Cluj-Napoca 400372, Romania, Emails: pacurar.anamaria@yahoo.com, suciualexandra1@yahoo.com

***Corresponding author***: suciualexandra1@yahoo.com

***Abstract***

*At present, the most important anthropod pest of the maize in Europe is the European corn borer, Ostrinia nubilalis Hbn. In the infested areas, O. nubilalis is found with great frequency, starting from 20% in Hungary to 60% in Spain, and estimated production losses are between 5% and 30%, being considered as typical losses without too many control measures. Due to the major importance of this pest, between 2013 and 2016, at SCDA Turda the effect of some insecticides has been tested during the treatments on vegetation for corn borer control, under conditions of natural and artificial infestation with Ostrinia nubilalis. The most efficient role in the protection of maize culture, and implicitly of production, goes to the active substances indoxacarb and deltamethrine, in both infestation conditions, leading to very significant increase compared to the test counterpart. The least efficient results for corn borer control were obtained with the active substance thiacloprid.*

***Key words***: *corn, Ostrinia nubilalis, natural and artificial infection, treatmets*

## INTRODUCTION

At present, the most important anthropod pest of the maize in Europe is the European corn borer, *Ostrinia nubilalis* Hbn. In the infested areas, *O. nubilalis* is found with great frequency, starting from 20% in Hungary to 60% in Spain, and estimated production losses are between 5% and 30%, being considered as typical losses without too many control measures. France and Spain have registered additional economic damages due to the Mediterranean corn borer *Sesamia nonagrioides* Lefèbvre [8]. It is estimated that between 2 and 4 million hectares of maize in Europe have registered economic damages due to these pests [Brookes, 2009 quote by 8]. The damages caused by *Ostrinia nubilalis* Hbn. in the corn field can be direct, through the reduction of the crop biological yield of the plants and indirect, as vector of pathogens for corn-smuts and fusarioses and for plant blight and fall, the contamination with fumonisin in temperate zones [2, 4, 5, 9, 10, 12]. Corn borer control is based mainly on preventive measures such as the cultivation of resistant genotypes and the diminuation of biological reserve from nature. Alongside the genetic resistance to the corn borer, chemical control or at least the reduction of the number of individuals through chemical methods are technological measures of great importance. At present, different active substances are available: azadirachtin and indoxacarb [13], as well as bacterial (*Bacillus thuringiensis*, Bt) and biological (*Trichogramma parasites*) control methods against the corn borer.

## MATERIALS AND METHODS

Due to the major importance of this pest, between 2013 and 2016, at SCDA Turda the effect of some insecticides has been tested during the treatments on vegetation for corn borer control, under conditions of natural and artificial infestation with *Ostrinia nubilalis*.

The artificial infestations were carried out with eggs of *Ostrinia* originating from INCDA Fundulea, produced under laboratory conditions, according to a technology described by Bărbulescu (1980) [2].

The experiment has been arranged according to the method of randomized complete block design with four repetitions, and the plant material used was the hybrid Turda Star. The composition of the experience was made up of the following factors:

-Factor A– the year, with two situations investigated

-Factor B– the infestation method, with two situations investigated

Factor C– treatments (Table 1), with five situations investigated.

Table 1. The insecticides used to treat corn in vegetation at Turda 2013 and 2016

| Insecticide | Spectrum of control | Dose | Action mode |
|---|---|---|---|
| Calypso 480 SC tiacloprid 480 g/l | *Tanymecus dilaticollis* | 0.9 l/ha | systemic insecticide, acts by contact and ingestion**;** |
| Decis Mega 50 EW deltametrin 50 g/l | *Diabrotica virgifera virgifera* | 0.25 l/ha | foliar pyrethroid insecticide acts by contact and ingestion of harmful insects in the larvae or adults; |
| | *Tanymecus dilaticollis* | 0.15 l/ha | |
| Avaunt 150 SC indoxacarb 150 g/l | *Ostrinia nubilalis* | 0.25 l/ha | insecticide that acts through contact and ingestion; |
| Actara 25 WG thiametoxam 25% | *Tanymecus dilaticollis* | 100 g/ha | systemic insecticide with long lasting effect that combats, through contact and ingestion, the pests in both the larval and adult stages. |

Source: [7].

With the purpose of diminuating crop damage caused by the corn borer through the application of some treatments on plants, some observations have been made in the field, before harvesting, in two infestation conditions (natural and artificial), having followed some parameters of attack of this pest on 20 infested and 20 uninfested plants:

-the number of plants affected by variant

-the length of plant galeries

-the evaluation of the attack on the plant

Starting from the observations made, the frequency and the intensity of the attack on the plant were determined in the laboratory. From these parameters, the degree of the attack on the variant was determined.

**The intensity of the attack (I %)** in fact refers to the percentage of plant, of foliage or of other parts of the plant destroyed by the pest.

As this parameter is often subjective [1], marks were given on a scale 1-9, described by Hudon and Chiang, (1991) [6]: 1 for intact plants, 2 for pierced panicle, 3 for plant broken directly under the panicle, 4 for plant broken under the panicle but not farther than the first knot, 5 for plant broken under the panicle but not farther than the second knot, 6 for plant broken under the panicle but not farther than the third knot, 7 for plant broken under the panicle but not farther than the fourth knot, 8 for plant broken above the cob and 9 for fallen cob or plant broken under the cob.

According to this scale:

$$I\% = \sum(I * f)/n,$$

where:

I – the mark given

f – the number of plants affected for each mark

n – total number of analyzed plants.

**The degree of attack (GA)** is obtained by multiplying the frequency of the attack (F%) with the intensity of the attack (I%) [3]:

$GA = F * I/100$.

**Production (kg/ha)** has been corrected for the standard humidity of 14%.

The data expressed in percentage have been transformed into arcsin√% so that the discontinuous values expressed in percents can be transformed into a string of continuous variation which can be subjected to the analysis of variance. Production was expressed in kg/ha for the statistical processing and in t/ha for the graphical representation.

The data obtained through note-taking in the field have been processed through the Excel program. Experimental data have been processed through the program Polifact.

## RESULTS AND DISCUSSIONS

The analysis of variance shows the very significant implication of the three factors: year, method and treatment in expressing the frequency of attacks on the plant (Table 2).

Table 2. The variance analysis for the attack frequency of *Ostrinia nubilalis* on plant in the testing of some insecticides, Turda 2013 and 2016

| Source of variation | DF | $s^2$ | F Test |
|---|---|---|---|
| Total | 70 | | |
| Year (Y) | 1 | 1,145,42 | 179.30*** |
| Method (M) | 1 | 1,257,78 | 113.52*** |
| Treatment (T) | 4 | 6,815,28 | 701.14*** |
| M x T | 4 | 161.96 | 16.66*** |
| Error A | 3 | 6.39 | |
| Error M | 6 | 11.08 | |
| Error T | 48 | 9.72 | |

Source: [7].

A much more reduced contribution in the occurence of the variance of the frequency of attacks on the plant can also be observed in the interaction method x treatment, which suggests the existence of differences between the treatment variants and obviously the infestation method.

The occurence of the frequency of attack on the plant is considerably influenced by the year of cultivation.

Thus, it has been noticed that in 2016 this attack parameter has registered significantly positive values, of approximately 71%.

Even if some pest eggs are destroyed through the intervention of certain factors (biological – *Coccinella septempunctata,* climatic – strong wid, heavy rainfall, insolation), nevertheless, artificial infestation leads to a growth of attack on the plant with over 10%.

Table 3. The factors influence on the attack frequency of *Ostrinia nubilalis* on plant in the testing of some insecticides, in conditions of natural and artificial infestation, Turda 2013 and 2016

| Factors | | Attack frequency on plant | | Difference to control | Significance |
|---|---|---|---|---|---|
| | | % | arcsin √% | | |
| A. Year | Average | 64.8 | 53.61 | 0.00 | Mt. |
| | 2013 | 58.4 | 49.83 | -3.78 | 00 |
| | 2016 | 71.0 | 57.40 | 3.79 | ** |
| | LSD (p 5%) = 1.80<br>LSD (p 1%) = 3.30<br>LSD (p 0.1%) = 7.31 | | | | |
| B. Infestation method | Natural | 58.1 | 49.65 | 0.00 | Mt. |
| | Artificial | 71.3 | 57.58 | 7.93 | *** |
| | LSD (p 5%) = 1.82<br>LSD (p 1%) = 2.76<br>LSD (p 0.1%) = 4.44 | | | | |
| C. Treatment | Untreated | 97.7 | 81.16 | 0.00 | Mt. |
| | Tiacloprid | 80.4 | 63.71 | -17.46 | 000 |
| | Deltametrin | 37.9 | 38.02 | -43.14 | 000 |
| | Indoxacarb | 23.8 | 29.23 | -51.93 | 000 |
| | Thiametoxam | 68.6 | 55.95 | -25.21 | 000 |
| | LSD (p 5%) = 2.22<br>LSD (p 1%) = 2.96<br>LSD (p 0.1%) = 3.86 | | | | |

Source: [7].

From among the substances used, it seems that indoxacarb (Avaunt 150 SC) in doses of 0.25 l p.c./ha have reduced the most the frequency of the attack on the plant, while the second place goes to deltamethrine (Decis Mega 50 EW) used in the same dose. The most reduced influence on the control of the level of the corn borer population and implicitly on the frequency of the attack on the plant has been attributed to thiacloprid (Calypso 480 SC).(Table 3).

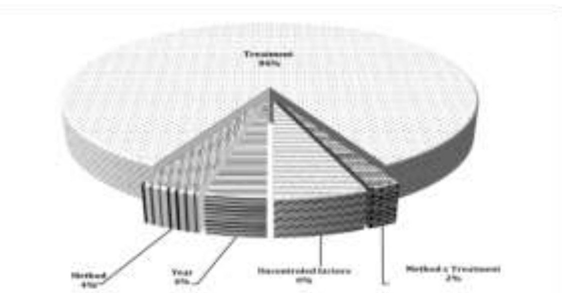


Fig. 1. The participation rate (%) of some factors implicated in the attack frequency of *Ostrinia nubilalis* on plant, in conditions of natural and artificial infestation, Turda 2013 and 2016
Source: [7].

A more suggestive representation regarding the contribution of factors in the variance of the frequency of attack on the plant can be seen in Figure 1. Treatment has the most implication in controlling this parameter, of approximately 84%.

The contribution of the year and of the infestation method is much more reduced compared to the one of the treatment, only 4%, which suggests the importance of treatment in controlling this pest.

Under both infestation circumstances, the application of insecticides leads to an important reduction of the number of plants attacked by *Ostrinia nubilalis* (Fig. 2), and the most reduced frequency of attacked plants has been recorded after using indoxacarb (Avaunt 150 SC), with differences between 48-56% compared with the test counterpart. The most inefficient results in corn borer control have been obtained with thiacloprid (Calypso 480 SC).

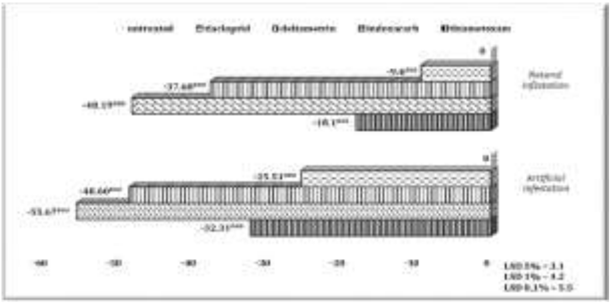

Fig. 2. The influence of treatment x method interaction on the attack frequency of *Ostrinia nubilalis* on plant in the testing of some insecticides, 2013 and 2016
Source: [7].

It seems that the degree of attack, as well as the frequency of attack on the plant are the most influenced by the treatment factor, after the method and the year. The values of sample F (Table 4) similarly indicate in the case of the interaction method x treatment a very significant influence on the degree of attack.

Table 4. The variance analysis for the degree of attack produced by *Ostrinia nubilalis* (arcsin√%) in the testing of some insecticides, Turda 2013 and 2016

| **Source of variation** | **DF** | **$s^2$** | **F Test** |
|---|---|---|---|
| Total | 70 | | |
| Year (Y) | 1 | 60.83 | 170.07*** |
| Method (M) | 1 | 81.69 | 428.92*** |
| Treatment (T) | 4 | 367.48 | 4,364.12*** |
| M x T | 4 | 0.72 | 8.60*** |
| Error A | 3 | 0.36 | |
| Error M | 6 | 0.19 | |
| Error T | 48 | 0.08 | |

Source: [7].

As shown in Figure 3, a considerable reduction, with very significantly negative differences, of the degree of attack is noticeable in both conditions of infestation, following the use of the active substance indoxacarb (Avaunt 150 SC). Deltamethrine (Decis Mega 50 EW) is placed second, with important limitations, close to the ones for the active substance indoxacarb. We can state that the other substances also have their contribution to the limitation of the degree of attack, but with relative values, noticeably smaller in comparison with indoxacarb.

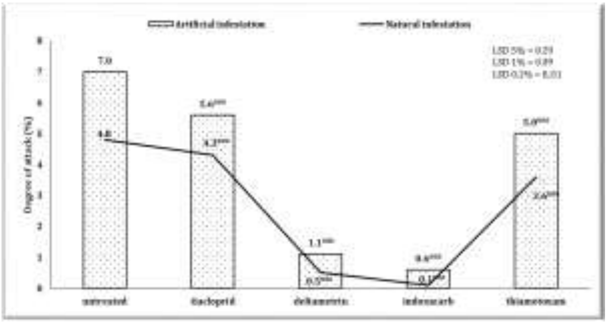

Fig. 3. The influence of treatment x method interaction on degree of attack in the testing of some insecticides, 2013 and 2016
Source: [7].

The reduction of the the degree of attack is obviously due to the efficiency of the insecticide used. The efficiency has been calculated based on the medium values of the degree of attack from the two infestation methods. As it can be seen in Table 5, the best results in corn borer control are due to the active substances, indoxacarb (Avaunt 150 SC) and deltamethrine (Decis Mega 50 EW), with 90 %, respectively 85 % efficiency.

Table 5. The effectiveness of some insecticides used in vegetation treatments in the control of *Ostrinia nubilalis* Hbn., Turda 2013 and 2016

| **Crt. no.** | **Active substance** | **Dose (ml p.c./ha)** | **DA (%) average** | **E (%) average** |
|---|---|---|---|---|
| 1. | tiacloprid | 150 | 5.0 | 15.0 |
| 2. | deltametrin | 250 | 0.9 | 85.0 |
| 3. | indoxacarb | 250 | 0.4 | 90.0 |
| 4. | thiametoxam | 100 g/ha | 4.3 | 27.0 |
| 5. | untreated | - | 5.9 | - |

Legend: DA – degree of attack, E – efficacity
Source: [7].

As concluded from the analysis of variance, gallery length is considerably influenced by the infestation method, followed by the environmental factor. An important contribution to gallery length is due to the treatment factor. The interaction between the factors also essentially contributes to the fluctuations in gallery length (Table 6).

Table 6. The variance analysis for the tunnel length (cm) produced by *Ostrinia nubilalis* in the testing of some insecticides, Turda 2013 and 2016

| Source of variation | DF | $s^2$ | F Test |
|---|---|---|---|
| Total | 70 | | |
| Year (Y) | 1 | 4,084.08 | 2,271.04*** |
| Method (M) | 1 | 4,767.87 | 4,028.34*** |
| Treatment (T) | 4 | 3,232.70 | 3,908.85*** |
| M x T | 4 | 726.60 | 878.57*** |
| Error A | 3 | 1.80 | |
| Error M | 6 | 1.18 | |
| Error T | 48 | 0.83 | |

Source: [7].

Similarly to the other attack parameters, the most efficient results in reducing the length of the galleries produced by the corn borer (Table 7), have been obtained with the active substances indoxacarb (Avaunt 150 SC) (30 cm) and deltamethrine (Decis Mega 50 EW) (28 cm) compared to the test counterpart. In fact, all the treatments limit up to a certain point this attack parameter.

Table 7. The factors influence on the tunnel lenght in the testing of some insecticides, in conditions of natural and artificial infestation, Turda 2013 and 2016

| Factors | | Tunnel lenght (cm) | Difference to control | Significance |
|---|---|---|---|---|
| A. Year | Average | 17.54 | 0.00 | Mt. |
| | 2013 | 10.40 | -7.15 | 000 |
| | 2016 | 24.69 | 7.15 | *** |
| | LSD (p 5%) = 0.95<br>LSD (p 1%) = 1.75<br>LSD (p 0.1%) = 3.88 | | | |
| B. Infestation method | Natural | 9.82 | 0.00 | Mt. |
| | Artificial | 25.26 | 15.44 | *** |
| | LSD (p 5%) = 0.60<br>LSD (p 1%) = 0.90<br>LSD (p 0.1%) =1.45 | | | |
| C. Treatment | Untreated | 31.65 | 0.00 | Mt. |
| | Tiacloprid | 30.69 | -0.96 | 00 |
| | Deltametrin | 3.94 | -27.71 | 000 |
| | Indoxacarb | 1.83 | -29.83 | 000 |
| | Thiametoxam | 19.60 | -12.05 | 000 |
| | LSD (p 5%) = 0.65<br>LSD (p 1%) = 0.86<br>LSD (p 0.1%) = 1.13 | | | |

Source: [7].

The most inefficient proved to be thiacloprid (Calypso 480 SC) (1 cm) şi thiametoxam (Actara 25 WG) (12 cm).

Among the treatments, indoxacarb (Avaunt 150 SC) ensures the best protection for the maize, expressed through reducing gallery length. This active substance leads to a limitation of this parameter with up to 44% compared to the untreated variant (the test counterpart), even under conditions of high level of infestation. Under natural conditions of infestation, the usage of this substance limits the damage caused by the corn borer through gallery length with almost 16% compared to the test counterpart (Figure 4).

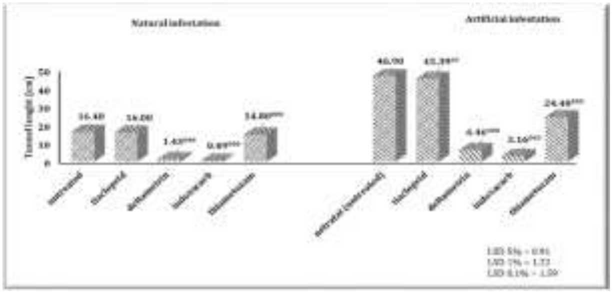


Fig. 4. The influence of treatment x method interaction on the tunnel lenght In the testing of some insecticides, 2013 and 2016

Source: [7].

The usage of these active substances limits the attack parameters of the corn borer in different proportions, the active substances indoxacarb şi deltamethrine (Decis Mega 50 EW) being the most efficient. We can highly recommend that the usage of these two products will considerably reduce the attack of *Ostrinia nubilalis* Hbn.

Production, as the final result of all the metabolic processes which take place in the plant, is highly complex and subject to the action of several abiotic and biotic stress factors, which finally contribute to the quantity and quality of production. Thus, we can say that production is in an extremely fragile balance with the great number of stress factors which can tip this balance any time in one or the other direction.

The tightest possible molding of all the technological links and pedoclimatic conditions on the requirements of the biological factor (hybrid) is one of the main conditions for inclining the „production" factor in a positive direction. In this regard, it is more and more necessary to apply the insecticides on the vegetation in maize cultivation for reducing the crop losses caused by *Ostrinia nubilalis.* The present experiment has had for its main purpose the identification, from among the existing insecticides, of those ones which have minimal impact on the environment, but at the same time significantly limit crop losses caused by the corn borer.

The genetic factor on which this experiment is based is the hybrid Turda Star, which was tested in two years of cultivation, under the same technological conditions (seed treatment, quantities of fertilizer, sowing density, herbicide and precursor plant). The most significant impact on maize production was the year factor, followed by method and treatment (Table 8). The interactions between the factors do not contribute significantly to production variance, with the exception of the double interaction year x method, 2016 was one of the most favourable years for maize culture, at least in the area where the experiment was carried out.

Table 8. The variance analysis for the mean production (kg/ha) obtained in the testing of some insecticides, Turda 2013 and 2016

| Source of variation | DF | $s^2$ | F Test |
|---|---|---|---|
| Total (Total) | 79 | | |
| An (A) Year (Y) | 1 | 84,542,720 | 1,410.27*** |
| Method (M) | 1 | 5,156,201 | 47.47*** |
| Treatment (T) | 4 | 2,292,888 | 19.67*** |
| A x M | 1 | 1,279,674 | 11.78*** |
| A x T | 4 | 170,172.6 | 1.46 |
| M x T | 4 | 248,770.5 | 2.13 |
| Error A | 3 | 59,947.9 | |
| Error M | 6 | 108,614.6 | |
| Error T | 48 | 116,570.4 | |

Source: [7].

Notable differences have been recorded for the two years of research, of 1,000 kg/ha (Table 9).

Obviously, artificial infestation with pest eggs led to important reductions in production, on the average 600 kg. From among the treatments, in the case of production, too, the most efficient substance was indoxacarb (Avaunt 150 SC). The most efficient substances in protecting the maize culture and implicitly production have proved to be indoxacarb şi deltamethrine (Decis Mega 50 EW), in both infesation conditions, leading to significant increase compared to the test counterpart.

Table 9. The factors influence on the mean production in the testing of some insecticides, in conditions of natural and artificial infestation, Turda 2013 and 2016

| Factors | | Mean production (kg/ha) | Difference to control | Significance |
|---|---|---|---|---|
| A. Year | Average | 7,892 | 0.00 | Mt. |
| | 2013 | 6,866 | -1,026.11 | 000 |
| | 2016 | 8,918 | 1,026.11 | *** |
| | LSD (p 5%) = 193.48<br>LSD (p 1%) = 355.32<br>LSD (p 0.1%) = 787.31 | | | |
| B. Infestation method | Natural | 8,180 | 0.00 | Mt. |
| | Artificial | 7,603 | -577.48 | 000 |
| | LSD (p 5%) = 164.69<br>LSD (p 1%) = 249.38<br>LSD (p 0.1%) = 400.63 | | | |
| C. Treatment | Untreated | 7,458 | 0.00 | Mt. |
| | Tiacloprid | 7,542 | 84.13 | - |
| | Deltametrin | 8,218 | 759.38 | *** |
| | Indoxacarb | 8,446 | 987.81 | *** |
| | Thiametoxam | 7,794 | 335.63 | ** |
| | LSD (p 5%) = 211.59<br>LSD (p 1%) = 282.54<br>LSD (p 0.1%) = 368.65 | | | |

Source: [7].

Under conditions of natural infestation, experiment results show that the active substance thiametoxam also ensures significant protection for maize production, leading to increase with 300 kg/ha comapred to the test counterpart. At great infestation pressure, nevertheless, this substance reacts less and ensures insignificant increase compared to the test counterpart (Fig. 5).

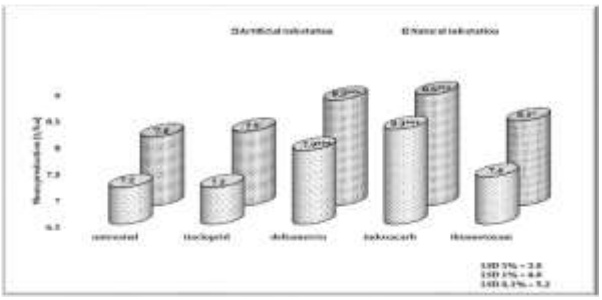

Fig. 5. The influence of treatment x method interaction on the mean production in the testing of some insecticides, 2013 and 2016
Source: [7].

The active substance indoxacarb (Avaunt 150 SC) ensures the best production increase, both in low or high degree infestation conditions.

For example, in natural infestations, the average differences compared to the test counterpart are 850 kg/ha (Fig. 6). The reference price for maize in the last years was 0.5-0.6 lei/kg, and by multiplying the average price with the production rate, compared to the test counterpart, we get an extra value of 470 lei/ha. By subtracting the price of the insecticide and of petrol, the profit amounts to 200 lei/ha. These simple calculations reflect the importance of using this product which, supported by suitable technology, can lead to important financial increase.

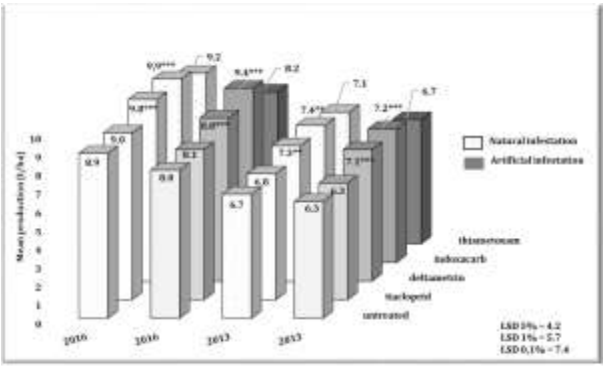

Fig. 6. The influence of treatment x year x method interaction on the mean production in the testing of some insecticides, 2013 and 2016
Source: [7].

The relationship between the degree of attack and average production, under both infestation conditions, is indirect and almost in all cases, significant.

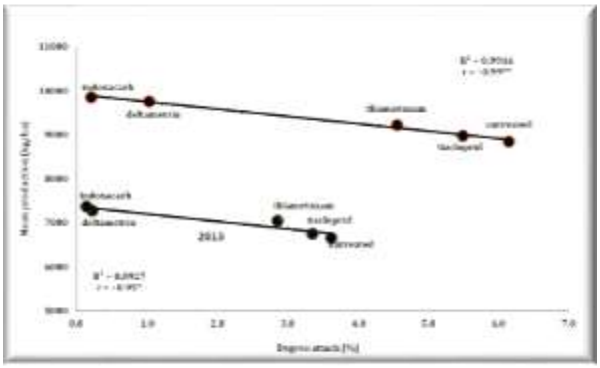

Fig. 7. Regression between mean production and degree of attack, in conditions of natural infestation
Source: [7]

Under conditions of natural infestation, the reduction of the regression line is obvious (Fig. 7), indicating the reduction of the degree of attack compared to the values of this indicator, but at higher pressures of infestation.

Nevertheless, the usage of insecticides somehow limits the degree of attack even under conditions of artificial infestation, but below the threshold of 7% (Figure 8). Under the natural infestation conditions from 2016, productions are much closer to the regression line, suggesting more reduced fluctuations of the productions (Fig.7).

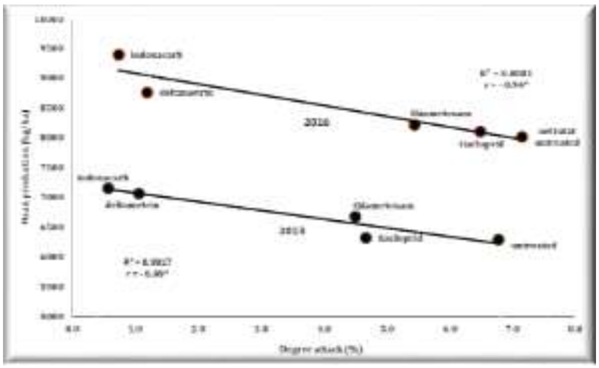

Fig. 8. Regression between mean production and degree of attack, in conditions of artificial infestation
Source: [7].

All the attack parameters of this pest finally lead to important crop losses. Following some thorough studies conducted in Câmpia Dunării in 1971, it was concluded that a single larva would produce a loss of 20 g/plant. Through simple calculations, implying plant density, one can get to production losses of 1,200 kg/ha [11].

Genetic resistance to *Ostrinia nubilalis* and the reduction of the number of broken plants has seen real progress only at genetically modified organisms. Until this objective is reached, for the protection of maize cultures it is necessary to strictly obey the technological chains, together with the execution of chemical treatments on vegetation with one of the active substances, indoxacarb or deltamethrine, especially when the pressures of infection grow, as well as in situations when some technological chains are not followed.

## CONCLUSIONS

The most efficient role in the protection of maize culture, and implicitly of production, goes to the active substances indoxacarb and deltamethrine, in both infestation conditions, leading to very significant increase compared to the test counterpart.

The least efficient results for corn borer control were obtained with the active substance thiacloprid.

Genetic resistance to *Ostrinia nubilalis* and the reduction of the number of broken plants has seen real progress only at genetically modified organisms. Until this objective is reached, for the protection of maize cultures it is necessary to strictly obey the technological chains, together with the execution of chemical treatments on vegetation with one of the active substances, indoxacarb or deltamethrine, especially when the pressures of infection grow, as well as in situations when some technological chains are not followed.

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