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PESTS OF MAIZE CROPS AND INTEGRATED CONTROL STRATEGY IN ROMANIA

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Abstract

Maize crop ranks the first place in Romania as cultivated area, representing 2.3-2.5 million ha annually, this being subjected to the attack of several pests. Various researches conducted in different locations of Romania indicated that pests (Tanymecus dilaticollis, Agriotes spp. Helicoverpa armigera, Diabrotica virgifera virgifera, Ostrinia nubilalis) can caused up to 100% losses in maize crops, especially because of those pests attacking in the first stages of vegetation. Recently, other very damaging pests have been reported to the maize crop as new threats or/and quarantine pests, which can cause major damages in the future, for example: Spodoptera frugiperda, Elasmopalpus lignosellus, Tylenchorhynchus claytoni, Chilo partellus. These new pests have established themselves in Europe, therefore the risk of spreading is very high. The data from literature were analysed on the pest short description, the damages produced to maize plants and the most effective control strategies through chemical, biological and cultural operations in the maize growing regions in Romania. It is important for growers to recognize all stages of these insects that attack maize crops, to making the correct decision by Integrated Pest Management (IPM) and/or other effective control methods.

Key words*: maize, pests, integrated control strategy, IPM.*

INTRODUCTION

Maize (*Zea mays* L.) is one of the most versatile spring crops, having great adaptability in very varied agro-pedo-climatic conditions (Saha et al., 2019). Globally, maize is a very important crop because it has the highest production potential among cereals (DMR, 2013), being grown on 203.47 million ha in 2022 according to FAO data (FAOSTAT) and being cultivated in 164 countries, with a wider diversity of soil and climatic conditions, biodiversity and management practices. Also, maize is a main crop, grown by smallholder farmers around the world and in Romania (Dragomir et al., 2022).

The area cultivated with maize in Romania, in 2022, was about 2.43 million ha and maize production of 8.03 million tons (FAOSTAT). According to Eurostat data, this trend was also maintained for the year 2023, respectively a cultivated area of 2.38 million ha and a production of 9.34 million tons. The low maize production in this years (2022 and 2023) was primarily due to the severe drought, especially in the southern part of the country where the area cultivated with maize represents over 50% of the total area.

From sowing to harvest, maize is subjected to many stress factors, both biotic and abiotic. Low temperatures at emergence, large temperature differences between day and night, drought and increasingly pronounced high temperatures, high temperatures during flowering and grain filling, weeds, diseases and pests, all these influence the growth, yields and development of the maize plant. Among these factors, pests have a significant effect on maize plants and their yielding capacity. And among the harmful animals, arthropods and implicitly insects are the most present in corn crops (Costea & Grozea, 2022).

There are a number of pests that attack maize crops and limit the grain yields with losses that

can reach even 100%. In the climate change context, the attack of harmful organisms, especially insects, increased. A team of researchers from University of Washington and the University of Colorado Boulder, both in the United States, used projected rises in global temperatures, crop yield statistics, and data on 38 insect species' population growth and metabolic rates to predict the impacts climate change will have on losses of the three grain crops (wheat, rice and maize) (Skendžić et al., 2021). While bug populations may actually decline in some tropical areas, major grain-producing regions in northern climates are projected to be among the hardest-hit (Skendžić et al., 2021).

Correct identification of maize pests, detailed knowledge of their behaviour, the management of crops protection against the attack of these pests, all these represent an imperative and always current necessity for all maize growers. To face the new problems regarding the behaviour of maize pests there were elaborated and proposed some possibilities to prevent their occurrence and to combat them through various methods (agrophytotechnical, biological and chemical means), which obliges every grower to be at up-to-date with all the information to use with maximum efficiency, for obtaining superior yields in terms of quantity and quality.

MATERIALS AND METHODS

The purpose of this study is to present the main pests that attack the maize crops in Romania every year, but also to signal new species of pests that may become very aggressive and of real risks in the future. From sowing to harvest, the maize crop is subject to frequent attack by some very damaging pests, such as: *Tanymecus dilaticollis* Gyll (maize leaf weevil), *Agriotes linetaus* L. (wireworm), *Helicoverpa armigera* Hübner (corn earworm), *Diabrotica virgifera virgifera* La Conte *(Diabrotica virgifera zeae*) (Western corn rootworm), *Ostrinia nubilalis* Hübner (European maize borer). In addition, other maize pests have recently been reported that did not cause significant damage, but in the future they may become as damaging as the current ones: *Spodoptera frugiperda* J.E. Smith (corn leaf worm), *Elasmopalpus lignosellus* Zeller (lesser cornstalk borer), *Tylenchorhynchus claytoni* Steiner (stunt nematode), *Chilo partellus* Swinhoe (spotted stalk borer).

The period analysed in this study was 2018-2023. The year 2018 was chosen, because insecticides from the neonicotinoid group, very effective in controlling maize pests, were banned by the European Commission completely in 2018, and Romania started to ask for derogations for using these insecticides every year.

It was analysed the specialized literature by Google Schoolar and Web of Knowledge, PlantwisePlus Knowledge Bank and European Plant Protection Organization (EPPO) databases, respectively scientific papers, monitoring, and reports that have as subject these pests. Also, the data collected and analysed on short description of pest, the mode of damage and the control strategies in Romania. It is important for growers to recognize all of these insects that attack maize crops, to making the correct decision by Integrated Pest Management (IPM) and/or other effective control methods.

RESULTS AND DISCUSSIONS

From the analysis carried out in the international databases of Google Scholar and Web of Knowledge (2018-2024) with specialized works, by scientific name and common name, Table 1 resulted.

Table 1. Number of scientific papers which include maize pest (International database Google Scholar and Web of Knowledge) (2018-2024)

Scientific name of pests	Common name of pests	Number of paper included the scientific name	Number of paper included the common name
Tanymecus dilaticollis	Maize leaf weevil	113	32,904
Agriotes linetaus	Wireworm	349	819
Helicoverpa armigera	Corn earworm	15,331	19
Diabrotica virgifera virgifera	Western corn rootwor	4,739	197
Ostrinia nubilalis	European maize borer	5,345	8,710
Spodoptera frugiperda	Corn leaf worm	17,846	16,900
Elasmopalpus lignosellus	Lesser cornstalk borer	529	3
Tylenchorhynchus claytoni	stunt nematode	110	-
Chilo partellus	Spotted stem borer	3,051	16,900

It can be observed that the most numerous studies had as subject *Helicoverpa armigera* (over 15,000 papers), followed by *Ostrinia nubilalis* (over 5,000 papers). According to the common name, the most frequently encountered is *Tanymecus dilaticollis*, with 32,904 studies.

The new pest *Spodoptera frugiperda* signalled in 2023 as a risk for maize in Romania by the researchers (https:/gd.eppo.int/reporting/article-7753) of Fundulea National Development Research Institute, appears in the specialized literature with over 17,000 papers.

Table 2 presented the main characteristics of maize pest with the aim of easier recognition by farmers.

Table 2. The description of the maize pests (authors processing from specialized literature) (PlantwisePlus Knowledge Bank and EPPO, Google Scholar and Web of Knowledge) (2018-2024)

Scientific and common pest name	Short description of pest
Tanymecus dilaticollis (maize leaf weevil)	The colour of the body is grey-brown, lighter ventrally and its length is between 6.5 and 8 mm. Females are larger than males. The adult has an oval-elongate shape and presents a beak, obviously called a rostrum. The larva is apodic, and at maturity reaches 8-9 mm, bright white in colour and presents a yellowish pubescence. The pupa is white, 5-9 mm long (Georgesccu et al., 2022).
Agriotes spp. (wireworm) 3 species are known: *A. lineatus, A. ustulatus* and *A. obscurus*.	Adults have an elongated and posteriorly narrowed body. The elytra are provided with four characteristic stripes. Characteristic for this group of insects is the jumping device, located at the insertion point between the prosternum and mesosternum. The colour varies from reddish brown to dark brown. At maturity, the larvae reach a length of 18-26 mm. The body is cylindrical, strongly chitinized, which gives them a certain rigidity, hence the name "wire worms". From the second age, the body colour changes from white-transparent to shiny yellow-orange, and the head is brown.
Helicoverpa armigera (cotton bollworm, corn earworm)	Adults are moth butterflies and are generally 1.4-1.9 cm long and have a wingspan of 3.5-4 cm. Females are orange-brown in color and have a reniform spot (in a shade of dark brown) in the central area of the forewings. Also, the hindwings are creamy white with a dark brown (or grey) band on the outside. Males, on the other hand, are colored yellowish, yellow-brown, or brown. The larvae has usually 1.5-2 cm long.
Diabrotica virgifera virgifera (western corn rootworm)	The adult has an elongated oval body, measuring between 4.4-4.6 mm for the male and 4.2-6.8 mm for the female, yellowish-green in color. The elytra of the male are brown, with the posterior part lighter, and the elytra of the female are well marked by three black bands. The eggs are oval, 0.5 mm, light yellow when laid, later turning brownish yellow. The length of the larva is between 10-18 mm. It has an elongated, thin, white shape, with a darker cephalic capsule. The ninth abdominal segment of the larva shows a dark spot in the dorsal part. It presents three larval ages.
Ostrinia nubilalis (European maize borer)	Adult butterflies are moths that have a body length of between 15 and 16 mm and a wingspan of 2-3 cm. There are certain differences between females and males. Females are larger, with a rounded, pale yellowish abdomen. The front wings have 3 transversal stripes, arranged in a zig-zag, of light yellow colour, and the rear wings are characterized by a uniform, yellow-gray colour, presenting a lighter stripe in the central area. The male is smaller, with the terminal abdomen sharper, darker in colour, with shades of brown. The hind wings are light yellow, with a darker stripe in the central area. The larvae are 2-2.5 cm long caterpillars, grey-yellow in colour that darken with maturity.
Spodoptera frugiperda (corn leaf worm)	Larvae attain lengths of about 1.7, 3.5, 6.4, 10.0, 17.2, and 34.2 mm, respectively, during these instars. Young larvae are greenish with a black head, the head turning orangish in the second instar. In the second, but particularly the third instar, the dorsal surface of the body becomes brownish, and lateral white lines begin to form. In the fourth to the sixth instars the head is reddish brown, mottled with white, and the brownish body bears white subdorsal and lateral lines. Elevated spots occur dorsally on the body; they are usually dark in color, and bear spines. The moths have a wingspan of 32 to 40 mm. In the male moth, the forewing generally is shaded gray and brown, with triangular white spots at the tip and near the center of the wing. The forewings of females are less distinctly marked, ranging from a uniform grayish brown to a fine mottling of gray and brown. The hind wing is iridescent silver-white with a narrow dark border in both sexes (https://entnemdept.ufl.edu/creatures/field/fallarmyworm.htm).
Elasmopalpus lignosellus (lesser cornstalk borer)	The moth has a wingspan of about 38.5 mm. The hind wings are grayish-white; the front wings are dark gray, mottled with lighter and darker splotches. Each forewing has a noticeable white spot near the extreme. Larvae are about 30 to 40 mm in length when full grown, color varies from light tan or green to nearly black. A longitudinal, pitch-colored stripe runs along each side of the body and a wider, yellowish-gray stripe runs down the back. The head of a larva is often marked with a pale, but prominent, inverted Y.
Tylenchorhynchus claytoni (stunt nematode)	Female: Body 520-825 µm in length, slightly arcuate to variable postures when heat relaxed. Cuticle annulated, annuli can be about 2 µm at mid-body region, smaller than 2 µm at lip region but can be coarser (more than 2 µm) around tail terminus. Lateral field with four lateral lines forming three bands of more or less equal width, outer two lines often crenated and outer two bands can be sometimes areolate (Zeidan & Geraert, 1990).
Chilo partellus (spotted stem borer)	Wingspan of 7-20 mm. Forewings are typically light yellow-brown with some darker scale patterns forming longitudinal striations, usually darker at wing margins. Hindwings are white. Up to 25 mm long when fully grown. Body is creamywhite to yellow-brown with 4 purple-brown longitudinal stripes and conspicuous dark brown dorsal spots. Head and prothoracic shield are reddish-brown to dark brown.

The damage thresholds and host plant of these pests are presented in Table 3. It can be seen that all the species presented are polyphagous pest, which makes it difficult to choose the plants assortment for the rotations.

Table 3. The damage and crops host of maize pests (authors processing from specialized literature) (PlantwisePlus Knowledge Bank and EPPO, Google Scholar and Web of Knowledge)

Scientific and common pest name	Damage	Economic thresholds (PlantwisePlus Knowledge Bank and EPPO)	Crops host (PlantwisePlus Knowledge Bank and EPPO)
Tanymecus dilaticollis (maize leaf weevil)	The larvae do not cause significant damage to the crops, instead the adult insects gnaw the edges of the leaves and destroy the apical meristems. Adults attack young seedlings (rarely germinating seeds) and destroy them. They feed on young leaves from the leaf margin, and most damage occurs before the 4-leaf stage. Higher temperatures enhance feeding (Georgescu et al, 2022).	1-3 larvae/ m^2	Polyphagous pest: 70 host plants (sunflower, soybean, alfalfa, wheat, barley, sugarbeet, etc.).
Agriotes spp. (wireworm)	Adults caused insignificant damage. The larvae are extremely harmful, feeding on the underground parts of the plants, on the germinating grains, the embryo or the barely formed roots. Attacked plants show yellowed leaves, after which they dry or grow weakly.	1 larvae/ m^2	Polyphagous pest: 30 host plants (maize, sunflower, potatoes, root plants, tomatoes, lettuce, eggplants, peppers, pumpkins, etc.).
Helicoverpa armigera (cotton bollworm, corn earworm)	There are two to three generations a year. Insects overwinters as pupae in the soil. Adults appear from May until the end of October. Eggs are laid on plants at or near flowering. The feeding larvae can be seen on the surface of plants, but they are often hidden within plant organs. Bore holes may be visible, but otherwise it is necessary to cut open the plant to detect the pest. Secondary infections are common.	10 larvae/plants	Polyphagous pest: 172 plant species.
Diabrotica virgifera virgifera (western corn rootworm)	The adult insect first feeds on the leaf blade, which it perforates in the form of longitudinal stripes along the ribs. During the flowering period, the attack extends to silk and pollen. Sometimes the grains from the top of the cob, in the milk phase, are eaten. The adults can then migrate to later seeded maize crops. The larvae feed on the maize roots, causing them to shorten. As a result of this method of attack, the roots can no longer support the plants, so they tend to bend towards the ground.	1-2 larvae/plants	Polyphagous pest: 20 host plants. It is mainly a pest of maize, but occasionally also other plants may be hosts: cereals (rye, oats, triticale etc.) for larvae, and peas, soybean, bean, sunflowers, rape, etc. for adults.
Ostrinia nubilalis (European maize borer)	In summer (end of June to the end of July), eggs are laid in clusters of 20-30, generally on the underside of the lower leaves. After an incubation of 5-15 days, young larvae penetrate into the upper leaves and feed through folded leaves, causing characteristic "windowing" (rounded holes). The caterpillars then very often damage tassels and, at flowering, penetrate into the stem near the leaf axil. The larvae tunnel stems, cob peduncles and the cob itself. In northern regions has one generation per year. In southern regions, may have a second complete or incomplete generation (EPPO Standards, Maize).	1-3 larvae/ m^2	Polyphagous pest: 200 host plants (maize, sunflower, sorghum, hemp, beet, wheat, millet, apple in nursery, chrysanthemum and those from the spontaneous flora (nettles, fodder beet, glasswort), redroot pigweed, forewing saltbush, etc).
Spodoptera frugiperda (corn leaf worm)	The young larva disrupts the photosynthetic system by feeding on the leaves. Also affects maize plants at all developmental stages, but the effect of damage is more severe at the young growing phase, besides maize cobs can be severely damaged under heavy infestation. One begins to notice some degree of damage as the egg hatches into larva between 3–6 days creating windows, while constant feeding results in skeletonized leaves and heavily windowed whorls loaded with larval frass patches on the leaves (EPPO Standards, Maize 16).	1-2 larvae/plants	Quarantine pest; Polyphagous pest: 80 host plants (maize, millet, sorghum, rice, and wheat, as well as sugar cane and vegetables).
Elasmopalpus lignosellus (lesser cornstalk borer)	Damage is caused by its larvae which feed and tunnel inside the stems (or stalks) of their host plants. Usually, larvae bore stems at their basal part or just below the soil surface. They bore upward within the plant, and as they feed, frass partially fills the gallery. Wilting is one of the first signs of attack which may be followed by stunting, deformation, and plant mortality (especially on plantlets) (EPPO Standards, Maize).	Economic thresholds were not reported. 2 larvae / plant (Overton et al., 2021).	Quarantine pest. Polyphagous pest : 100 host plants (maize, sorghum, wheat, vegetables, soybean, etc.).
Tylenchorhynchus claytoni (stunt nematode)	It's are not visible to the naked eye but usually visible under light microscope. Symptoms caused to the root system, can result in lateral root proliferation, pruning of fibrous roots and the presence of dark brown discrete lesions in coarse and fibrous roots (EPPO Standards, Maize).	Economic thresholds were not reported. 300-350 nematodes / 100 cm^3 soil) (EPPO Standards, Maize)	Quarantine pest. Polyphagous pest: 40 host plants (maize, sorghum, wheat, vegetables, oats, etc).
Chilo partellus (spotted stem borer)	This pest infests maize crops during all plant growth stages. The larvae are cryptic feeders inside the stems of maize plants. They also feed on maize ears. Infestation of seedlings often results in the death of the growth point which manifests as dead hearts. Older larvae tunnel extensively in stems and in maize ears, weakening the stems, which may break and lodge.	3-4 larvae/plant for 20 and 40 days old maize (EPPO Standards, Maize).	Quarantine pest. Polyphagous pest; 100 host plants (maize, sorghum, wheat, vegetables, soybean, etc.).

In the case of quarantine pests, a serious problem in their spread is the trade in agricultural products from countries where the infestation and attack is major. It is worrisome when there are no clear specifications regarding the economic threshold and it is up to the manufacturer to assess it. In this case, there may be some major risks to the environment by increasing the number of applications followed by pollution or, on the contrary, its application not being economically efficient.

From the analysis of the approaches practiced by farmers, it was concluded that the integrated struggle must not be based on isolated organisms from an ecosystem, but on all plant and animal organisms (flora and fauna) that populate the respective agrobiocenosis, with all the mutual links between them.

Consequently, the basic link of the integrated fight is the principle by which the total eradication of the pest is not aimed at following the application of various means of combating it, but maintaining it at a level at which it does not cause damage (below the economic threshold of damage). This procedure presents the advantage that it avoids making unnecessary expenses and, at the same time, ensures the survival of natural enemies (parasites and predators), which have a determining role in the evolution of the pest.

On the other hand, in the European context, reducing the use of pesticides and Integrated Pest Management (IPM) practices can be a solution to control the damage caused by these pests to the maize crop. There are over 67 definitions of IPM, issued by governments, research organizations, NGOs, and universities (Bajwa & Kogan, 2002), the concept being explicitly defined in 1965 at a symposium sponsored by the Food and Agriculture Organization (FAO), of the United Nations, held in Rome, Italy (Kogan & Bajwa, 1999). Some definitions assume that IPM will eliminate the use of crop protection products specially the chemical pesticides, which is most unlikely.

Extreme views equating IPM with “pest free” farming will become increasingly marginalised and more balanced views will prevail (Kumat et al., 2012). There is no reason not to support IPM as defined by the FAO International Code of Conduct on the Distribution and Use of Pesticides (Article 2): IPM means a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economically unacceptable damage or loss (FAO, 2021).

Thus, IPM is the best combination of cultural, biological and chemical measures that provides the most cost effective, environmentally sound and socially acceptable method of managing diseases, insects, weeds and other pests (https://croplifeeurope.eu/what-is-ipm/). IPM is a system of regulating pest populations which, taking into account the specific environment and the dynamics of the species under consideration, uses all the appropriate techniques and methods in a compatible way to keep pests at a level that do not cause economic damage (Deguine et al., 2021). Through the research carried out in different countries, the preventive methods refer to: phytosanitary quarantine, conditioning of the seed material and the one to be planted, the destruction of problem weeds and, in addition, forecasting and warning and also, application of insecticides remain the most important solutions for combating maize pests. In Romania, according the *Guide to recognition and combat diseases and pests to the maize* of National Phytosanitary Authority, successful pest management is ensured by applying a program of integrated protection, which includes a series of components, including agrophytotechnical, mechanical, physical, biological and chemical methods. In order to reduce the damage caused by maize pests, the most important measures and control strategies presented in the specialized literature were analysed (Table 4).

Table 4. Control strategy for maize pest in Romania
(Guide to recognition and combat diseases and pests to the maize, National Phytosanitary Authority in Romania)

Scientific and common pest name	Cultural measures	Chemical and biological active substance/Dose of application of commercial product containing respectively active substance
Tanymecus dilaticollis (maize leaf weevil)	✓ Crop rotation and avoiding monoculture; ✓ Correct establishment of the sowing period; ✓ Ensureng conditions that favor rapid emergence; ✓ Establishing an appropriate density of plants.	• Romania requests authorizations for application every year for neonocotinoide substances: ➢ 600 g/l Imidacloprid - 6-8 l/t seed; ➢ 350 g/l Thiamethoxam - 9 l/t seed. • Chemical products by applying the following protection products: ➢ 50 g/l Lamda-cihalotrin – 0.15 l/ha, applied in vegetation; ➢ 50 g/l Deltametrin - 0,25 l/ha, applied in vegetation; ➢ 200 g/kg Acetomiprid – 0.1 kg/ha. • Biochemical methods by applying the following protection products: ➢ 100% natural plant and fruit extracts and oils - 10 l/t seeds; ➢ 100% neem oil of *Azadirachta indica* - 8-10 l/t seeds.
Agriotes spp. (wireworm)	✓ Performing summer and autumn plowing immediately after harvesting the crops; ✓ Tilling the soil to reduce the biological reserve of the pest through exposure to the weather and attack by natural predators of the larvae; ✓ Application of mineral fertilizers, especially those with nitrogen, which have a harmful effect on larvae; ✓ Calcium amendment of acid soils and drainage of lands with excess moisture; ✓ Compliance with the optimal sowing depth; ✓ Crop rotation and sowing on infested lands of some species that are less attacked by larvae. ✓ Larvae are extremely harmful especially to crops in the first stages of vegetation that either stops sprouting or withers and then dries up.	• Chemical products by applying the following protection products: ➢ 300 g/l Cipermetrin - 2.0 l/t seed; ➢ 8 g/kg Cipermetrin - 12 kg/ha, with application in the furrow by incorporation at sowing; ➢ 0.4% Lambda-cihalotrin - 10-15 kg/ha, direct application to the soil, together with seeds, at sowing; ➢ 4 g/kg Lambda-cihalotrin - 10-15 kg/ha, with application to the soil, together with seeds, at sowing; ➢ 5 g/kg Teflutrin - 16 kg/ha, applied at sowing.
Helicoverpa armigera (cotton bollworm, corn earworm)	✓ Frequent inspection of the crop, given the short biological cycle and very rapid development; ✓ Removal of weeds from neighboring areas because they can be a source of infestation; ✓ Deep plowing in autumn to destroy hibernating chrysalises; ✓ Early sowing to speed up plant development. ✓ Adults are migratory and can travel long distances (>100 km).	• Chemical products by applying the following protection products: ➢ 50 g/l Lamda-cihalotrin + 100 g/l Clorantraniliprol - 0.2 l/ha, with application from the appearance of the 4th internode up to the stage of grain in milk; ➢ 150 g/l Indoxacarb - 250 ml/ha; ➢ 200 g/l Clorantraniliprol - 125 ml/ha. • Biochemical methods by applying the following protection products: ➢ Some products based on bacteria, e.g. *Bacillus thuringiensis* (applied to the larvae of the first and a second generation) and viruses, e.g. *Helicoverpa armigera* nuclear polyhedrosis virus; ➢ Parasites of the type *Trichogramma evanescens* (oophage) and predators *Podisus maculiventris*.
Diabrotica virgifera virgifera (western corn rootworm)	✓ Crop rotation is mandatory where the presence of the pest is recorded; ✓ Deep plowing immediately after the abolition of the corn crop, exposing most of it to frost eggs laid in the soil; ✓ Use of corn varieties resistant to larval attack; ✓ Use of pheromonal traps for the detection of adults and for establishing the population density, in in order to apply the treatments. ✓ Avoiding corn monoculture is the most effective and cheapest method pest control. ✓ Pest is a vector of Maize chlorotic mottle virus.	• Chemical products by applying the following protection products: ➢ 50 g/l Lamda-cihalotrin + 100 g/l Clorantraniliprol - 0.2 l/ha, with application from the appearance of the 4th internode up to the stage of grain in milk; ➢ 5 g/kg Teflutrin - 20 kg/ha, applied at sowing; ➢ 1.5% Teflutrin - 12-15 kg/ha, applied on row, at sowing; ➢ 50 g/l Lambda-cihalotrin - 0.15 l/ha, applied to warning, repetition after 7 days; ➢ 4 g/kg Lambda-cihalotrin - 10-15 kg/ha, with direct application to the soil, together with seeds, at sowing; ➢ 25 g/l Deltametrin - 0.03-0.05%; ➢ 4 g/kg Lambda-cihalotrin - 12-15 kg/ha, applied along the row with the first mechanical weeding, when the plant has 5-8 leaves; ➢ 150 g/l Indoxacarb - 250 ml/ha. • Biological products by applying the following protection products: ➢ Pheromonal traps - 10 kg pheromons/ha; ➢ The pest is parasitized by the bacterium *Bacillus thurigiensis* and fungi of the genus *Beauveria*, effective against adult and larval stages. Other known natural predators are: *Argiope bruennichi* (*Araneae: Araneidae*), *Speira diadematа* (*Araneae: Araneidae*), *Theridion impressum* (*Araneae: Theriidae*), *Pseudophomus rufipes* (*Coleoptera: Carabidae*). Larval development can be negatively influenced by entomopathogenic nematodes *Steinerma carpocapsae, Heterorhabditis bactiophora.*
Ostrinia nubilalis (European maize borer)	✓ Performing autumn plowing; ✓ Destruction of affected plant remains; ✓ Avoiding monoculture; ✓ Use of resistant hybrid lines; ✓ Weed control to avoid host plants.	• The first treatment is applied at warning. • Chemical products by applying the following protection products: ➢ 50 g/l Lamda-cihalotrin + 100 g/l Clorantraniliprol - 0.2 l/ha, applied from the appearance of the 4th internode up to the stage of grain in milk; ➢ 25 g/l Deltametrin - 0.03-0.05%; ➢ 150 g/l Indoxacarb - 250 ml/ha; ➢ 200 g/l Clorantraniliprol - 125 ml/ha. • Biological products by applying the following protection products: ➢ Bioinsecticides based on *Beauveria bassiana* and *Bacillus*

		thuringiensis kurstaki - 0.6 - 1 kg/ha, with application at hatching and the first larval stages) (Lereclus et al., 1993). ➢ 54% *Bacillus thuringiensis* subsp. kurstaki (strains ABTS 351, PB 54, SA 11, SA 12, EG 2348) (Lereclus et al., 1993); 1-3 applications; ➢ 100,000 wasps/ha (2 applications) *Trichogramma maydis*. Releases of oophagous wasps.
Spodoptera frugiperda (corn leaf worm)	✓ Phytosanitary quarantine and forecast and warning; ✓ Sowing time adjustments, ✓ Weed management; ✓ Soil-health management; ✓ Balanced fertilization; ✓ Intercropping; ✓ Crop rotation.	• Any specific chemical control recommendations in EU or Romania, but any other insecticide used for corn can be used. • Biological products by applying the following protection products: ➢ 100% neem oil of *Azadirachta indica* - 8-10 l/t seeds ➢ nucleopolyhedrovirus (NPV), ➢ extracts of *Cassia fistula, Cleome viscosa, Melia azedarach, Portulaca oleracea*, *Stemona tuberosa*.
Elasmopalpus lignosellus (lesser cornstalk borer)	✓ Phytosanitary quarantine and forecast and warning; ✓ Tillage and destruction of weeds; ✓ Destroying infested stubble over winter; ✓ Crop rotation.	• Any specific chemical control recommendations in EU or Romania but any other insecticide used for corn can be used. • Insecticides applied for suppression of lesser cornstalk borer are usually applied in a granular formulation in the seed furrow or in a band over the seed bed, using restricted pesticides according to label recommendations. Liquid formulations can also be applied, but it is important that they be directed to the root zone (https://ipm.uga.edu/files/2020/06/Lesser-Cornstalk-Borer.pdf, University of Florida, 2020). • Biological products by applying the following protection products: ➢ The predominant parasitoids are: *Orgilus elasmopalpi* Muesebeck and *Chelonus elasmopalpi* McComb (both *Hymenoptera: Braconidae*), *Pristomerus spinator* (Fabricius) (*Hymenoptera: Ichneumonidae*), and *Stomatomyia floridensis* Townsend (*Diptera: Tachinidae*) (Gill et al., 2023). ➢ Other parasitoids sometimes present include: *Bracon gelechiae* Ashmead (Hymenoptera: Braconidae), *Geron aridus* Painter (*Diptera: Bombyliidae*), and *Invreia* spp. (*Hymenoptera: Chalcididae*). Parasitoids rarely cause more than 10% mortality (Gill et al., 2023). ➢ Among the predators thought to be important mortality factors are a ground beetle, *Plilophuga viridicolis* LeConte (*Coleoptera: Carabidae*); big-eyed bugs, *Geocoris* spp. (*Hemiptera*: *Lygaeidae*); and larval stiletto flies (*Diptera: Therevidae*) (Gill et al., 2023). ➢ Natural enemies generally did not greatly affect population levels of lesser cornstalk borer, perhaps due to its subterranean habits, silken webbing, and sporadic nature (Gill et al., 2023).
Tylenchorhynchus claytoni (stunt nematode)	✓ Phytosanitary quarantine and forecast and warning; ✓ Crop rotation; ✓ Balanced fertilization ✓ Destruction of affected plant remains; ✓ Tillage of soil.	• Any specific chemical control recommendations in EU or Romania but any other nematicides used for corn can be used. ➢ 10% Fostiazat 10-15 kg/ha, applied one at a time, at least 8-10 days before sowing, on a width of 30 cm, followed by incorporation into the soil at 15 cm, in order to create a protective barrier for the roots. On soils with a high degree of infestation, it is recommended to apply on the entire surface and not only on the rows. ➢ 510 g/l Metam of sodium - 700 l/ha.
Chilo partellus (spotted stem borer)	✓ Phytosanitary quarantine and forecast and warning. ✓ Weed management; ✓ Crop rotation; ✓ Balanced fertilization.	• Any specific chemical control recommendations in EU or Romania but any other insecticide used for maize can be used. ➢ 250,000/ha *Trichogramma chilonis*, release egg parasitoid, thrice at weekly intervals. ➢ 150 ml/ha dimethoate, when infestation crosses 10% - 660 ml/ha.

CONCLUSIONS

Pest control is a very important component of the maize crop technology. Therefore, according to the specialized literature, there are many researches, reviews, articles, case studies which highlight the most important damage of maize crop and the risk of losing 100% of the crop, if agrophytotechnical, chemical, biological methods are not used.

Integrated Pest Management (IPM) can become a viable solution in the current context of European Agricultural Policies and Romanian Agriculture Strategy, in order to reduce the use of pesticides and find alternatives to some problematic pests, such as *Tanymecus dilaticollis* for maize crop.

At the same time, in addition, there is a risk of the appearance of new species that can become an imminent danger for maize crops in Romania, especially in the context of climate change, and global warming that can influence the biology of the species and their adaptation to new environmental conditions.

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