The effects of agrotechnological and ecological factors on the swarming patterns of European sunflower moth (*Homoeosoma nebulellum* Den. et Schiff.) and its damages

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1. FOREGOING AND OBJECTIVES

Sunflower is one of the most important crops in arable farming. The production area in Hungary has recently exceeded 500,000 ha. The production of confectionary sunflower, whose production area represents nearly ten per cent of the total sunflower production area, is also developing intensely. The reason for this derives from the favourable nutritional properties and the changes in customs of nutrition. Among the confectionary cultivars, a special part is played by the Kisvárda variety, whose production started in Hungary more than 50 years ago. However, the production of this variety faces several farming difficulties. Its height can reach 3.5-4 m; it has a long vegetation period (150-160 days), and it is susceptible to *Orabanche ramosa*. It can only be harvested by hand because of its thin, vulnerable achene shell and its height. In unfavourable weather it is easily beaten down, so producing without hilling is unsafe.

Among the agronomic disadvantages, one of the most important is the susceptibility to sunflower moth. The chemical plant protection is hindered by several factors. Spraying with field machines cannot be carried out because of the height of the cultivar, while the small plot sizes set limit to aerial spraying. A further hindering factor is that the appropriate date of plant protection coincides with the beginning of flowering.

Knowing the damages caused by the sunflower moth and the agronomic problems of plant protection, we have regarded the deepest possible exploration of the moth lifecycle together with the factors influencing the damages as important.

Our major objectives are as follows:

- The evaluation of the swarming patterns of the pest between 2005 and 2008 together with the examination of meteorological elements influencing the former ones
- The identification of the host plants of the first generation in Nyírség
- The reckoning of the generation coefficient of the pest
- The identification of the differences between the susceptibility of different confectionary sunflower cultivars
- The examination of the relations between the extent of the damage and the dates of sowing and flowering
- The examination of the relations between the size of the sunflower moth population and the damages
- The examination of the impact of the preceding crop on the number of specimen

Beyond our findings, we wish to make useful technological proposals so as to produce the Kisvárdai variety in Nyírség even more safely.

2. MATERIAL AND METHODS

2.1. Presentation of the experimental areas

Our observations of swarming patterns took place in the four most important production areas of confectionary sunflower in Szabolcs-Szatmár-Bereg county: Kisvárda, Nyíregyháza, Szatmár, and Újfehértó production areas. The numbers of the investigated plots were as follows: 32 in 2005, 12 in 2006 (and five further plots where only the number of specimen of the second generation was observed), 15 in 2007 and four in 2008.

In 2006, 2007 and 2008 experiments on sowing dates and cultivars were established in the Nyíregyháza estate of the Research Centre of DE AMTC. Three sunflower cultivars (Anita, Eagle, Kisvárdai) were examined in 2006, five (Anita, Eagle, Marica 2, Ajaki, Kisvárdai) in 2007, and four (Anita, Eagle, Marica 2, Kisvárdai) in 2008, with three different sowing dates respectively. The gross plot size of the four-repetition experiments in small plot was 25.2 m^2, that is net 19.6 m^2, with a row spacing of 70 cm and a plant-to-plant distance of 35 cm.

2.2. The material and methods of the investigations into swarming patterns

For tracing the flight, transparent, sticky triangle shaped CSALOMON traps made of plastic were used (Plant Protection Institute, Hungarian Academy of Sciences, Budapest, Hungary). Two traps were placed out per plot 50-500 m away from each other, depending on the size of the plot. They were mounted on wooden rods of 1 m at the beginning of the vegetation period, later, in order that they could be as close to the flowers as possible, they were shifted onto the stems to a height of 2 m. The dates of placing were as follows: 23-25th May 2005, 3-5th May 2006, 30th April-1st May 2007. The numbers of male moths trapped were controlled and registered every week. The pheromone capsules were exchanged every five weeks, and the sticky plates as circumstances required. The last registration dates were: 16th September 2005, 24th October 2006 and 17th October 2007.

2.3. The method of host plant survey

The presence of host plants was surveyed with GPS (eTrex Legend C) within 500 m from the plots. During the identification of the host plant species, only the number of specimen was counted but not the number of capitula (except for 20 *Onopordum acanthium* L. plants). Knowing the data of swarming pattern, we started to collect the host plants that feeded the first moth generation three weeks after their swarming peak. The identification of host plants was carried out per hectare. We looked for *Carduus, Cirsium* and *Onopordum* species. This method of observation allowed us to gain data concerning the species composition within at least 500 m from the plots, depending on their sizes. The spread of each host plant was expressed in a figure of value. A scale from one to nine was established based on the number of specimen detected in the field (**Table 1.)**

Table 1. Figures of value attributed to the feral host plant (calibration table)

	Number of host plants within 500 m around the sunflower plots (host plant/100 ha)					
Host plants / **Figures of value**	*Cirsium arvense*	*Cirsium brachycephalum*	*Cirsium canum*	*Carduus acanthoides*	*Onopordum acanthium*	*Carduus nutans*
0	0	0	0	0	0	0
1	1-100	1-20	1-20	1-20	1-10	1-10
2	100-200	20-40	20-40	20-40	10-20	10-20
3	200-300	40-60	40-60	40-60	20-30	20-30
4	300-400	60-80	60-80	60-80	30-40	30-40
5	400-500	80-100	80-100	80-100	40-50	40-50
6	500-600	100-120	100-120	100-120	50-60	50-60
7	600-700	120-140	120-140	120-140	60-70	60-70
8	700-800	140-160	140-160	140-160	70-80	70-80
9	800-	160-	160-	160-	80-	80-

In 2007 there were 500 capitula of *Cirsium arvense* (L.)Scop. and *Cirsium brachycephalum* Jur. collected respectively. As for *Cirsium canum* (L.) ALL., *Carduus acanthoides* L., *Carduus nutans* L. and *Onopordum acanthium* L., a hundred capitula were collected respectively in each area. Every capitulum was taken to pieces in order to find moth larvae.

Fewer capitula were examined in the case of certain host plants, in certain production areas in 2006. The larvae were grown up and identified as European sunflower moth (*Homoeosoma nebulellum* DENIS et SCHIIFFMÜLLER). The identification was controlled by dr Zoltán Mészáros in 2007.

2.4. The method of the examination of moth contamination

As the damages in sunflower are caused by the larvae of the second and the occurrent third generations, we focused our attention on the number of specimen of the second generation. The extent of damage was surveyed three weeks after the swarming of the second generation every year. During our observations the sampling followed the regulation of representativity. We registered the starting date of flowering of the different species. We surveyed the flowering plants every day. The statistical evaluation of the data was implemented according to Sváb (1981).

2.5. The method of calculating the generation coefficient

For the comparision between the proportions of the first and second generations, Mészáros's (1964) generation coefficient was applied. The principle of the method is that the numbers of specimen of the generations that can be distinguished according to the swarming patterns of the two-generation moths are totalled respectively. The proportion of the generations can be expressed in figure by dividing the number of specimen of the second swarming by that of the first. Thus, we obtain the generation coefficient (G). The specimens trapped between 11th May and 6th July made up the first generation, while those between 20th July and 31st August the second.

2.6. The method of the investigation into the preceding crop's effects

Sunflower fields with different preceding crops were observed in 2005. The preceding crops were classified into four main categories during the evaluation: spiciferous, maize, sunflower, and other row crops. The mean number of specimen per trap was determined in each category of the first and second generations.

3. RESULTS

3.1. Evaluation of the swarming patterns of 2005-2008

In 2005 the appearance of the first moth generation was detained by the extremely changeable weather. The swarming peak of the first generation took place during the second week of June. The abundant precipitation in the early summer was favourable to the survival of the eggs laid; thus, helping the development a vigorous second generation. The canicular days at the end of July started the swarming of the second generation that reached a high peak.

The swarming of the first moth generation began with a relatively low number of specimens towards the middle of May in 2006. The long-lasting cold weather that characterised the first half of June postponed the swarming peak, so it occurred two weeks later than normally. The development of the second generation accelerated due to the hot, dry July. However, the following cool rainy weather, which was unfavourable to the pest, moderated and broadened the peak. The development of the third moth generation was assisted by the weather in September, which was much warmer and drier than usually. In the long autumn, swarming ended only towards the middle of October. Such a late swarming of the third generation in Nyírség had not taken place for four decades.

The swarming of the first generation reached its peak during the third week of June in 2007. In the case of the first generation, the numbers of specimen exceeded those of the previous year in both the Nyíregyháza and Kisvárda production areas. However, the number of specimen of the second generation was low, even in the swarming peak. The second and the third generations could not be distinguished sharply.

As opposed to the preceding three years, in 2008 fewer moths were captured. The first specimens appeared at the beginning of May, and their swarming culminated at the end of June, though with a low number of specimens (the average of the four experimental plots stayed under eight males a week). The swarming of the second generation prolonged due to the September weather, which was colder and wetter than usually. As for 2005 - 2007, the crosschecks between the data of swarming patterns and air temperature revealed that a daily mean air temperature of 18 ^{0}C was necessary for the appearance of the first generation en masse.

3.2. Host plants of the first sunflower moth generation

The host plants of the sunflower moth belong to the Compositae, which comprises more than 2000 species. The host plants of the first generation are those that flower early, until the second half of June. As for the level of species, the Hungarian scientific literature treats only *Carduus nutans* L. and *Onopordum acanthium* L. Apart from these, the larvae of the first generation were also found in the capitula of *Cirsium arvense* (L.) SCOP., *Carduus acanthoides* L., *Cirsium canum* (L.) ALL. and *Cirsium brachycephalum* JUR.(**Table 2**).

Table 2. Host plants of the first sunflower moth generation and the levels of infection (2006 and 2007)

Kisvárda production area						
	Numbers of capitula examined		**Capitula infected [%]**		**Mean number of larvae in capitula**	
Host plants	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**
Corn thistle (*Cirsium arvense*)	500	500	0.6	1.0	1.0	1.0
Scottish thistle (*Onopordum acanthium*)	100	100	64.0	54.0	1.2	1.2
Plumless thistle (*Carduus acanthoides*)	100	100	7.0	9.0	1.0	1.0
Queen Anne's thistle (*Cirsium canum*)	100	100	3.0	2.0	1.0	1.0
Nyíregyháza production area						
	Numbers of capitula examined		**Capitula infected [%]**		**Mean number of larvae in capitula**	
Host plants	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**
Corn thistle (*Cirsium arvense*)	500	500	1.2	1.2	1.0	1.0
Scottish thistle (*Onopordum acanthium*)		100		57.0		1.1
Plumless thistle (*Carduus acanthoides*)	15	100	6.7	5.0	1.0	1.0
(*Cirsium brachycephalum*)		500		2.6		1.0
Queen Anne's thistle (*Cirsium canum*)		100		4.0		1.0
Újfehértó production area						
	Numbers of capitula examined		**Capitula infected [%]**		**Mean number of larvae in capitula**	
Host plants	**2006**	**2007**	**2006**	**2007**	**2006**	**2007**
Musk thistle (*Carduus nutans*)	50	100	74.0	71.0	1.4	1.1
Scottish thistle (*Onopordum acanthium*)	50	100	46.0	42.0	1.1	1.1

3.3. The generation coefficient of the sunflower moth

One of our objectives was to examine what kind of effects the feral host plants of the first generation had on the number of specimen of the pest. The interrelations between the numbers of specimen of the first and second generations can be illustrated the best by the generation coefficient.

Table 3. The frequencies of host plants, numbers of specimen of the generations and the generation coefficients in the Nyíregyháza production area in 2005

Host plants	Plot codes						Mean
	N-1	N-3	N-4	N-5	N-7	N-8	
Corn thistle (*Cirsium arvense*)	5	9	9	7	9	9	8.00
Queen Anne's thistle (*Cirsium canum*)	0	6	2	0	0	0	1.33
Plumless thistle (*Carduus acanthoides*)	6	0	1	1	0	0	1.33
Scottish thistle (*Onopordum acanthium*)	2	0	0	0	0	0	0.33
numbers of specimen of the first generation	74	48	111	227	35	48	91
numbers of specimen of the second generation	208	71	201	276	55	59	145
generation coefficient	2.81	1.48	1.81	1.22	1.23	1.57	1.69

As for the generation coefficient, the greatest standard deviation was observed in the case of the plot N-1 in Nyíregyháza in 2005 (**Table 3**). The difference between this plot and the other ones was that *Carduus acanthoides* L. was found around the plot in great numbers and *Onopordum acanthium* L. was also present.

The mean of the generation coefficient was the highest in the Kisvárda production area. Here, the generation coefficient exceeded 4 in the plots where all the four host plants were detected: K-1, K-2 (**Table 4**). While the lowest value (2.21) was obtained in the plot where neither *Carduus acanthoides* L nor *Onopordum acanthium* L. was found: K-8.

Table 4. The frequencies of host plants, numbers of specimen of the generations and the generation coefficients in the Kisvárda production area in 2005

Host plants	Plot codes								Mean
	K-1	K-2	K-3	K-4	K-5	K-6	K-7	K-8	
Corn thistle (*Cirsium arvense*)	9	9	9	9	9	9	3	3	7.50
Queen Anne's thistle (*Cirsium canum*)	2	1	0	0	5	2	4	4	2.25
Plumless thistle (*Carduus acanthoides*)	7	5	4	4	3	6	0	0	3.63
Scottish thistle (*Onopordum acanthium*)	4	5	0	0	0	0	0	0	1.13
numbers of specimen of the first generation	50	62	75	72	38	94	98	146	79
numbers of specimen of the second generation	215	300	220	232	110	340	323	322	258
generation coefficient	4.30	4.84	2.93	3.22	2.89	3.62	3.30	2.21	3.41

The generation coefficients of the production areas revealed again great differences in 2006. In the Nyíregyháza and Kisvárda production areas the highest values were reached by the plots where both *Carduus acanthoides* and *Onopordum acanthium* were detected: N-10, K-10, while the lowest where neither was present: K-7 (**Tables 5 and 6**).

Table 5. The frequencies of host plants, numbers of specimen of the generations and the generation coefficients in the Nyíregyháza production area in 2006

Host plants	Plot codes					Mean
	N-3	N-7	N-8	N-9	N-10	
Corn thistle (*Cirsium arvense*)	9	9	9	9	9	9.00
Queen Anne's thistle (*Cirsium canum*)	6	0	0	0	0	1.20
Plumless thistle (*Carduus acanthoides*)	0	0	0	0	3	0.60
Scottish thistle (*Onopordum acanthium*)	0	0	0	0	3	0.60
Numbers of specimen of the first generation	46	28	26	47	21	34
Numbers of specimen of the second generation	46	31	28	62	67	47
generation coefficient	1.00	1.07	1.04	1.33	3.24	1.54

Table 6. The frequencies of host plants, numbers of specimen of the generations and the generation coefficients in the Kisvárda production area in 2006

Host plants	Plot codes					Mean
	K-5	K-6	K-7	K-9	K-10	
Corn thistle (*Cirsium arvense*)	9	9	3	9	9	7.80
Queen Anne's thistle (*Cirsium canum*)	5	2	4	1	1	2.60
Plumless thistle (*Carduus acanthoides*)	3	6	0	5	5	3.80
Scottish thistle (*Onopordum acanthium*)	0	0	0	0	5	1.00
numbers of specimen of the first generation	34	50	76	50	66	55
numbers of specimen of the second generation	90	142	122	135	217	141
generation coefficient	2.67	2.87	1.61	2.74	3.32	2.64

On account of these, we can state that in the plots where *Carduus acanthoides* was detected in great numbers the generation coefficient exceeded the mean of the production area in the given year. However, the highest value was reached by the plots where *Onopordum acanthium* was also present.

3.4. The differences between the moth susceptibilities of confectionary sunflower cultivars in terms of sowing times

Regarding moth infection, the cultivars revealed significant differences every year, every sowing date. The cultivars that flower at the same time in spite of the different sowing dates do not show any significant differences (**Tables 7 and 8**).

Table 7. The extents of moth infection and initial dates of flowering in terms of the different dates of sowing in the Nyíregyháza production area in 2007

Cultivars	Sowing dates					
	26 April		11 May		25 May	
	Infection [%]*	Date of flowering	Infection [%]*	Date of flowering	Infection [%]*	Date of flowering
Anita	0.42	25 June	0.00	7 July	6.25	16 July
Eagle	0.00	28 June	0.42	7 July	8.33	17 July
Marica 2	0.00	24 June	0.00	4 July	4.17	15 July
Ajaki	2.50	12 July	3.33	13 July	10.42	22 July
Kisvárdai	11.25	23 July	20.00	28 July	22.92	6 August
* between any combinations: $SD_{p=5\%}$ = 3.49						

Table 8. The extents of moth infection and initial dates of flowering in terms of the different dates of sowing in the Nyíregyháza production area in 2008

Cultivars	Sowing dates					
	15 April		2 May		21 May	
	Infection [%]*	Date of flowering	Infection [%]*	Date of flowering	Infection [%]*	Date of flowering
Anita	0.00	1 July	2.10	14 July	7.50	27 July
Eagle	0.00	28 June	2.50	12 July	7.53	26 July
Marica 2	0.00	28 June	2.10	11 July	9.15	25 July
Kisvárdai	6.68	25 July	27.93	6 August	33.35	15 August
* between any combinations: $SD_{p=5\%}$ = 2.76						

Regarding 2007 and 2008, we can state that the extent of infection depended strongly on the date of flowering, rather than on the genotypes of the cultivars. The two types that belong to the Kisvárdai cultivar (Kisvárdai and Ajaki) started flowering nearly at the same time (22th July and 23th July), though the Ajaki type was sown a month later. The same phenomenon could be observed in 2008 in the case of the Kisvárdai cultivar and the hybrids (Anita, Eagle, Marica 2) examined.

3.5. The effects of the preceding crops on the number of specimen of moth

The effects of the preceding crops on the sunflower moth were examined in 2005, as in the following years no other crop than sunflower was sown. The most important data of our observations are indicated in **Table 9**.

Table 9. Mean numbers of specimen of moth (males) classified according to preceding crops in 2005

Dates	Preceding crops			
	spiciferous	maize	sunflower	other row crops
30 May	11.0	10.2	13.6	7.9
6 June	16.5	9.9	17.7	6.9
13 June	12.8	15.4	21.0	8.8
20 June	5.4	10.0	10.2	5.9
27 June	3.8	7.3	4.8	2.4
4 July	nd	nd	nd	nd
11 July	nd	nd	nd	nd
18 July	nd	nd	nd	nd
26 July	5.3	8.1	4.8	3.1
2 August	10.2	14.5	14.3	9.3
9 August	23.3	23.2	19.2	14.0
16 August	45.8	42.9	35.7	36.6
23 August	32.5	30.2	26.2	25.9
30 August	14.7	12.8	12.2	12.7
6 September	11.5	16.3	14.0	7.5
13 September	3.7	4.8	4.1	1.9
Numbers of specimen				
1st generation	49.5	52.8	67.2	31.9
2nd generation	131.7	131.7	112.3	101.5

The differences of the preceding crops entailed great differences in the numbers of specimen of the first generation. The highest number of specimen was observed in sunflower monoculture, while the lowest in the case of other row crops: about half of the former one. As for the extent of the preceding crops' effect, that of the spiciferous did not reveal any remarkable difference from that of maize.

From an experimental methodological perspective, the one-year observation did not allow the statistical evaluation of the results, though the values obtained revealed considerable differences. The tendencies observed in the case of the first generation did not characterise the number of specimen of the second generation. The spiciferous preceding crop and the maize showed higher numbers of specimen than that of the sunflower monoculture.

3.6. The examinations of the interrelations between the size of the sunflower moth population and the extent of the damage

Evaluating the relation between the number of specimen of the second generation and the damages (**Figure 1**) in the Kisvárda, Nyíregyháza, and Újfehértó production areas, we obtained positive correlation (r = +0.665) in 2006.

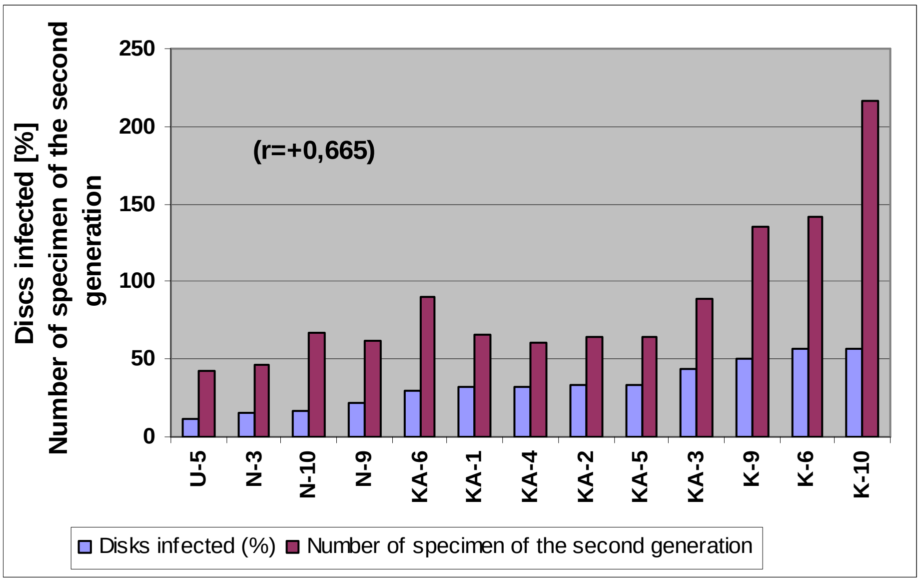

Figure 1. The extents of the damages and the number of specimen of the second generation in the Kisvárda, Nyíregyháza, and Újfehértó production areas in 2006

The strongest correlation (r = + 0.906) between the extents of infection and the numbers of specimen of the second generation was observed when we investigated the relations in the case of a single village within the Kisvárda production area (**Figure 2**).

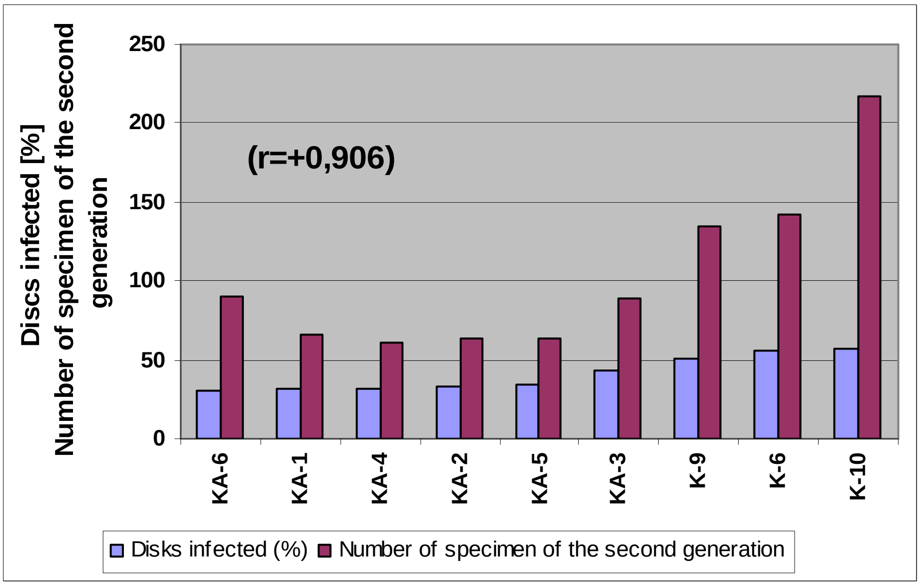

Figure 2. The extents of the damages and the numbers of specimen of the second generation in Ajak in 2006

3.7. New scientific results

1. From among the effects of meteorological factors, the most important is that of the air temperature. Every year the swarming peak was brought about after reaching a daily mean temperature of 18 °C.

2. The host plants of the first sunflower moth generation at species level were identified in Nyírség and the Szatmár-Bereg Plain. According to the preferences of the pest based on the percentages of the infected capitula, the host plants are as follows:

Musk thistle (*Carduus nutans* L.)
Scottish thistle (*Onopordum acanthium* L.)
Plumless thistle (*Carduus acanthoides* L.)
Cirsium brachycephalum Jur.
Queen Anne's thistle (*Cirsium canum* (L) All.)
Corn thistle (*Cirsium arvense* (L) Scop.)

3. The generation coefficients of the pest was also calculated. The values varied with the production areas and the years. The lowest mean (0.23) was measured in the Nyíregyháza production area in 2007, while the highest (3.41) in the Kisvárda production area in 2005. Having examined the generation coefficients in terms of the host plants of the first generation, we can state that in the plots where *Carduus acanthoides* was detected in great numbers the generation coefficient exceeded the mean of the production area in the given year. However, the highest value was reached by the plots where *Onopordum acanthium* was also present.

4. Regarding the means of infectedness with the different sowing dates, that of the Kisvárdai cultivar was significantly higher than the others in all the three years. As for the means of the cultivars, the infectedness of the sunflower sown after the middle of May exceeded that of the ones sown earlier in all the three years. No significant difference was detected between the extents of infection of the cultivars flowering at the same time. Having evaluated different cultivars with different sowing dates, we can state that it is the date of flowering that determines basically the extent of moth infection.

5. The mean of the number of specimen of the first generation was the highest in sunflower monoculture (67.2). It is followed by the sunflower fields that had maize (52.8), spiciferous (49,5) and other row crops (31.9) as their preceding crop. The tendencies observed in the case of the first generation did not characterise the number of specimen of the second generation. The mean number of specimen of the second generation in monoculture was 112.3, in the case of maize and spiciferous preceding crops it was 131.7, while it was 101.5 with other row crops.

6. Regarding the means of the production areas examined, we observed obvious positive correlation between the extents of the damages and the numbers of specimen of the second generation ($r = +0.665$). The correlation was even stronger ($r = +0.906$) when we examined the plots of a single village within a production area.

4. DISCUSSION OF THE FINDINGS AND SUGGESTIONS FOR FURTHER RESEARCH

The most important objectives of our work were to observe the swarming pattern of the sunflower moth, to identify the host plants of the first generation, to explore the factors influencing the damages caused by the second generation together with their correlations. A further objective was to make technological proposals aiming at reducing the extent of damages for the producers.

During the years examined the two moth generations were well traceable; however, both the timing of the swarming peak and the numbers of specimen were influenced by meteorological elements.

The third generation described by the scientific literature (Uzonyi, 1942) was observed in three production areas: Nyíregyháza, Kisvárda and Szatmár in 2006, and Nyíregyháza, Kisvárda and Újfehértó in 2007.

The swarming pattern of the first sunflower moth generation is determined by the interactions of biotic and abiotic factors. From among the effects of meteorological factors, the most important was that of the air temperature. Every year the swarming peak was brought about after reaching a daily mean temperature of 18 °C.

The identification of the host plants at species level was inevitable for working out protective proposals. On account of the investigation into the infectedness, we can state that *Onopordum acanthium* and *Carduus nutans* are preferred primarily by the pest. The flowering period and the size of capitulum make the *Onopordum acanthium* the most convenient for oviposition. Similar circumstances are provided by the *Carduus nutans* flowering a bit earlier. The *Cirsium arvense*, which is widespread in Hungary, means lesser extent of damages, which can also be explained by the smaller capitulum. *Carduus acanthoides* can be found in the middle of the list of preferences. In spite of its capitulum of medium size, *Cirsium canum* cannot be regarded as a popular host plant, as its flowering period coincides with the end of the swarming of the first generation.

The numerical proportion of the consecutive sunflower moth generations could be determined by the generation coefficient. As the abiotic factors influencing the pest within a given production site and a given year were similar, the generation coefficients of the plots examined derived from the biotic factors characterising the plots. From among the biotic factors, the most important was represented by the Compositae weeds that are the host plants of the first generation. Their frequencies showed great differences from plot to plot. As for the yearly determined generation coefficient, the mean values of the distinct production sites were exceeded by the values of plots where *Carduus acanthoides* was detected in great numbers: N-1, K-1, K-2, K-3, K-4, K-6, U-2, U-3, U-6, U-7 in 2005, N-10, K-6, K-9, K-10 in 2006, and N-4, N-8, K-6, K-9, K-10, K-12 in 2007.

However, the generation coefficient reached the highest value where the *Onopordum acanthium,* the most preferred and infected host plant was present. In these plots the mean values of the production sites were exceeded by 66, 110 and 69% in Nyíregyháza in 2005, 2006 and 2007 respectively, and 34, 26 and 36 % in the Kisvárda production area in the same years.

The different cultivars resist to moth infection to various extents. Apart from the genotype, it is the date of sowing that basically determines the extent of infection: the later the sowing takes place, the greater the extent of damages becomes. Regarding the means of the cultivars, the extent of infectedness increased significantly (p=0.05) between the first (3rd May) and second (23rd May) dates of sowing. However, there was no significant difference between the second and the third (8th June) dates of sowing.

In 2007 as well, it was only the means of the sunflowers sown in May that revealed significant difference (p=0.05) in terms of the infectedness. In 2008, as time was passing, the extent of infectedness was growing, and differences became significant between the three dates of sowing (15th April, 2nd May, and 21st May).

The extents of infection of the cultivars flowering at the same time did not reveal significant differences, regardless of the dates of sowing. It means that the factor determining essentially the moth infection is the flowering date, which is influenced by the vegetation period, the sowing date and the meteorological parameters. Although as the sowing starts later and later, the number of days until the flowering is decreasing, but it cannot compensate for the greater extent of moth contamination deriving from the later flowering.

The correlation between the size of the population and the damage caused is proved. In 2006 a positive correlation (r= 0.655, n=13) was found between the population size of the second generation and the extent of the damage. When we restricted our observations to a single production site, the correlation became even stronger (r=0.906, n=9).

The preceding crop exercised great influence on the numbers of specimen of the first moth generation. The greatest numbers was detected in sunflower monoculture, while the lowest with other row preceding crops. The tendencies observed with the first generation could not be found in the case of the second. Here, a higher number of specimen was obtained in the case of spiciferous and maize preceding crops than with monocultures.

On account of the results, our practical proposals are as follows:

The larvae of the first moth generation can be thinned the most effectively by the eradication of the *Onopordum acanthium,* and *Carduus acanthoides*. The scything should take place two or three weeks after the swarming peak. The exact date of the swarming peak can be determined by pheromone traps. A less precise method is based on the fact that massive swarming occurs after reaching a daily mean temperature of 18 ^{0}C.

In the case of the Kisvárdai cultivar an early sowing is expedient in order to avoid the moth damages as well as to increase the quantity of yield. The light, sand soils that get warm fast in the Nyírség allow us an early sowing during the last week of March or at the beginning of April. Although the temperature of soil is below 8 ^{0}C, which is suggested by the scientific literature, the Kisvárdai cultivar tolerates this lower temperature well.

As for our preceding crop examinations, sunflower monoculture increased only the number of specimen of the first generation. However, so as to mitigate its indirect effects of yield reduction, we suggest the avoidance of monoculture cropping systems that are frequent in the Nyírség.

The Kisvárdai cultivar has been popular for more than fifty years due to its marketability. Still, several of its agronomic parameters have become dated. Its susceptibility to moth infection derives from the lack of phytomelane layer and its long vegetation period. Beside conserving the marketability of the achene, it would be expedient to shorten the vegetation period by improving breeding of the cultivar.

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