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Population Dynamics and Effect of Seed Treatment on *Plutella xylostella* Control in Romania

Emil Georgescu [1], Maria Toader [2,*], Ioan Sebastian Brumă [3,4], Lidia Cană [1], Luxița Rîșnoveanu [5,6], Cristina Fătu [7] and Roxana Zaharia [7]

1 Agricultural Engineering Laboratory, National Agricultural Research and Development Institute Fundulea, 915200 Fundulea, Romania; emilgeorgescu2013@gmail.com (E.G.); lidiacana@yahoo.com (L.C.)
2 Faculty of the Agriculture, Department of Crop Science, University of Agronomic Sciences and Veterinary Medicine of Bucharest, 011464 Bucharest, Romania
3 "Gh. Zane" Institute for Economic and Social Research, Romanian Academy, 700481 Iasi, Romania; sebastianbruma1978@gmail.com
4 Faculty of Agriculture, "Ion Ionescu de la Brad" Iasi University of Life Sciences, 700490 Iasi, Romania
5 Faculty of Agrifood and Environmental Economics, Bucharest University Economic Studies, 010374 Bucharest, Romania; luxita_risnoveanu@yahoo.co.uk
6 Agricultural Research Development Station Brăila, 818008 Brăila, Romania
7 Institute of Research-Development for Plant Protection, 013811 Bucharest, Romania; catos2411@yahoo.com (C.F.); roxyanna_21@yahoo.com (R.Z.)
* Correspondence: maria.toader@agro-bucuresti.ro

Simple Summary: The diamondback moth (*Plutella xylostella*) is a major pest of oilseed rape (OSR) worldwide. In Romania, the diamondback moth (DBM) was considered a minor pest of this crop, without economic importance. Increasing the temperatures due to global warming can have consequences in increasing the pest's attack on main crops. During our study, the average annual temperature in Southeast Romania was higher than long-term averages. At the same time, a tendency toward decrease rainfalls was observed, especially in the autumn. Our study found higher DBM larva attacks in the OSR field in the autumn that previously weren't mentioned in the Romanian scientific literature. Seed treatment decreases the DBM larvae attack on OSR plants but not the number of larvae per plant. We found higher moth activity in the November and December. Our findings indicate a higher DBM pressure in the OSR field. This can have negative consequences for Romanian OSR growers in the future.

Abstract: This paper presents a three-year study concerning the effectiveness of the OSR seed treatment with the cyantraniliprole active ingredient in controlling the DBM larvae attack in autumn and four-year monitoring of the DBM flight pattern, using pheromone sticky traps. The experiment and the monitoring were conducted at the experimental field from the National Agricultural Research and Development Institute (NARDI) Fundulea in Southeast Romania. For the field assessments, each OSR sampled plant was photographed in macro mode, and then images were downloaded and magnified on the PC screen to determine the DBM larva attack. The traps were placed in the OSR crop from mid-March till December and checked twice weekly. Data from the field assessment revealed a higher pest attack on OSR plants on 11 November 2020, when the DBM larvae attack degree was 16.26% in the untreated variant and 11.24% in the variant with treated seeds. The results evidenced unusually higher activity for the diamondback moths during November 2019, 2020, and 2022; the beginning of December 2020 and 2021; and mid-December 2022. This is the first report from the Romanian scientific literature concerning higher DBM attacks at OSR plants in autumn and high moth activity during November and December.

Keywords: diamondbackmoth; oilseed rape; higher larvae attack; monitoring; late autumn

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Citation: Georgescu, E.; Toader, M.; Brumă, I.S.; Cană, L.; Rîșnoveanu, L.; Fătu, C.; Zaharia, R. Population Dynamics and Effect of Seed Treatment on *Plutella xylostella* Control in Romania. *Agronomy* **2023**, *13*, 1236. https://doi.org/10.3390/agronomy13051236

Academic Editors: Flávio Roberto Mello Garcia, Sérgio M. Ovruski and Stanislav Trdan

Received: 21 March 2023
Revised: 11 April 2023
Accepted: 24 April 2023
Published: 27 April 2023

1. Introduction

Oilseed rape (OSR, *Brassica napus* L.) is one of the most important oleaginous crops in the world [1]. In the last 20 years, the increasing demand for biofuels has made this crop profitable for farmers [2–5]. At the same time, the cultivation of OSR can be a solution for areas with pollution of heavy metals [6–8]. Romania is in fourth place on the OSR cultivated area list from the EU27 [9]. In this country, the area cultivated with OSR increased after 2010, arriving at peaks of 455.95 thousand ha in 2016 and 632.68 in 2017, while in the last few years, it ranged from 342.60 to 445.90 thousand ha [10–12]. From this total area with OSR, only a small size is cultivated in an ecological system, but the areas increased from 498 ha in 2017 to 5798 ha in 2019 [13]. The average OSR production in Romania ranged from 2124 to 2835 kg/ha, with a 3084 kg/ha peak in 2021 [10,11]. Many hazards often limit the yield potential of the OSR crop across the world [14,15]. In Romania, especially in the southern regions, drought from the autumn can have negative consequences for OSR plants' emergence and development in the early vegetation stages [16–18]. Frost during the winter is another important hazard for OSR production in temperate climate regions, including Romania [19,20]. However, in the last ten years, because of climate changes, frost frequency during the cold season has decreased [21–23]. In recent years, invasive weed species have threatened OSR crops in Southeast Romania [24]. Plant diseases such as phoma stem canker or *Sclerotinia* are another European OSR production risk [25,26].

Pests are a main limiting factor for OSR production worldwide [27–32]. The diamond-back moth *Plutella xylostella* (Lepidoptera: Plutellidae) is the major pest of this crop, with a global distribution on all continents [33–37]. The moths have an excellent capacity for migration; they can fly 400–500 km in one night and up to 1500 km in a few nights [38,39]. A recent study from China shows that moths can migrate more than 2000 km [40]. DBM has a limited capacity for overwintering, preferring tropical and temperate Mediterranean climates [37]. The DBM high migration capacity is because of moths' ability to use warm air currents and low jet streams [41]. During the summer, moths can migrate to areas with a temperate climate, such as Canada or the UK, or even cooler climates, such as the Svalbard Archipelago [38,39,42–44]. This is why DBM is considered the most widely distributed species of the Lepidoptera order. At the same time, it is regarded as one of the most distributed pests of cruciferous plants across the globe [45]. DBM is resistant to different insecticide classes, such as organophosphate, pyrethroids, and neonicotinoids [46–49]. In some countries, it has been reported that DBM has resistance to newer ryanoid insecticide classes [50,51]. Data from the literature concluded the resistance of DBM at 91 active ingredients that placed this species in second place in the world, after two-spotted spider mites (*Tetranychus urticae*), for insecticide resistance [36,52]. DBM is the first insect species found to be resistant to *Bacillus thuringiensis* [53–55]. Studies from different regions demonstrate DBM resistance at Cry1Ab, Cry1Ac, or Cry2Ad toxins [56–58]. The increasing temperatures because of global warming can cause a shift in the migration patterns of the DBM [59]. As a result, in the future, the northern latitudes can be registered as having higher pest densities and attackson cruciferous crops, including OSR [60]. At the same time, climate changes can disrupt the synchronization between DMB and parasitoids; as a result, these pest populations can increase in the future [33,61]. A high migration capacity combined with resistance to insecticides and Bt toxins makes the DBM one of the world's most dangerous pests of the OSR crop. The damages produced by DBMs were evaluated at 4–5 billion dollars annually [62]. For this reason, scientists considered DBM a highly economically costly pest in world agriculture [36]. The situation can be worse in the future because of global warming [63].

The main pests of OSR crops in Romanian agriculture that attack in the autumn are flea beetles (*Phyllotreta* spp. and *Psylliodeschrysocephala*), turnip sawfly (*Athalia rosae*), and the large white (*Pieris brassicae*). In the spring, the OSR crop is attacked mainly by the stem weevils (*Ceutorhynchus napi*, *C. quadridens*), apple blossom beetle (*Epicometis hirta*), pollen beetle (*Meligethes aeneus*), and cabbage seedpod weevil (*C. assimillis*) [64–69]. In some years, the cabbage aphid (*Brevicoryne brassicae*) can attack OSR when plants are in the early maturity stages at the beginning of the summer [64,66,70]. Recent studies show that more the 77% of the total pest species of OSR crops from Romania belong to the Coleoptera order, and only 6% belong to the Lepidoptera order [71]. This situation is quite similar in other European countries [15,27]. To control the main OSR pests, Romanian farmers relied on seed treatment with neonicotinoids or foliar treatments with neonicotinoids and pyrethroid insecticides [62,72,73]. Seed treatment with neonicotinoid insecticides was the most effective method of protecting the OSR in Romania against pests that attack this crop in early vegetation stages during the autumn [64,68,69]. After the ban on neonicotinoids in the EU in 2018 [74–76], only the cyantraniliprole active ingredient remains available for OSR seed treatment in Romania. This is an insecticide from the ryanoid class, authorized in November 2017, used for OSR seed treatment in autumn for controlling the flea beetles (*Phyllotreta* spp. and *Psylliodes chrysocephala*), turnip sawfly (*Athalia rosae*), and cabbage root fly (*Delia radicum*) [77]. At the same time, only a few active ingredients from the pyrethroid class remained available for foliar treatments of OSR to control the main pests of this crop in the autumn or spring. These facts can affect the costs of controlling these pests [78]. Without effective control methods, the OSR pest population can increase in the future [79]. In the following years, more insecticides may be banned due to the Green Deal EU politics of cutting the chemical-pesticide usein half by 2030 [80,81].

Data from the Romanian scientific literature reveals that the DBM is this country's primary pest of cabbage crops [82,83]. Although the presence of DBMs in the OSR crop have been observed before, till now, no damage has been reported in this country. Instead, it was considered a secondary pest of OSR, with no economic impact. A study made in the Moldavia region (East Romania) in 2003 concluded that DBM populations from the cabbage crops are controlled in the proportion of 80–90% by the primary parasitoids of this pest [84]. A recent study reported the presence of DBM larvae in OSR crops in Olt County, located in the south of Romania, in the autumn of 2020 [85]. At the same time, in the last 30 years, there has been a need for more data concerning the flight dynamic of the diamondback moths in the main areas cultivated with *Brassica* crops from Romania.

Our previous research reveals high densities of the green peach aphid (*Myzus persicae*) in OSR crops, in the warm days of November, in the southeast of Romania [86]. This species was considered a secondary pest of OSR, and no damage was reported. However, our study found that even if they are considered to be a secondary pest of OSR, green peach aphids can now have high densities and damage this crop. Many studies demonstrate that, in different regions from northern latitudes, global warming can increase the populations of some pest species that previously were considered to be without negative economic impact on agricultural or horticultural crops [87,88].

The aim of this study was as follows:

(i) To evaluate if there are registered higher attacks of DBM on OSR crops in Southeast Romania, in the autumn, in the conditions of higher temperatures, compared with the long-term average;
(ii) To evaluate the effectiveness of the seed treatment with the cyantraniliprole active ingredient in protecting the OSR crop, when plants were in early vegetation stages, against the attack of the DBM larvae in conditions of the warm autumns from Southeast Romania;
(iii) To evaluate if the higher temperatures from the southeast of Romania influenced the flight dynamics of the diamondback moths from the OSR field.

2. Materials and Methods

2.1. Experimental Site

The field experiment was conducted in autumn, from 2019 to 2021, at the Agricultural Engineering Laboratory experimental field of he National Agricultural Research and Development Institute (NARDI) Fundulea, Călărași County, Southeast Romania (latitude: 44°46′ N; longitude: 26°32′ E). The DBM flying activity was monitored at the same location, for four years, from 2019 to 2022.

The climate from the experimental site is the temperate continental type, with an average annual temperature of 10–11 °C and average annual rainfall of 571 mm [89,90]. According to long-term averages (1962–2022), more than 70% of the yearly rainfall is registered in the growing season, especially in May–June. At the same time, drought periods of 30 days are frequent in early spring and late summer, but drought periods of 10–14 days can occur in May and June [89]. Generally, the incidence of the draught years is 40%. Long-term average temperatures in the summer months are higher than 20 °C and lower than 0 °C in January and February (Tables 1 and 2).

Table 1. Mean temperature (°C) registered at the NARDI Fundulea field site (Southeast Romania) from 2019 to 2022. Blue color is for moths with average temperature below long-term average.

Month	Year				Long-Term Average (°C)
	2019	2020	2021	2022	
January	−1.2	0.9	1.6	2.1	−2.4
February	4.1	5.2	3.2	4.7	−0.4
March	9.3	8.3	5.1	4.4	4.9
April	11.2	12.3	9.7	11.2	11.3
May	17.2	17.0	17.2	17.9	17.0
June	23.6	21.7	21.1	22.5	20.8
July	23.0	25.1	25.3	25.0	22.7
August	24.7	25.5	24.2	25.6	22.3
September	19.3	20.8	17.3	18.6	17.5
October	12.8	14.7	10.2	13.5	11.3
November	10.3	6.1	7.7	9.0	5.4
December	3.8	3.9	2.6	3.5	0.0

Table 2. Rainfall amount (mm) registered at the NARDI Fundulea field site (Southeast Romania) from 2019 to 2022. Blue color is moths with rainfalls amount higher than the long-term average.

Month	Year				Long-Term Average (mm)
	2019	2020	2021	2022	
January	53.8	2.0	77.0	4.8	35.1
February	21.4	16.6	16.2	5.4	32.0
March	22.4	29.8	59.0	12.3	37.4
April	51.4	14.0	31.0	47.6	45.1
May	124.2	58.0	57.6	30.0	62.5
June	74.6	68.4	135.0	59.4	74.9
July	87.4	34.2	21.2	29.2	71.1
August	12.6	5.4	24.4	14.4	49.7
September	6.2	68.6	4.0	35.4	48.5
October	38.2	28.6	56.4	5.2	42.3
November	33.2	20.0	33.8	19.6	42.0
December	16.2	77.6	37.6	21.8	43.7

At the experimental site, the field is flat, with an average altitude of 68 m. The soil type is clay loam with medium texture, humus content of 2.8–3.2%, pH of 6.4–6.8, nitrogen content of 0.17–0.18%, potassium content of 135–170 ppm, and phosphorus content of 10–25 ppm.

In the last ten years, the average annual temperatures registered at NARDI Fundulea in Southeast Romania were higher than long-term averages (Figure 1). In 2015 and 2016, the average annual temperature was higher than 12 °C. In 2019, for the first time, the average yearly temperature was higher than 13 °C. From the beginning of the meteorological recording data at NARDI Fundulea (from 1958), this was the first time when the average annual temperature was higher than 13 °C. In 2020, it registered an even higher yearly average temperature of 13.45 °C.

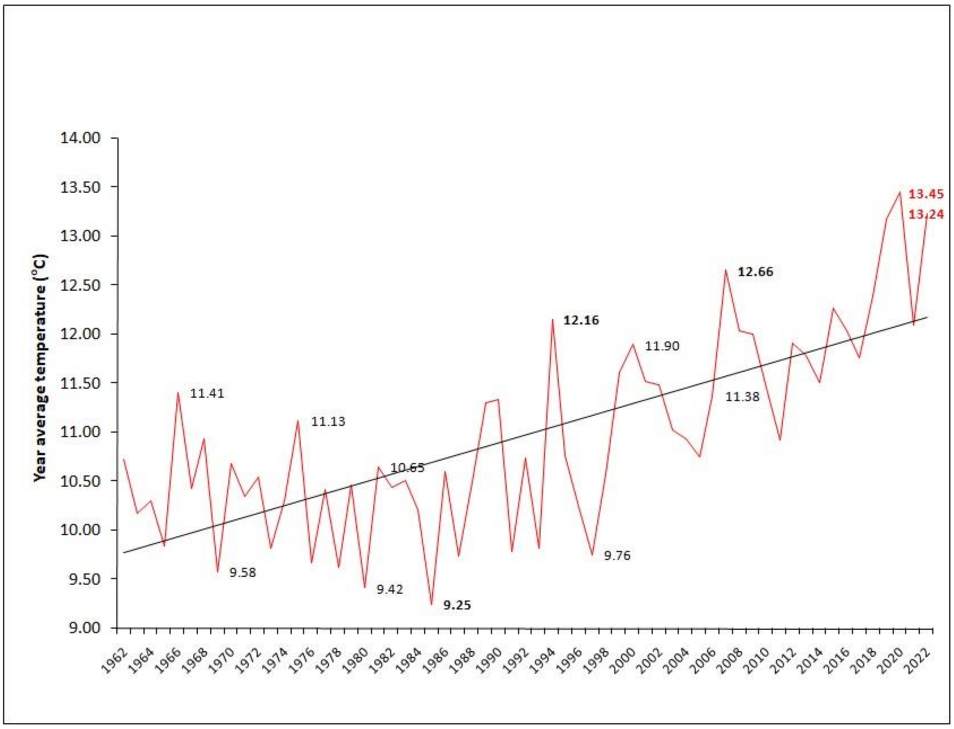

Figure 1. Year means temperature (°C) registered at NARDI Fundulea field site (Romania) from 1962 to 2022.

According to long-term averages, at NARDI Fundulea, from 1962 to 2022, we can ascertain a high variability of the yearly rainfall amount (Figure 2). However, in the last ten years, a tendency for a slight decrease in annual rainfall can be observed. In our study, in 2019 and 2021, the rainfall amount was similar to the long-term average. However, in 2020 and 2022, rainfall was lower than the long-term average. Moreover, in 2022, we registered the lowest rainfall amount (285.2 mm) at NARDI Fundulea from the beginning of the meteorological recording, since 1958.

Data from Table 1 show that, during this field experiment, from 2019 to 2021, and the DBM monitoring flight activity, between 2019 and 2022, at the NARDI Fundulea field site, from 48 months, only in 6, the temperatures were lower than the long-term average. In 2020, all months were warmer than the long-term average. Regarding the autumn period, only in 2021, temperatures from September and October were lower than the multiyear average. In all four years, temperatures from November were higher than long-term averages, with the highest positive deviation in 2020 and 2022. In this study, average temperatures registered in December were closer to the last month of autumn than the first month of winter. In all four years, in December, positive deviation from the long-term average ranged from 2.6 °C (in 2021) to 3.9 °C (in 2020).Moreover, from 2019 to 2022, average temperatures registered in January and February were higher than long-term averages. Only in 2019 was the average temperature recorded in January below 0 °C, but it was still higher than the long-term average. The situation was similar in all summer months when average temperatures were higher than the long-term average.

Generally, this study observed a tendency of decreased rainfall in the autumn and the first month of winter. Only in September 2020 were rainfall amounts higher than the long-term average. However, over 86% of the total rainfall amount from this month was registered only for one day (4 September). Contrarily, in 2019 and 2021, in September, we registered only a few mm of rain. The drought from this period followed after the rainfall deficit recorded in August. In this study, only in one autumn month (October 2021), the rainfall amount was higher than the long-term averages. At the same time, rainfalls from November were lower than long-term averages in all four years (Table 2).

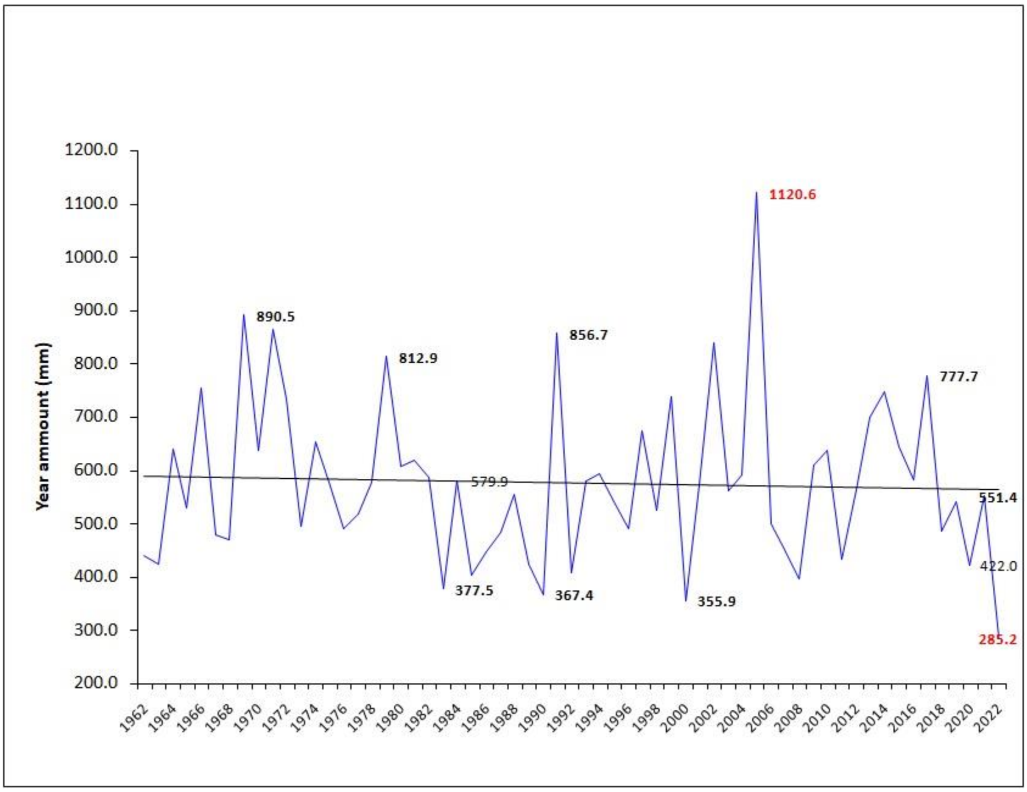

Figure 2. Year rainfalls (mm) registered at NARDI Fundulea field site (Romania) from 1962 to 2022.

Overall weather conditions from the NARDI Fundulea field site, located in Southeast Romania, are higher temperatures than the averages and lower rainfall amounts, especially in the last month of the summer, the autumn, and the first month of winter. Daily temperatures, rainfalls, and RH from the field site were presented in Tables S1–S4 (Supplementary files).

2.2. Experimental Design

The experiment was in accordance with good experimental practice (GEP) principles for pesticide evaluation and safety risk, following EPPO Standard PP 1/181(5) [91]. OSR was sown in September in all three years of this field trial. The sowing and emergence data are presented in Table 3. The main reason for delaying sowing in the autumn of 2021 was lower humidity in the upper soil layer due to drought in the summer (July and August) and September (Table 2). The situation was quite similar in the autumn of 2019. Contrarily, in 2020, full plant emergence occurred less than a week from the sowing. Each year, the previous crop was barley. OSR was seeded in September with WintersteigerPlotseed TC A-4910 machine at a depth of 3 cm. The distance between rows was 25 cm, and within seeds on a row was 6.67 cm. The sowing density was 60 seeds/m^2, typically for Romanian farms from the southeast. For this field experiment, PT 271 hybrid was used. For better crop protection against soil-borne diseases, the seeds were treated with a fungicide on the base of *Bacillus amyloliquefaciens*, strain MBI600 (Integral Pro). The OSR crop technology was similar to that of commercial farms. In the autumn, a herbicide was applied to control the barley volunteer crop, while in the spring, a herbicide was used to control monocotyledonous and dicotyledonous weeds. Because seed treatment with insecticide was evaluated in this study, no foliar treatment with insecticide was applied to OSR crops in the autumn or spring.

Table 3. OSR sowing and emergence data in this experience at the NARDI Fundulea field site, Romania.

Year	Sowing Data	Beginning of Plants' Emergence	Full Plants Emergence
2019	6 September	24 September	12 October
2020	10 September	14 September	16 September
2021	22 September	22 October	27 October

There are two experimental variants, which are presented briefly in Table 4. The plot size for each variant was 2500 m^2. Each variant took ten assessment points in the diagonal of the plot. At each assessment point, it evaluated 100 OSR plants from 5 rows (20 OSR plants/row). The plants from each row were marked with thin wooden sticks. Each assessment point represents a repetition.

Table 4. Experimental variants from the field experience.

Variant	Insecticide	Active Ingredient	Dose	Treatment Type
Control	Untreated	-	-	-
Seed treatment (ST)	Lumiposa 625 FS	cyantraniliprole 625 g/L	1.14 L.p.r/100 kg.s. *	Seed Treatment **

* Liter commercial product, ** Seed treatment before sowing (BBCH 00).

2.3. Field Assessments

2.3.1. DBM Larvae Attack at OSR Plants

Four assessments were made in the autumn concerning the DBM larvae attack degree (%) at OSR, when plants were in the early vegetation stages, from BBCH 11–12 to BBCH 16–18. The attack degree, AD(%) was calculated after the formula presented below, where F(%) is the DBM attack incidence (number of the attacked plants from the total number of analyzed plants), and I(%) is the DBM attack intensity:

$$AD(\%) = [F(\%) \times I(\%)]/100$$

The AD(%) methodology for diseases and pests is often used in the Romanian scientific literature [68,92,93]. The assessment time for each year is presented in Table 5. Each OSR plant from the assessment points was photographed with a Panasonic DMC TZ-200 photo compact camera with a Leica DC Vario-Elmar lens (F3.3–6.4) and MOS sensor with 20.1 megapixels resolution. The lower side of the plant's leaves was photographed in the macro mode, at approximately a distance of 10 cm from the photo camera. After each assessment, the images of OSR plants were downloaded onto a computer and analyzed on the screen. The attack produced by the DBM larva was diagnosed on a PC screen with magnified images of OSR plants. The DBM larva attack symptoms at OSR leaves can be easily distinguished from other pest attack symptoms [36].

Table 5. Assessments time concerning DBM larvae attack and larvae count at OSR field trial from NARDI Fundulea, Romania.

Year	Assessment 1 BBCH 11–12	Assessment 2 BBCH 13–14	Assessment 3 BBCH 15–16	Assessment 4 BBCH 16–18
2019	23 October	28 October	6 November	20 November
2020	24 September	2 October	12 October	11 November
2021	29 October	5 November	12 November	3 December

This data-acquisition methodology from the field replaces direct observations on the OSR plants with a magnifier glass (3×), with plant photography and analysis of the images taken from the experimental area on a PC screen.

2.3.2. DBM Larvae Count at OSR Plants

The observations concerning the larvae counting from the OSR field experiment were made simultaneously with those concerning the DBM attack degree at the same plants from the assessment points and at the same time (Table 5). Each photographed plant was magnified and analyzed on the PC screen. The results were presented as average DBM larvae/plant. The DBM larvae were shown at the lower side of the OSR plants, and they can easily distinguish and count on the base of the images taken from the field.

2.3.3. OSR Plants Density

The OSR plant density was assessed twice, at the end of the autumn and the beginning of the spring, at the same assessment points where we previously determined the DBM larvae attack degree and larvae counting. The assessment time for each year is presented in Table 6.

Table 6. OSR plants' density assessments time at the field trial from NARDI Fundulea, Romania.

Assessment 1 End of Autumn	Assessment 2 Early Spring
28 November 2019	20 March 2020
27 November 2020	15 March 2021
3 December 2021	14 March 2022

At each assessment point, the OSR plants were counted on four random square meters, using a metric frame. The results were presented as average OSR plants per square meter.

2.4. DiamondbackMoths' Flight Pattern

The DBM flight pattern was monitored at the OSR crop at the NARDI Fundulea experimental field, between 2019 and 2022. It has used four pheromone transparent sticky delta traps, RAG type, from Csalomon® family [94]. The active pheromone ingredients are traces of the fatty acid derivates. The traps were placed in a square, at an equal distance of 25 m. At the same time, the traps were seated at a distance of 10 m from the OSR field margins. The traps were positioned at the level of the top of the OSR crop, and their height was adjusted periodically, according to crop development. The traps were maintained in the same place after the harvest of the OSR crop, which usually occurs in mid-July. At the same time, the debris from the harvested OSR crop and volunteer crop remains in the field till autumn. The traps were moved in the autumn, into the neighbor field, after the emergence of the new OSR crop. The distance between the two areas was smaller than 200 m. The time of the beginning and ending of the DBM flight monitoring each year is presented in Table 7. The traps were checked twice per week. The sticky plaques from the taps were photographed with a Panasonic DMC TZ-200 compact photo camera, and the images were analyzed on the computer screen. This method replaces the direct counting of moths from the traps in the field. Instead, the catches are counted by studying the photos of the sticky plaques taken from the traps. Moreover, the images can be magnified on the PC screen for easier counting of the catches.

The sticky plaques were replaced once every two weeks in the case of low DBM flight activity. However, during the flight peak, when the catch number exceeded 100, the sticky plaques were replaced weekly. The pheromone bait was replaced once every six weeks in the spring or autumn and one every four weeks in the summer months. The delta trap body was replaced once every two months. The pheromone has a high degree of selectivity for diamondback moths, and the other Noctuids species that occasionally were trapped are bigger in size and can be easily distinguished from the target pest. Moreover, the traps sometimes catch individuals from the *Delia radicum* species, but the differences from the target pest are pretty evident. In the monitored OSR field, no foliar treatments with insecticide occurred. The results are presented in the form of the average catch number per trap.

Table 7. DBM flight monitoring time period at the OSR field from NARDI Fundulea, Romania.

Year	Start of Monitoring	End of Monitoring
2019	14 March	20 December
2020	13 March	21 December
2021	15 March	21 December
2022	15 March	22 December

2.5. Statistical Analyses

Data were statistically analyzed using Tukey's honestly significant difference test (HSD), at a significance level of $p \leq 0.05$. For the statistical analysis, we used ARM 2022 software [95]. The results of the field trial were presented as mean values for the DBM larva attack degree, (AD)%; DMB larva average number per plant; average OSR plants number per square meter; standard deviation (SD) from the average values; and the coefficient of variation (CV). The results of the DBM flight monitoring were presented as average DBM catches/trap and total DBM catches/trap per season. The charts with DBM flight patterns were made in Microsoft Excel 2007, while a chart with annual DBM captures/trap per season was made with ARM 2022 software.

3. Results

3.1. DBM Larvae Attack at OSR Plants

In the autumn of 2019, at the experimental field from NARDI Fundulea, full OSR plant emergence occurred on 12 October. At the first two assessments in the last ten days of October, no DBM attack was detected. On 6 November, the DBM larvae attack degree was 0.67% for OSR plants from the untreated variant and 0.26% for OSR plants from the variant with a seed treatment. The highest DBM larvae attack from the autumn of 2019 was recorded on 20 November, when the DBM attack degree was 3.04% in the untreated variant and 2.72% in the variant with treated seeds (Table 8). In this case, there were no significant statistical differences between the two variants.

Table 8. DBM larvae attack degree (%) for OSR plants at experimental site from NARDI Fundulea, Romania.

Year	Variant	Assessment 1	Assessment 2	Assessment 3	Assessment 4
2019	Control	0 ± 0 [a]	0 ± 0 [a]	0.67 ± 0.39 [a]	3.04 ± 1.00 [a]
	ST	0 ± 0 [a]	0 ± 0 [a]	0.26 ± 0.13 [b]	2.72 ± 0.56 [a]
	Tukey's HSD	0	0	0.328	0.860
	CV	0	0	69.76	29.51
2020	Control	0.24 ± 0.23 [a]	0.29 ± 0.20 [a]	4.39 ± 1.21 [a]	16.26 ± 1.82 [a]
	ST	0.03 ± 0.02 [b]	0.05 ± 0.04 [b]	2.03 ± 0.16 [b]	11.24 ± 1.55 [b]
	Tukey's HSD	0.187	0.141	0.876	1.981
	CV	147.75	82.92	26.95	14.24
2021	Control	0 ± 0 [a]	0 ± 0[a]	0.14 ± 0.06 [a]	0.27 ± 0.13 [a]
	ST	0 ± 0 [a]	0 ± 0[a]	0.10 ± 0.06 [a]	0.14 ± 0.06 [b]
	Tukey's HSD	0	0	0.068	0.115
	CV	0	0	58.01	55.50

The results are presented as mean values ± standard deviation (SD). Means followed by the same letter do not significantly differ $p \leq 0.05$, Tukey's HSD test. Control—untreated; ST—seed treatment; CV—coefficient of variation.

In the autumn of 2020, we registered the highest DBM larvae attack at OSR plants from this study. At the first two assessments, made on 24 September and 2 October, the attack of DBM larvae at OSR plants was low. In the control variant, the DBM larvae attack degree was below 0.30%, while in the variant with treated seeds (ST), the attack degree was equal to or lowers than 0.05%. The DBM larvae attack degree at OSR plants increased on 12 October, at 4.39% in the case of the control (untreated) variant and 2.03% at plants from the treated seeds variant. One month later, on 11 November, we registered the highest DBM larvae attack at OSR plants from this field trial. For plants from the untreated variant, the DBM larvae attack degree was 16.26%, while for plants from the variant with treated seeds, the DBM larvae attack degree was 11.24%. However, during that period, when we made the last assessment, more than 50% of the plants were in BBCH 16 stage (6 leaves), but a significant number were in BBCH 17–18 stage (7–8 leaves). Due to earlier emergence data, the OSR plants were more developed in this period than they were in the previous year (16 September). The presence of DBM larvae on OSR plants was observed till the end of November, but the attack degree was not increased from 11 November. According to Tukey's HSD test, for all assessments from the autumn of 2020, there were significant statistical differences concerning the DBM larvae attack degree between the two variants.

The attack of DBM larvae at OSR crop from the field site was low in the autumn of 2021, compared with the first two years of this study. A possible explication is the lower October temperatures than long-term averages and higher rainfall amounts (see Tables 1 and 2). Moreover, the OSR crop emergence was delayed because of the drought registered in the summer and September. As a result, plants emerged at the end of October, with more than a one-month delay from Southeast Romania's average OSR emergence period. At the first two assessments, on 29 October and 5 November, no DBM larvae attack occurred. Upon the third assessment, made on 12 November, when more than 50% of the OSR plants were in the five leaves stage (BBCH 15), the DBM larvae attack degree was 0.14% at plants from the untreated variant and 0.10% at plants from the treated variant (ST). The pest activity continues till the beginning of December due to the higher air temperatures. However, at the last assessment, on 3 December, the DBM larvae attack degree at OSR crop was lower than 1% (Table 8). Only the last assessment registered significant statistical differences between the two variants from this study.

3.2. DBM Larvae Count

In the autumn of 2019, no DBM larva was found on the analyzed OSR plants at the field site at the first two assessments. At the third assessment, on 6 November, OSR plants from the control (untreated) variant registered an average of 0.23 larvae/plant. The variant with treated seeds showed a slight decrease in the DBM larvae number; no significant statistical difference was found. The fourth assessment, on 20 November, registered the highest number of DBM larvae in the OSR crop from this autumn (Table 9). However, the situation at the variant with treated seeds was the same as in the previous assessment; it registered only a slight decrease of the DBM larvae at the OSR plant compared with the untreated variant. No significant statistical difference was observed.

In the autumn of 2020, the first two assessments on 24 September and 2 October registered a low DBM larvae number at OSR plants of both variants. There were no significant statistical differences between the two experimental variants. However, the third assessment, made on 12 October, registered relatively close values of the DBM larvae/plant to those from the previous year, on 20 November. A possible reason is that, in the middle of autumn 2020, diamondback moths arrived early in the OSR crop, and the larvae hatched earlier than in the previous year. The variant with seed treatment showed a slight decrease in the DBM larvae number/plant, although there were no significant statistical differences compared with the control variant.

The highest DMB larvae number/plant was registered in the autumn of 2020 on 11 November. However, seed treatment did not significantly decrease the DBM larvae number on OSR plants in November. A possible explication for this is that DBM larvae appear in late autumn, more than 30 days from the OSR plants' emergence, when the seed treatment's effectiveness starts decreasing.

Table 9. DBM larvae count (larva/plant) at the experimental site from NARDI Fundulea, Romania.

Year	Variant	Assessment 1	Assessment 2	Assessment 3	Assessment 4
2019	Control	0 ± 0 [a]	0 ± 0 [a]	0.23 ± 0.21 [a]	0.61 ± 0.26 [a]
	ST	0 ± 0 [a]	0 ± 0 [a]	0.11 ± 0.05 [a]	0.53 ± 0.21 [a]
	Tukey's HSD	0	0	0.173	0.178
	CV	0	0	102.08	30.83
2020	Control	0.07 ± 0.07 [a]	0.02 ± 0.02 [a]	0.52 ± 0.34 [a]	1.81 ± 0.41 [a]
	ST	0.03 ± 0.02 [a]	0 ± 0 [a]	0.35 ± 0.11 [a]	1.64 ± 0.31 [a]
	Tukey's HSD	0.069	0.030	0.257	0.416
	CV	136.63	298.14	58.38	23.83
2021	Control	0 ± 0 [a]	0 ± 0 [a]	0.05 ± 0.05 [a]	0.07 ± 0.05 [a]
	ST	0 ± 0 [a]	0 ± 0 [a]	0.03 ± 0.03 [a]	0.05 ± 0.05 [a]
	Tukey's HSD	0	0	0.056	0.056
	CV	0	0	139.44	92.96

Means followed by same the letter do not significantly differ ($p \leq 0.05$, Tukey's HSD test).

The pest remains present in OSR crops from this field site, but in low numbers compared with previous years. In the autumn of 2021, we registered fewer DBM larvae at OSR plants (Table 9). The first larvae were observed at the third assessment on 12 November. However, the highest DBM larvae number from the third year of this experiment was registered at the beginning of December. At the same time, there were no significant statistical differences between the two variants from this study.

3.3. OSR Plants Density

Table 10 presents the results concerning OSR plants' plant density at the end of autumn, before winter and the early spring, after plants started their vegetation again. In the first year of this study, at the field site from NARDI Fundulea, the OSR plant density for the variant with treated seeds was statistically higher than that of the control (untreated) variant, and statistically, differences were assigned. In the control variant, the OSR plant density was almost half the sowing density. The main reason for this is the high attack of the other autumn pests, especially the large white (*Pieris brassicae*). In the spring of 2020, most of the OSR plants from the untreated variants were destroyed, while the OSR plants' density from variants with seeds treatment decreased slightly.

Table 10. OSR plants' density at the experimental site from NARDI Fundulea, Romania.

Season	Variant	Assessment 1 (End of Autumn)	Assessment 2 (Early Spring)
2019–2020	Control	30.14 ± 6.61 [b]	5.38 ± 4.22 [b]
	ST	54.13 ± 4.59 [a]	49.23 ± 8.99 [a]
	Tukey's HSD	5.177	8.631
	CV	12.14	31.24
2020–2021	Control	38.45 ± 6.18 [b]	36.39 ± 4.01 [b]
	ST	52.89 ± 2.96 [a]	50.73 ± 2.29 [a]
	Tukey's HSD	5.033	3.206
	CV	4.974	7.27
2021–2022	Control	37.37 ± 3.47 [b]	17.49 ± 5.20 [b]
	ST	40.59 ± 4.97 [a]	24.08 ± 5.31 [a]
	Tukey's HSD	2.869	4.644
	CV	7.34	22.08

Means followed by the same letter do not significantly differ ($p \leq 0.05$, Tukey's HSD test).

In the autumn of 2020, at the end of November, the OSR plant density was almost similar to the densities registered in the previous year. However, the differences between the two experimental variants were lower. At the same time, we registered significant statistical differences between the OSR plant density in the control variant and OSR plants' density in the seed-treated variant. During the cold season (2020–2021), the OSR plant's density was slightly reduced. Higher DBM larva attacks registered in November 2020 have a low impact on OSR crops; during that period, plants were more developed than in the other two years from this study (2019 and 2021).

In the autumn of 2021, because of drought registered in the summer and the first month of the autumn, OSR plant emergence occurred at the end of October. As a result, OSR crops had delayed development compared with previous years, and plants were more sensitive to pest attacks from November. At the end of autumn, the OSR plant density between the two variants was slighter than in the previous two years of this study, although it was statistically assigned. Even if the cold season was mild, compared with long-term averages, in the early spring of 2022, we registered a high reduction in the OSR plants density, for both variants, compared with autumn. A possible explication is that the plants werenot prepared for the winter season because of the late emergence.

3.4. The Monitoring of the DBM Flight

Analyzing the diamondback moth catches from the Delta traps (RAG type) placed in the OSR field site from NARDI Fundulea (Southeast Romania), we observed that, in 2019, the first DBM captures were recorded on 1 April. The first flight peak was registered on 12 May (35.50 moths/trap), followed by a second peak on 5 June (43.50 moths/trap). The moths were trapped continuously from 5 June to 1 July, but the DBM flight curve decreased. An occasional moth was recorded on the traps on 26 July. The third flight peak of DBM at the NARDI Fundulea field site was registered in the late autumn, on 20 November, with an average of 88.50 moths/trap. The last peaks of 2019 were registered in a short flight period (15 days) and were higher than all three peaks (Figure 3). The last moths were recorded in the traps on 28 November. The moth numbers caught data from the delta pheromone traps suggesting that, in 2019, the highest diamondback moth population from the OSR crop occurred in the late autumn, in the middle of November. A possible explanation for that is a higher air temperature registered in November, when this month's temperature average was almost two times higher than long-term averages (Table 1).

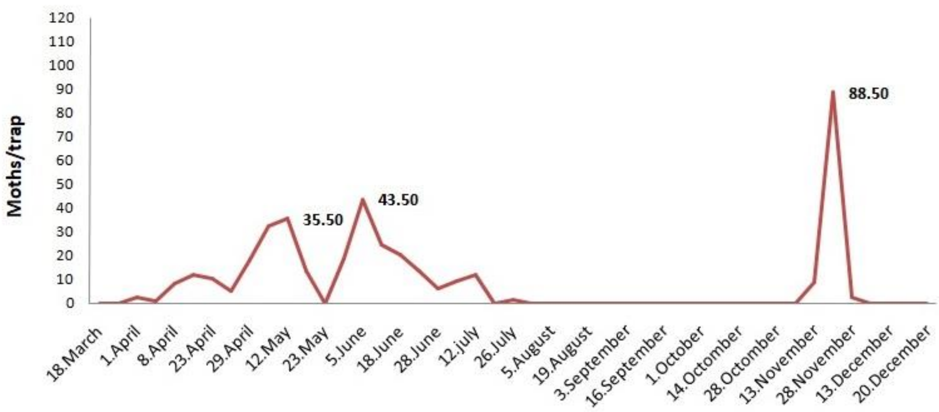

Figure 3. Trap results of the DBM flight monitoring at the field site from NARDI Fundulea, Romania, in 2019.

In 2020, the first diamondback moths were recorded on 9 April, followed by a constant increase of the weekly captures till 26 May, when it registered the first flight peak of this year. The number of moths caught was almost three times higher (90.25 moths/trap) the numbers recorded at the first peak of the previous year. The number of moths decreased till 14 July. A few diamondback moths were recorded occasionally on 11 August, and then the traps began to catch moths again in the traps from 8 September. This year, we recorded two DBM flight peaks in autumn (Figure 4). The second peak of this year was recorded on 20 October, with an average of 61.75 moths/trap, while the third flight peak was recorded on 24 November and was higher than 100 moths/trap. Like the previous year, a higher DBM flight peak was recorded in the late autumn, in the last ten days of November. The diamondback moths were observed in the OSR crop from the field site, flying close to the ground during the day in the last half of November. At the same time, on the OSR lower side of the leaves, we observed DBM larvae. On 2 December, we registered a significant number of DMB captured moths (57.00 moths/trap), while the last captured moth was registered on 9 December. It was the first time that diamondbackmoths were observed in the first ten days of December at NARDI Fundulea. Similar to the previous year, the third DBM flight peak from late November occurred in a short period of time. Moreover, the high numbers of moths caught in November can be related to the DBM larva's higher attack degree at OSR plants from that period. In 2020, average temperatures from all autumn months and the first month of winter were higher than the long-term average, while rainfall was lower than the averages in October and November (Tables 1 and 2).

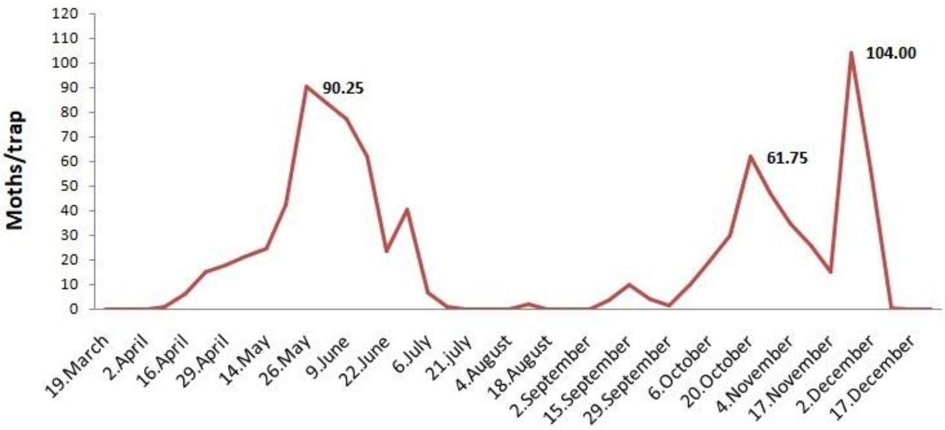

Figure 4. Trap results of the DBM flight monitoring at the field site from NARDI Fundulea, Romania, 2020.

In 2021, the first diamondback moths were recorded later than the two previous years, on 13 April. This year, we recorded only two flight peaks, compared with the last two years: first, the peak registered on 5 May, with an average of 39.00 moths/trap, followed by a narrow decreasing of the captured moths till 18 May (7.00 moths/trap). From 26 May, the DBM flight curve increased (except at the beginning of June), arriving at a new peak on 17 June (80.25 moths/trap). We registered significant captures between 25 June and 8 July, but this peak was lower than the second peak (Figure 5). This year, at the NARDI Fundulea field site, from 13 April to 27 August, we registered constant diamondback moth numbers caught in the delta pheromone traps. However, from 21 July to 27 August, the average number of moths caught was very low (1.00–3.25 moths/trap). In 2021, there was no registered flight peak in November, like in the previous two years. Only a few moths were registered in the last eight days of this month. The last catches were recorded on 3 December, but the moth numbers from traps were lower (4.75 moths/trap). Even if we found a few moths in the traps, it was the second year of this monitoring study when diamondback moths occurred at the beginning of December. Higher air temperatures and lower rainfall amounts from November and December 2021 can be a possible explanation for this pest activity in the field site, located in the southeast of Romania, so late in autumn and even the beginning of December. At the same time, because of the late emergence of the OSR crop and higher rainfalls from October, the DBMs arrived later in the field site this autumn, compared with a similar period from the previous two years.

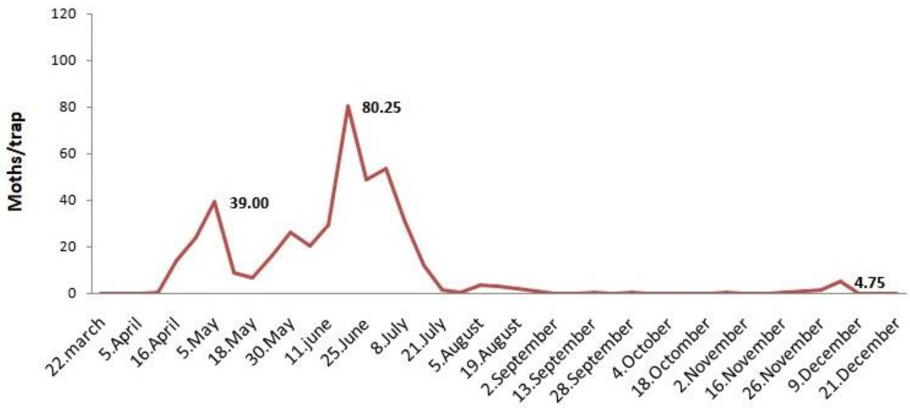

Figure 5. Trap results of the DBM flight monitoring at the field site from NARDI Fundulea, Romania, 2021.

In 2022, at the OSR field site at NARDI Fundulea, the first diamondback moths were recorded on 31 March. It was the first year of this monitoring study when pests appeared early, at the end of March. Till 20 May, the diamondback moths captured in delta traps were lower and ranged from 0.50 to 9.00 moths/trap. The first flight peak was registered on 31 May, with an average of 72.50 moths/trap. The flight curve decreased from 31 May to 9 June, then increased again till 14 June (60.25 moths/trap) but below the first peak. From 17 June till 17 July, it has registered constant captures in the traps, but in low numbers (Figure 6). A few moths were recorded from 29 July to 6 August, but also in low numbers (1.50–4.00 moths/trap). The diamondback moths were present again in the delta pheromone traps from 26 August, and the presence of this pest was constant till December. The DBM flight pattern year had some particularities in 2022 compared with the previous three years of this monitoring study. In November, there were two DBM flight peaks: the first was registered on 8 November (103.25 moths/trap), and the second was registered on 25 November (119.00 catches/trap). It was the first time in this study period that we registered two flight peaks in the last month of autumn. The numbers of moths caught decreased from 25 November to 5 December, registering only 0.25 moths/trap. However, more moths started recording again in the traps, with a peak of 60.25 moths/trap on 11 December. It was the first time during this study that we registered a high number of DBMs after 10 December. In the previous years (2020 and 2021), we found DBMs in the traps at the beginning of December, but in low numbers. A possible reason for this unusually high DBM flight activity in December, considered till now, winter month, was high air temperatures that reached 14.9 °C on 10 December 2022 and 18.9 °C on 11 December (see daily meteorological data from Tables S1–S4 from Supplementary material). The temperatures registered on 11 December 2022 were higher compared with the similar period from all four years taken in this monitoring. The numbers of moths caught decreased in mid-December, although the number of moths in the traps was higher for this period (13.00 moths/trap). The last captured DBMs in the traps were on 19 December (1.00 moths/trap). The decreasing of the temperatures after 18 December finally stopped this pest activity in the OSR field. For the first time during this study, we registered three flight peaks of DBMs in the last two months of the year, and this was for 2022. Moreover, it was the first time we found high DBM activity on OSR crops from the field site, on 11 December. Weather conditions from the last four months of 2022 favored DBM activity. The average air temperatures registered from September to December were higher than long-term averages, while the rainfalls were lower than the averages, especially in October (5.2 mm; Tables 1 and 2).

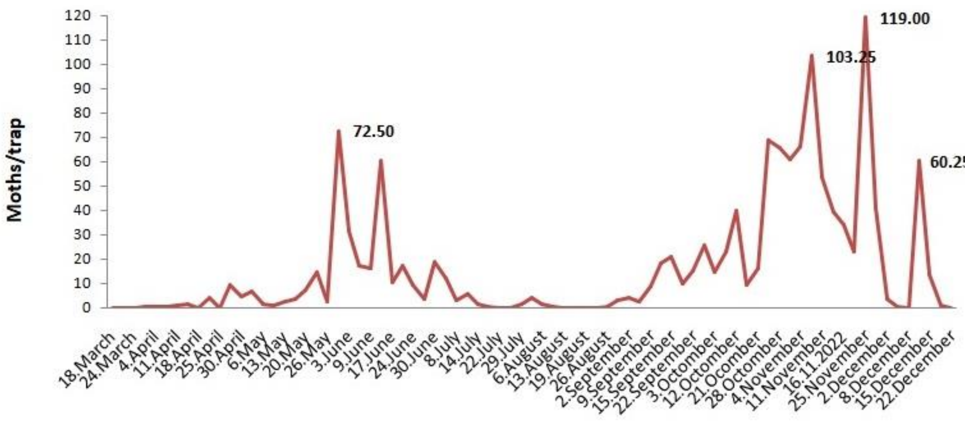

Figure 6. Trap results of the DBM flight monitoring at the field site from NARDI Fundulea, Romania, 2022.

In summary, after four years of monitoring DBM flight patterns at OSR crops at the NARDI Fundulea field site, which is located in Southeast Romania, we found a higher total number of captures in 2020 (1262.75 captured moths/trap per season), followed by 2020 (929.75 captured moths/trap per season). In 2019 and 2021, we registered the lowest moth numbers captured moths per season from this study (Figure 7).

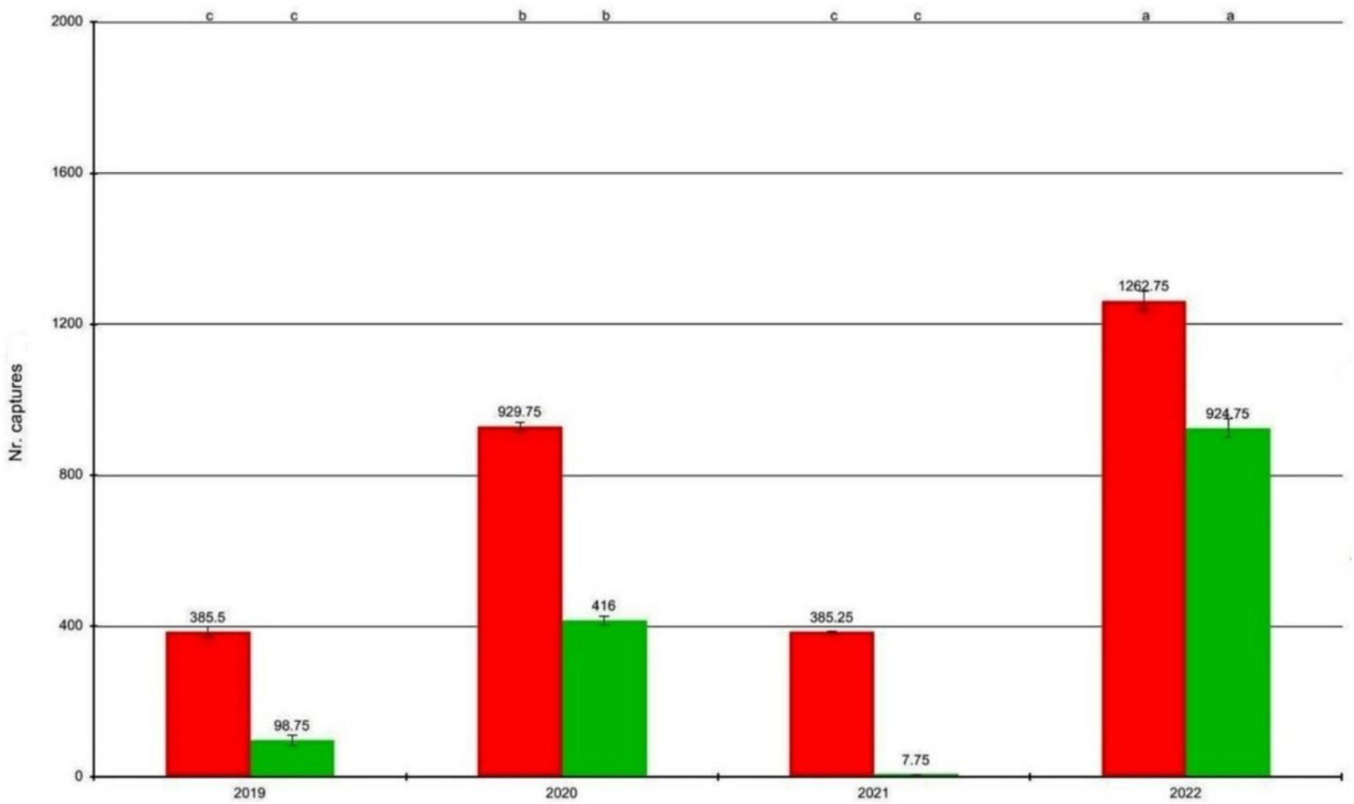

Figure 7. Trap results of the DBM flight monitoring at the field site from NARDI Fundulea, Romania, from 2019 to 2022. Red bars—total catches number/trap per season (March–December);green bars—total catches number/trap during autumn and the first month of winter (September–December). Means followed by same the letter do not significantly differ ($p \leq 0.05$, Tukey's HSD test).

Regardingt he DBM flight during the autumn, when OSR was in early vegetation stages and plants could be more susceptible to this pest attack, we found a high number of moths in the delta pheromone traps in the last four months of the year 2022 (924.75 captured moths/trap), followed by 2020 (416.00 captured moths/trap). In the autumn of 2021 and the beginning of December, it registered only a few catches (7.75 captured moths/trap). In both cases (total captures per season and total captures number registered in September–December), the highest statistical difference was registered in 2022, followed by 2020.

4. Discussion

This study confirms the presence of the DBM in the OSR crops, from the field site located in Southeast Romania, in the autumn each year, from 2019 to 2022. Moreover, this study evidenced high diamondback moth activity in late November 2019, 2020, and 2022 and at the beginning of December 2020 and 2021. In 2022, the moths were in high numbers on December 11, at higher temperatures than the long-term average, while the last captures were after 15 December.

This paper is the first report from the Romanian scientific literature concerning a higher attack of the DBM larvae in OSR crops in November, with an attack degree higher than 16% at untreated OSR plants and higher than 11% at cyantraniliprole seed-treated OSR plants. In a recent study performed at Boianu Plain, Olt County, located in South Romania, the authors mentioned that the DBM was the biggest challenge for the OSR growers in the autumn of 2020 [85]. However, no data were presented concerning the DBM larva attack degree at OSR plants or DBM larva density. Some pictures suggest a high DBM larva attack at the OSR crop at the beginning of October. The authors present a study concerning the effectiveness of foliar treatments from the autumn of 2020 concerning the mortality of DBM larvae. The most effective treatment for controlling DMB in the autumn of 2020 was a biological insecticide on a base of *Bacillus thuringiensis* subsp. *Kurstaki* (270 g a.i./ha) that determined an average larvae mortality of 71.75%. This information can be significant, revealing that the DBM populations from the Boianu Plane (south of Romania) werenot resistant to *B. thuringiensis*. The resistance of DBM to biological and chemical insecticides is a serious problem worldwide [49,55,58,96,97]. In the areas where it registered higher DBM attacks at OSR crops, the costs for the control of this pest were estimated to be more than USD 1 billion annually [36,62]. This fact can seriously challenge the countries where DBM has become a recent problem. Farmers will attempt to increase the number of chemical treatments for controlling the DBM from OSR crops in the autumn [85]. In the journals for farmers, there are several warnings concerning high DBM attacks on OSR crops in the autumn of 2022 in Romania's south and west regions [98]. These are not scientific articles and are relayed in interviews with farmers. Increasing the foliar chemical treatments' number for OSR crops can save the OSR yield but, in the long term, can negatively affect the DBM parasitoids and predators [84,99]. At the same time, the higher number of chemical treatments in the field during one growing season can increase the selection pressure for DBM resistance to insecticides [47,50].

In this study, we evaluate the influence of seed treatment with the cyantraniliprole active ingredient, an insecticide from the ryanoid class, in reducing DBM attack and larvae number at OSR plants. Our results suggest that seed treatment in the autumn of 2019 reduced the DBM larvae attack degree by more than half compared with untreated plants in November. However, in the autumn of 2020, in November, in the case of higher pest pressure, the DBM attack degree was higher in the seed treatment variant; but, there were also significant statistical differences from the untreated variant. European researchers found that seed treatment with cyantraniliprole as the active ingredient reduced damage from cabbage stem flea beetle (*Psylliodes chrysocephala*) at OSR plants by 65% [100]. Not in all cases, seed treatment with this active ingredient can effectively control cabbage stem flea beetles [101]. Other studies concluded that seed treatment with cyantraniliprole as the active ingredient didnot influence pest populations in the autumn, such as cabbage fly (*Delia radicum*), cabbage stem flea beetle (*P. chrysocephala*), and aphids (mainly *Myzus persicae*) [102]. A possible explanation for this fact is the delayed appearance of the OSR pests in the autumn, such as flea beetles. As a result, the seed treatment didnot clearly affect the number of larvae per plant [102]. Our previous research reveals that, in the autumn of 2021, the cabbage flea beetle (*Phyllotreta atra*) made a moderate attack on OSR crops in Southeast Romania in late autumn. A cabbage stem flea beetle (*P. chrysocephala*) had a high attack at OSR plants in the same location in late November due to the higher temperatures registered in that period [103]. Similar to the results of this study, OSR seed treatment with cyantraniliprole active ingredient reduces flea beetle attacks compared with untreated plants. Still, in our previous study, on 19 November, the attack degree of cabbage stem flea beetle adults was higher than 19% in the case of seed-treated plants and higher than 31% at untreated OSR plants. These results suggested that if the pest attack occurs in late November, foliar insecticide treatments can be necessary to protect OSR plants, especially in the case of late crop emergence. Research from China concluded that foliar treatment of the OSR plants with cyantraniliprole as the active ingredient could reduce the DBM larvae growth and development and can reduce the DBM populations in the next generation [104,105]. However, in Romania, there were no authorized insecticides on base of cyantraniliprole used for foliar treatments to control pests at the OSR crop. Recently published articles showed that, in some areas, the DBM becomes resistant to cyantraniliprole insecticides [106,107].

A study in the Moldavia region (East Romania) in 2003 evidenced 14 main parasitoid species that controlled 80–90% of the DBM populations from the cabbage crop [83]. At that time, higher dominance of the main DBM parasitoid species in East Romania, i.e., *Diadegma semiclausum*, *D. fenestralis*, *Cotesia plutellae*, and *Apantelesappellator* was evident. At the same time, this study reported an increase in the number of secondary parasitoid species that feed with DBM primary parasitoids. The growth of the secondary parasitoid populations can have consequences on reducing the DBM primary parasitoid population. As a result, DBM populations can increase in the future, with negative implications for OSR growers. This aspect has been less studied in Romania in the last 20 years. Further studies are necessary for many regions in Romania to determine the level of DBM populations from OSR crops, primary parasitoids, and secondary parasitoid populations.

In the Romanian scientific literature, there were mentions concerning DBM flights in the warm autumns [108–110]. However, this was the first study presenting monitoring data from the OSR field in Southeast Romania. At the same time, this is the first report from the Romanian literature concerning the presence of diamondback moths in the OSR field after 10 December. In a study made in 1979–1980, in 40% of the cases, diamondback moth captured in the traps were correlated with larval population from the cabbage field 11–21 days later [111]. At the same time, the DBM flight peaks from that period were in the summer months, rather than in the autumn. Similar results concerning the DBM flight peak in the cabbage crops were observed in Romania at the beginning of the year 1980 [112]. Our study found the highest flight peak of diamondback moths in OSR crops in the autumn months in 2019, 2020, and 2022. Moreover, in the autumn of 2022, we found a DBM flight peak in October, November, and the first half of December. This unusually high activity of this pest in the autumn can be related to the increasing temperatures in Romania in the last ten years due to the global warming phenomenon. According to data from the literature, the DBM has a higher ecological plasticity [36]. This pest prefers warm and temperate climates, too. Concerning the temperate climate, the DBM prefers areas with an average temperature of the coldest month higher than 0 °C [113]. In our study, from 2019 to 2022, in Southeast Romania, only in January 2019, the average monthly temperature was below 0 °C. The average temperature was positive in other winter months from 2019 to 2022. In December, the average monthly temperature was closer to the expected values for November in all four years. Our study demonstrates that DBM pest pressure can increase in late autumn or even in the first month of winter in the case of higher temperatures than the long-term average. At the same time, lower rainfall amounts during the autumn favor this pest development in the OSR crop. As a result, the DBM can be more challenging for Romanian farmers in the future if the temperatures during autumn continue to increase due to global warming. At the same time, Romanian farmers will have fewer chemical options to control this pest due to the EU Green Deal politics of reducing pesticides [80,81]. Integrated pest management (IPM) for DBM control can be a solution [114,115]. However, there are several challenges in the future concerning IPM in the case of the DBM because of higher resistance to insecticides, highly migrant characteristics combined with shifts in the parasitoids, and changes in predator populations because of climate changes [33]. Improving the field monitoring of the DBM parasitoids in OSR crops is important to establish precise timing of applying insecticides to control this pest with the lowest impact on beneficial insects.

Further studies are necessary concerning using digital image techniques to rapidly detect this pest in the OSR field. In this study, we used a compact photo camera for data acquisition from the OSR field. This method replaces direct observations from the field by analyzing the OSR images on a PC screen, using a higher zoom rate to evaluate the larvae attack degree or larva counting precisely. Because DBM larvae are placed mainly on the lower side of the OSR leaves, it is not possible to use drones for early DBM detection. Instead, using agricultural robots in the future with high-resolution cameras can be a solution for DBM rapid detection and the targeted control of this pest [116]. Moreover, the automatic monitoring system can be used in the future for the early detection of DBM arrival in the OSR fields and more precise establishment of the spraying timing [117].

5. Conclusions

In the three years of field experiment and four years of field monitoring at an experimental site from NARDI Fundulea, located in Southeast Romania, we demonstrated that higher temperatures from the autumn increased the activity and attack of DBMs in the OSR crop.

In the autumn of 2019 and 2020, the highest DBM larva attack degree at OSR plants was in November during the autumn of 2021. However, the pest activity in the OSR crop was low, and the highest larva attack degree was at the beginning of December. In this experience, seed treatment with the cyantraniliprole active ingredient only slightly decreases the DBM larva number in the OSR crop. At the same time, seed treatment determined a reduction of the DBM larvae attack degree statistically assigned from the untreated plants variant.

In four years of monitoring, the highest DBM flight peak was registered in November 2019; October and November 2020; June 2021; and October and November 2022. At the same time, on 11 December 2022, we recorded high DBM activity due to the higher temperatures compared with the long-term averages registered in that period. The last DBM catches from the pheromone traps were registered in the same year, on 19 December. In 2020 and 2021, the previous DBM catches were registered at the beginning of December. Warmer autumns than usual and higher temperatures from December prolonged the DBM flight from the OSR field till December for three consecutive years.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/agronomy13051236/s1, Daily meteorological data (temperature, precipitations, and RH) recorded at NARDI Fundulea field site, Romania, from 2019 to 2022 (Table S1 to Table S4).

Author Contributions: Conceptualization, E.G. and M.T.; methodology, E.G.; software, E.G.; validation, L.C., L.R. and C.F.; formal analysis, M.T.; investigation, E.G.; resources, I.S.B.; data curation, L.C.; writing—original draft preparation, E.G.; writing—review and editing, I.S.B.; visualization, M.T.; supervision, L.R.; project administration, R.Z.; funding acquisition, I.S.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by the Ministry of Agriculture and Rural Development, Romania, through the ADER Program, 2019–2022, within the project ADER 2.2.1, "Research on the impact of neonicotinoid insecticides use on plants and agricultural products of honey crops, bees and beehive products and the development of integrated pest control systems for honey crops"; (contract no. 2.2.1./27.09.2019) and the APC was funded by Rural Development Research Platform, Romania.

Data Availability Statement: Not applicable.

Acknowledgments: The authors especially thank the field technicians Loghinescu Ioana, Stoian Silvia, Radu Daniela, Cenea Daniela, Vasilescu Nicolae, laboratory technician Putineanu Felicia, and OSR crop technology responsible Gunică Daniel. All works were performed at the Plant Protection Collective, Agricultural Engineering Laboratory from National Agricultural Research and Development Institute Fundulea, Romania.

Conflicts of Interest: The authors declare no conflict of interest.

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