JOURNAL OF PLANT PROTECTION RESEARCH
Vol. 45, No. 4 (2005)

FEEDING PREFERENCES OF LEAFROLLER CATERPILLARS (*LEPIDOPTERA, TORTRICIDAE*) FOR SOME APPLE CULTIVARS

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Accepted: October 20, 2005

Abstract: Evaluation of fruits and leaves of seventeen apple cultivars in respect of their attraction as food for caterpillars of leafroller species occurring in an experimental apple orchard was carried out over 1995 to 1998 in the Institute of Pomology and Floriculture at Skierniewice. The highest levels of injuries were observed on two cultivars: 'Ligol' and 'Elstar'. High number of injured fruits was noted on the following cultivars: 'Gala', 'Jonagold', 'Cortland', 'Idared', 'Lodel' and 'Szampion'. By far the number of injured fruits was lower on 'Lobo' and 'Jonathan', and the least on 'Rubinette', 'Starkrimson' and 'Gloster'.
Significant differences in the number of caterpillars settled down in leaf/flower clusters of particular cultivars during the vernal period were also confirmed. In each season the highest number of caterpillars of *Pandemis heparana* and *Archips rosana* were observed on leaves of 'Alwa'. To cultivars whose leaves were also readily settled down by the two aforementioned species were: 'Jonathan', 'Cortland', 'Ligol', 'Lobo', 'Jonagold' and 'Elstar'. Relatively less caterpillars were observed on leaves of 'Arlet', 'Gloster', 'Szampion', 'Starkrimson', 'Pilot', 'Pinowa' and 'Rubinette'.

Key words: leafrollers, apple cultivars, feeding preferences, damages, *Pandemis heparana*, *Archips rosana*

INTRODUCTION

Results of studies on damage of apple varieties by caterpillars of leafrollers (*Lepidoptera: Torticidae*) point out important differences between particular apple cultivars in having an attraction for the pests in question. This fact was conspicuous for several authors such as de Jong et al. (1971) and Graf et al. (1992).

Leaf morphology, structure of the fruit flesh, length of the peduncle and intensity of covering the fruits by leaves are mentioned among factors deciding on more or less numerous populating of particular apple cultivars by leafrollers (de Jong et

al. 1971). According to Masse (1951), soft fleshed fruits are preferred. Łabanowski (1979) showed that 'Malinowa Oberlandzka' and 'Landsberska' had fruits heavier damaged (3.3 and 2.6 %, respectively) than 'Wealthy', 'Boiken' and 'Jonathan' (2.3, 1.1 and 1.3%, respectively). According to Gottwald (1987), *Adoxophyes orana* (F.v.R.) preferred the 'James Grieve' and 'Auralia' to others cultivars, whilst Reede et al. (1985) observed more damaged fruits on 'Boskoop' than on 'James Grieve'.

In Polish as well as in the foreign literature there is a lack of more detailed information about the intensity of populating by leafrollers those apple cultivars, which have an important share in the structure of orchards having been established in the last ten years.

MATERIALS AND METHODS

Fruits of several apple cultivarse were valuated in respect of their attraction as food for caterpillars of leafrollers. Analysis were conducted over the 1995 to 1998 period in the experimental orchard of the Institute of Pomology and Floriculture at Dąbrowice (plots I–VI).

During the period of the research work in this orchard dominant species of the tortricid complex were *Pandemis heparana* (Den. et Schiff.) and *Archips rosana* (L.) with the shares of 55.8 to 100% and 33.1%, respectively. The joint share of the remaining species occuring there, i.e. *Pandemis ribeana* (Hbn.), *Archips podana* (Scop.), *Spilonota ocellana* (Den. et Schiff.), *Hedya nubiferana* (Hw.) and *Acleris rhombana* (Den. et Schiff.) did not exceed 10%. For the purpose of research 17 apple cultivars differing in the time of ripening were chosen, among which, however, early winter and late winter cultivars had prevailed.

Each cultivar was presented by 10 randomly selected trees, from which a sample of 1000 fruits was picked up at the time of harvest (5 replicates × 200 fruits). The particular plots of the orchard were treated as separate units. During the spring of the 1996 to 1998 period, all leaf flower clusters of the tested varieties were subjected to a valuation of settlement of leafroller caterpillars just before the blooming time. From 20 randomly chosen trees representing each cultivar a sample of 10 leaf clusters was taken (4 replicates × 50 clusters) and the number of specimens of this pest group was counted.

The results were elaborated statistically using analysis of variance on data transformed according to Bliss formula. Mean differences were evaluated with Duncan's multiple range test at 5% level of significance.

RESULTS

Settling down the leaf/flower clusters by caterpillars

Significant differences were ascertained in numbers of leafroller caterpillars settled down in leaf clusters of particular apple cultivars during the vernal period (Table 1, plots I–VI). In each of the seasons during the study period the highest number of caterpillars of both *P. heparana* and *A. rosana* was observed on 'Alwa' (Table 1, plot I). These two leafroller species also willingly settled down the leaves of 'Jonathan', 'Cortland', 'Idared', 'Ligol' 'Lobo' 'Jonagold' and 'Elstar'. Distincly less caterpillars were noted on leaves of 'Arlet', 'Gloster', 'Szampion', 'Starkrimson',

'Pilot', 'Pinowa' and 'Rubinette'. In the ease of some cultivars, the considerable number of leafroller caterpillars which settled down the leaf clusters, had found reflection in an appreciable number of damaged fruits. Such relationship was ascer-

Table 1. Density of leaf/flower clusters settled down by caterpillars of leafrollers in springtime and damages on fruits in the apple orchard at Dąbrowice

Cultivar	Injuried fruits and settled clusters (in %)							
	fruits 1995	clusters 1996	fruits 1996	clusters 1997	fruits 1997	clusters 1998	mean years	
							fruits	clusters
Plot I								
'Alwa'	11.2 ab*	17.7 b	5.7 b	10.3 c	2.7 ab	14.2 c	6.1 b	13.9 c
'Gala'**	14.5 b	9.9 ab	3.2 a	0.0 a	3.4 ab	1.8 a	6.2 b	2.3 a
'Gala'***	12.5 ab	8.0 a	7.3 bc	2.8 ab	6.5 c	5.9 b	8.6 c	5.4 b
'Gloster'	9.5 a	9.0 ab	2.6 a	3.3 b	1.8 a	5.4 b	4.1 a	5.7 b
'Jonagold'	14.2 b	15.4 b	6.8 bc	2.4 ab	3.9 b	16.9 c	7.8 c	10.4 c
'Lodel'	10.8 ab	10.2 ab	8.1 c	2.4 ab	5.8 bc	1.5 a	8.1 c	4.0 ab
Plot II								
'Cortland'	17.1 c	2.5 ab	4.1 b	3.7 c	6.2 ab	8.0 bc	8.4 b	4.5 bc
'Gloster'	6.8 ab	0.5 a	0.7 a	0.5 a	8.3 b	5.0 b	4.5 a	1.5 a
'Idared'	10.5 b	4.3 b	1.4 a	2.4 b	3.6 a	2.8 a	4.5 a	3.1 ab
'Jonagold'	8.3 ab	4.1 b	7.2 b	1.1 ab	6.1 ab	5.0 b	7.2 b	3.2 ab
'Jonathan'	5.3 a	9.9 c	1.4 a	2.2 b	5.3 ab	10.9 c	3.7 a	7.0 c
Plot III								
'Arlet'	8.2 b	1.0 a	2.3 b	0.0 a	1.2 ab	0.7 a	3.3 b	0.4 a
'Gloster'	5.8 ab	3.7 b	0.3 a	0.1 a	0.4 a	0.5 a	1.5 a	1.0 a
'Jonagold'	7.1 ab	0.0 a	3.7 bc	1.5 a	1.6 ab	1.8 a	3.8 b	0.7 a
'Pilot'	6.4 ab	0.0 a	2.5 b	0.5 a	2.9 b	2.3 a	3.8 b	0.5 a
'Pinowa'	7.7 ab	0.0 a	4.7 c	0.5 a	2.2 b	0.1 a	4.6 b	0.1 a
'Rubinette'	4.7 a	0.5 a	0.5 a	0.5 a	0.5 a	0.7 a	1.4 a	0.6 a
Plot IV								
'Elstar'	19.1 b	20.9 c	19.3 c	2.6 a	18.9 c	2.9 b	19.1 c	7.1 bc
'Idared'**	10.2 a	10.7 b	3.4 ab	1.5 a	2.9 a	3.4 b	5.1 a	4.5 b
'Idared'***	18.4 b	31.4 d	1.2 a	3.3 a	3.0 a	2.9 b	5.8 a	9.7 c
'Szampion'	13.6 ab	0.0 a	5.9 b	1.8 a	7.0 b	0.7 a	8.5 b	0.5 a
Plot V								
'Cortland'	4.6 b	16.0 c	2.9 a	11.0 b	2.2 a	5.0 a	3.1 a	10.2 bc
'Elstar'	11.0 cd	5.4 b	5.0 ab	5.9 a	13.7 d	11.8 b	9.5 d	7.5 ab
'Gloster'	7.9 c	4.5 a	3.9 a	9.8 ab	2.7 a	6.9 ab	4.6 bc	6.9 a
'Jonagold'	2.1 a	4.9 ab	10.8 c	10.6 b	7.1 bc	7.4 ab	6.1 c	7.5 ab
'Ligol'	15.3 d	14.4 c	13.9 c	9.7 ab	10.2 cd	7.8 ab	13.0 e	10.5 c
'Lobo'	1.7 a	20.7 c	3.9 a	9.4 ab	5.6 b	5.9 ab	3.6 ab	11.3 c
Plot VI								
'Idared'	2.9 b	4.6 b	5.6 a	5.0 b	9.8 b	5.4 a	5.8 b	5.0 b
'Starkrimson'	0.2 a	0.5 a	6.6 a	1.8 a	2.8 a	4.0 a	2.5 a	1.8 a

*values indicated by the same letter do not differ significantly according to the multiple range Duncan's – test, at 5% significance level
**the younger trees – formed as spindel
***the older trees – formed as turn

tained on 'Elstar', 'Ligol', 'Cortland' and 'Jonagold'. Beside, on 'Gloster', 'Starkrimson' and 'Rubinette', where the number of caterpillars present in leaf clusters was low, less damaged fruits was stated, likewise. On the other hand, on 'Alwa', 'Jonathan' and 'Lobo', despite a considerable number of caterpillars present on the leaves, the number of damaged fruits was little. These correlations could be remarkably altered by the control treatments. A direct correlation was ascertained, instead, between the number of fruits injuried by leafroller caterpillars the year before and the number of clusters settled down by the pest the following year in springtime. The highest number of damaged fruits was noted in 1995, and as a result of that, a high number of caterpillars appeared in the leaf clusters during the spring of the year 1996.

An intensive control program (3 sprayings) was applied against leafrollers in the growth season of 1996 (plots I–IV). It decreased as well the number of fruits damaged during this season as the number of caterpillars feeding in the spring of the following year 1997.

Analysis of fruit damage in the orchard

The number of injuried fruits was determined first of all by the presence of *P. heparana* in the orchard. It was a species dominating within the complex of leafrollers (even to 100%). Caterpillars of that species were present in the orchard from the early spring beginning till the fruit harvest. Instead, caterpillars of *A. rosana* the second numerous species, fed only till the end of June.

An appearance of significant differences between the numbers of damaged fruits within particular cultivars was ascertained during the study (Table 1). While the 3 years research most of all fruits injuried by caterpillars of leafrollers was stated on 'Ligol' and 'Elstar'. To the group of cultivars with a high number of damaged fruits belonged also 'Gala' and 'Jonagold'. Fairly damaged were fruits of 'Cortland', 'Idared', 'Lodel', 'Szampion', 'Arlet', 'Pilot', 'Pinowa' and 'Alwa'. Remarkably less fruits with damages caused by leafrollers were noted on 'Lobo' and 'Jonathan', and least of all – on 'Rubinette', 'Starkrimson' and 'Gloster'. The injuries of fruits belonging to varieties most readily settled down by caterpillars of *P. heparana* ('Ligol', 'Elstar') assumed the shape of widespread corrosions, while on fruits of 'Gloster' and 'Starkrimson' the signs of feeding were in the majority limited to 1–2 diminutive wounds (Table 2).

Table 2. Damage caused by caterpillars of leafrollers to fruits of some apple cultivars in 1997

Cultivar	% of injured fruits		
	in total	widespread	small (1–2 apertures)
Dąbrowice – plot V			
'Elstar'	13.9	9.4	4.5
'Gloster'	2.8	0.7	2.1
'Ligol'	10.2	5.8	4.4
Dąbrowice – plot VI			
'Starkrimson'	2.9	0.1	2.8

The least injuries were stated on earlier picked fruits of 'Lobo'. In late-winter cultivars instead, no relationship between the number of injuried fruits and the time of harvest was ascertained. Fruits of 'Ligol' and 'Elstar', picked up at September were damaged more often than fruits of other harvested at the same time, e.g. 'Lodel', 'Alwa', 'Cortland'. A low number of damaged fruits was observed on 'Rubinette' and 'Starkrimson', despite their picking at the latest of all (the early part of October).

The research work conducted has shown a differentiation in the number of injuried fruits within a particular variety, according to the size and shape of the tree. In young trees of 'Gala' (Table 1, plot II) and 'Idared' (Table 1, plot IV) trained in the form of a spindle, the number of injuried fruits was lower than on older trees trained in the form of a whorl. In older trees with more thickened crowns, where leaves more often clung to the fruits, feeding conditions for caterpillars of leafrollers were more advantageous. On trees of 'Idared' the number of damaged fruits decreased decidedly in 1996 and 1997 as a result of executing a summer clearing cut. Over two preceding years, trees in this plot were not cut at all.

DISCUSSION

The results of the presented study show that with a similar number of leafrollers the number of injuried fruits at particular apple cultivars can be different. Among apple cultivars included into the study, the caterpillars of *P. heparana* injuried most of the fruits of 'Ligol' and 'Elstar', and least – on 'Starkrimson' and 'Rubinette'.

The differentiation of cultivars chosen for purposes of the study delivered also some information on feeding preferences of these leafrollers whose caterpillars feed on leaves. The decidedly greatest number of caterpillars of *P. heparana* and *A. rosana* was observed each year on leaves of 'Alwa'. However, this did not influence the number of injuried fruits. Such a relationship has not been ascertained on 'Jonathan' and 'Lobo' either. A lack of any correlation between the number of caterpillars of *Archips rosana* and the number of injuried fruits was stated also by Łabanowski and Sokolowski (1996) on 'Wealthy' and 'Jonathan'.

In some other cultivars ('Elstar', 'Ligol', 'Cortland' and 'Jonagold') instead, it was ascertained that a high number of caterpillars found in leaf clusters had resulted in a considerable number of injuried fruits. Beside, on 'Gloster', 'Starkrimson' and 'Rubinette', a low number of caterpillars found in the clusters was correlated with a low number of injuried fruits. The results of the research show that in case of some cultivars the caterpillars of leafrollers accept to the same degree both leaves and fruits while in other this acceptance is weak. A consecutive group constituted cultivars in which no significant relationship was found between the acceptance of leaves from one side, and fruits from the other.

The varying number of injuried fruits in particular cultivars did not result from the location of the trees within the orchard. At Dąbrowice, trees of 'Ligol' (plot IV) grew in one row, in the vicinity of 'Gloster'. Over the study years the number of injuried fruits was 2–3 times lower on the latter than on 'Ligol'. On trees of 'Alwa' instead, despite their location in the middle of the plot, markedly more caterpillars were observed than on other cultivars growing in the immediate vicinity (e.g.

'Gloster'). It is well known from the European literature, that the location of the orchard exerces an important influence on the occurrence of determined leafroller species and on the extent of damages they cause. Demyanenko and Tretyakov (1990) ascertained that the number of leaf clusters damaged by caterpillars of leafrollers were the greater in trees growing along the extreme rows of an apple orchard and in the vicinity of forests. The greater damages at the edges of orchards ascertained also Charmillot et al. (1983) and Reede et al. (1985). According to the latter authors the reason of this phenomenon lies in migration of females and in carrying them by the wind from unsufficiently protected orchards. The factors described above may modify the extent of damage in particular cultivars.

The age of trees and the fashion their crowns are formed were factors distinctly modifying the level of damages caused by leafrollers. On older trees, not subjected to cutting and thus very thickened in their crowns the number of injuried fruits was always higher than on trees subjected to clearing cut. This was likely connected with the behaviour of the caterpillars of leafrollers which always feed in hiding. In trees with thickened crowns they found their preferred conditions, because markedly more often occurred there fruits and leaves adhering to each other.

CONCLUSIONS

1. The size of damages caused by leafrollers in apple orchard depends on the cultivar composition. The most fruits injuried by caterpillars of *Pandemis heparana* were found on 'Ligol', 'Elstar', 'Gala', 'Jonagold', 'Cortland', 'Idared', 'Szampion' and 'Lodel', and the least on 'Rubinette', 'Starkrimson' and 'Gloster'.
2. Leafrollers show also a differentiated preference to apple leaves. Caterpillars of *Pandemis heparana* and *Archips rosana* most readily settled down the leaves of 'Alwa'. On the other hand relatively less caterpillars were stated, on leaves of 'Arlet', 'Gloster', 'Szampion', 'Starkrimson', 'Pilot', 'Pinowa' and 'Rubinette'.
3. Markedly more damage caused by leafrollers occurs on older trees with very thickened crowns.

ACKNOWLEDGEMENTS

We wish to thank very much to Mrs U. Tworkowska for technical assistance and Dr R. Z. Zając for his critical reading of the manuscript.

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POLISH SUMMARY

OCENA ATRAKCYJNOŚCI NIEKTÓRYCH ODMIAN JABŁONI DLA GĄSIENIC ZWÓJKÓWEK LIŚCIOWYCH

Ocenę atrakcyjności owoców i liści różnych odmian jabłoni dla gąsienic zwójkówek liściowych prowadzono w latach 1995–1998 w sadzie doświadczalnym Instytutu Sadownictwa i Kwiaciarstwa w Skierniewicach. W latach badań w sadzie tym dominowały dwa gatunki zwójkówek: zwójka bukóweczka (*Pandemis heparana*) i zwójka różóweczka (*Archips rosana*). Do badań wybrano 17 odmian jabłoni o różnej porze dojrzewania owoców. Wynikiem badań było stwierdzenie istotnych różnic w liczbie uszkodzonych owoców poszczególnych odmian. We wszystkich latach badań zdecydowanie najwięcej owoców uszkodzonych przez gąsienice zwójkówek stwierdzono na odmianie 'Ligol' i 'Elstar'. Do odmian o dużej liczbie uszkodzonych owoców należały również 'Gala', 'Jonagold', 'Cortland', 'Idared', 'Lodel' i 'Szampion'. Znacznie mniejszą liczbę uszkodzonych owoców stwierdzono na odmianach 'Lobo' i 'Jonatan', a najmniejszą na 'Rubinette', 'Starkrimson' i 'Gloster'.

Stwierdzono także istotne różnice w liczebności gąsienic zwójkówek w okresie wiosennym w rozetach liściowo-kwiatowych poszczególnych odmian. W każdym sezonie największą liczbę gąsienic zwójki bukóweczki i zwójki różóweczki obserwowano na liściach odmiany 'Alwa'. Do odmian, których liście chętnie były zasiedlane przez te dwa gatunki zwójkówek, należały również 'Jonatan', 'Cortland', 'Ligol', 'Lobo', 'Jonagold' i 'Elstar'. Stosunkowo mniej gąsienic stwierdzono na liściach odmian 'Gloster', 'Szampion', 'Starkrimson', 'Pilot', 'Pinowa' i 'Rubinette'.