

## Developing methods for testing the resistance of white cabbage against *Thrips tabaci*

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**Abstract:** Since the damage of the onion thrips (*Thrips tabaci* Lindemann) first occurred on white cabbage in Hungary several observations have been carried out, both in Hungary and abroad, to assess varietal resistance. The use of a new evaluation method for field screening is described and the result of the monitoring of 64 varieties is reported. The most susceptible varieties were 'Bejo 1860', 'SG 3164', 'Quisto', 'Green Gem' and 'Ramada'. On the other hand, 'Golden Cross', 'Balashi', 'Riana', 'Autumn Queen', 'Leopard', 'Ama-Daneza' and 'Galaxy' suffered the least damage under natural infestation. Methods for testing the patterns of resistance are also described and evaluated. In case of plants at the few leaf growth stage significant negative correlation was found between egg mortality and the egg laying preference of adults. The results of the other antibiotic and antixenotic tests were greatly affected by differences in the physiological age and condition of the varieties.

### Introduction

Although there had been early reports of the onion thrips (*Thrips tabaci*) damaging white cabbage (*Brassica oleracea* L. convar. *capitata* provar. *capitata* Duch.) outdoors (Wolfenbarger and Hibbs, 1958) and in storage (Fox and Delbridge, 1977), this thrips had not been considered an important cabbage pest until the 1980s. Then the species appeared to be a new pest of cabbage, due to alterations in the cultivation technology and to the underdeveloped procedure of protection (Kristofne and Penzes, 1984). Since then, it has become one of the main obstacles in the development of quality cabbage growing in Hungary and in several regions of the world.

Thrips injury appears as bronze discoloration and rough texture on the head leaves and results in cabbage that does not meet fresh market standards (North and Shelton, 1986a). According to North and Shelton, all stages of thrips can be found in the first 11 layers of mature head (North and Shelton, 1986b). However, sometimes the symptoms of infestation occur down to the 38<sup>th</sup> leaf of the head (Legutowska, 1997). After head formation has started, onion thrips colonise the cabbage plant in mass from other hosts, including different cereal crops, alfalfa, red clover (Shelton and North, 1986) and amongst many others all kinds of onion. The possible role of cereals as a reservoir for the

onion thrips is questioned by Kahrer, who found no evidence of early development on cereal crops prior to mass invasion to cabbage (Kahrer, 1993).

The use of insecticides usually results in poor control of onion thrips on cabbage (Andaloro et al., 1983), and the release of predatory mites on cabbage fields does not give adequate control either (Hoy and Glenister, 1991). Based on extensive research, Shelton stated that the primary control for thrips damaging cabbage should be the selection of tolerant varieties (Shelton et al., 1998) although the timing of planting is also a possible mean of protection, as it can reduce thrips damage (Stoner and Shelton, 1988a). Field trials have been carried out in order to assess the resistance of several cabbage varieties against onion thrips. The screening method has been based on either the extent of the injury observed on leaves (Kristofne et al., 1988; Penzes and Szani, 1990, 1992a, 1992b; Penzes et al., 1996, 1998, 2000), or on both the extent of the injury and the number of thrips collected (Shelton et al., 1983; Shelton et al., 1988; Stoner and Shelton, 1988b).

Very few studies have been carried out with cabbage varieties in order to identify the patterns of resistance against onion thrips. Since Painter, three mechanisms of resistance has been defined: nonpreference, antibiosis and tolerance (Painter, 1951). Nonpreference 'denotes the group of plant

characters and insect responses that lead to or away from the use of particular plant or variety, for oviposition, for food, or for shelter, or for combination of the three'. Antibiosis express 'those adverse effects on the insect life history which result when the insect uses a resistant host-plant variety for food'. Tolerance is a 'basis of resistance on which the plant shows an ability to grow and reproduce itself or to repair injury to a marked degree in spite of supporting a population approximately equal to that damaging a susceptible host'. Later on, antixenosis was proposed to be used instead of the former term, nonpreference (Kogan and Ortman, 1978) and trials on antixenotic resistance of cabbage varieties against onion thrips under field conditions and in laboratory were carried out (Stoner and Shelton, 1988). Although in the leaf disk array onion thrips showed no preference for any of the varieties, in the field tests the number of thrips collected from the head leaves and frame leaves of the plants were significantly different.

In our study, we aimed to gain further data on varietal resistance with the use of a modified screening method. We carried out greenhouse trials to gain some preliminary experience on antixenotic and antibiotic resistance evaluation.

### Material and methods

Field screening tests were carried out at two stations (Tordas, Fertod) of the National Institute for Agricultural Quality Control (NIAQC) in 2000. Greenhouse-grown plants of 44 varieties were transplanted on 18. May in Tordas and 20 varieties on 23. June in Fertod. Plots were composed of 5 rows of 14 plants, both rows and plants spaced 0,5 m apart. Plots were replicated twice in a randomised complete block design with an alleyway of 2 m separating replicates. Standard herbicide and fertilization practices were employed. Two applications of phosphamidon, pirimicarb and lambda-cyhalothrin were used for the control of cabbage maggot, brassica flea beetles, aphids, bugs and lepidopteran pests. Varieties matured at different times and each was screened during the period of its optimum maturity. Data were collected on 14., 19. and 27. June; 5., 14., 19. and 26. July; 8., 15. and 22. August; 5. and 21. September; 5., 12. and 25. October; 16. and 23. November. One variety was sampled only

once by evaluating the thrips injury observed only on the head leaves of 5 randomly chosen plants per replicates. For this purpose, a six-degree damage rating scale was elaborated based on the extent of the symptoms appearing on the leaves:

- 0 - No damage
- 1 - Few rough brown blisters, less than 5 % of the leaf is covered
- 2 - Blisters covering not more than 1/3 of the leaf
- 3 - Blisters covering not more than half of the leaf
- 4 - Blisters covering not more than 3/4 of the leaf
- 5 - Blisters covering more than 3/4 of the leaf.

Leaves were evaluated and peeled off the head one after the other until four consecutive leaves showed no damage. The extent of damage (ratings of the scale) and the number of the leaf (the first one being the outer, the second being the one below it and so on) on which it was observed were noted. For analyses, the ratings for each leaf were multiplied by the square root of the leaf-number. One head was represented by the sum of these values. Stochastic homogeneity tests and analysis of variance were performed on cumulated damage ratings for separate groups of varieties screened roughly at the same time. Varieties were compared in pairs by Tukey-Kramer or Games-Howell tests.

The resistance evaluation tests were carried out at Szent Istvan University, Faculty of Horticultural Sciences, Budapest under greenhouse conditions from January until May 2001. Four varieties ('Quisto', 'Coronet', 'Histona' and 'Szentesi Lapos') were raised in plastic containers. 'Quisto', 'Coronet' and 'Szentesi Lapos' were sown on the 2. October, 2000. but 'Histona' was sown on 15. October and 20. December, 2000. Fertilisers were applied to the irrigation water weekly and no pesticide was used. At the few leaf growth-stage of plants, antixenotic and two antibiotic resistance tests were carried out with the replication of the former test in May, 2001. when heading has started. For the antixenotic and the second antibiotic tests of

the young plants the earlier sown 'Histona' was used but the first antibiotic experiment of the few leaf stage plants and the replication of the antixenotic test were carried out on the latter sown 'Histona'. Another greenhouse raised plants of the four varieties were brought in (11. December 2000.) from our experimental station (Soroksar, Budapest) at harvest maturity for two antibiotic resistance tests. Plants were sown at various dates (10. August, 20. August and 1. September 2000.) in order to make them reach heading stage roughly at the same time. They were raised in the same way as the plants mentioned above. Thrips for the tests were collected from a thelotokous stock culture maintained on living onion plants in our insectory.

For the antixenotic resistance test, 10 arena covered with agricultural plastic were created with dimensions of 1 X 0,8 X 0,6 m. Through the perforation of the plastic sheet air movement could take place without letting the thrips to invade to or to escape from the confined space. One plant of each variety was placed in every arena and in the middle 40 adult onion thrips were released. One week later the number of adults (leaf by leaf) and the number of eggs laid on the most injured leaf were counted for each variety. The extent of feeding spots were also assessed using the scale mentioned above, with the difference that on the leaves no blisters but silvery damage were observed. Since the size of the leaves were not identical and the above-mentioned scale is size-sensitive, the cumulated damage ratings were modified by the relative size of the leaves (assessed by the use of a 10 degree scale). Stochastic homogeneity tests were performed on the numbers of adults, eggs and cumulated damage ratings.

For the antibiotic resistance test, clip-on leaf cages similar to the one described by Lewis

(Lewis, 1973; chapter 5.) were created. 10 mm rings were cut from a PVC pipe 25,4 mm in diameter and attached to hair clips. A disc of fine (90 µm) steel-mesh was glued to the ring on one side and a flexible ring of felt on the other. The porules of the felt were filled up with silicon rubber to prevent escaping without loosing much of its original flexibility. A tiny piece of cotton wool were placed in the cage and under microscope 10 living onion thrips larvae (not differentiating L<sub>1</sub> from L<sub>2</sub>) were transferred into the cage by means of a moistened fine brush. In case of plants at a few leaf stage, 30 cages were clipped on leaves of each variety. In case of mature plants some outer head leaves were carefully unfolded and 10 cages were clipped on leaves inside the head. The head was covered back with the removed leaves. For better sealing an additional steel clip was put on the leaf-cages to increase pressure holding the cage to the plant surface. After two weeks, cages were removed and under a microscope the number of all different life stages of thrips was counted (from egg to adult). For analysis, thrips mortality and the swiftness of development were calculated. For the latter, the life stages were valued (Table 1) on the basis of their relative duration to the full cycle (from egg to egg).

The values of 'Duration' were calculated from Murai's life table parameters for *Thrips tabaci* (Murai, 2000). The number of individuals found living in the cage were multiplied by their 'Value' and then summed up. The cumulated value was divided by the number of individuals resulting in one number (LV-living value), representing the particular variety. The same procedure was done for dead individuals found in the same cage with the result of another number (DV-dead value). Then 'DV' was distracted from 'LV' resulting in the susceptibility value ('SV'). Stochastic

Life stages	Duration	'Value' of the living thrips	'Value' of the dead thrips
I and II Larva	33%	17	83
Prepupa	7%	21	79
Pupa	17%	33	67
Adult preoviposition	16%	49	51
Mature adult		79	21
Egg	27%	71	29
I and II Larva		100	0
			100 % duration: from egg to mature adult

Table 1. Value of living and dead thrips individuals.

homogeneity tests were performed on the number of thrips found in the leaf-cages, as well as on SV and on thrips mortality. After the tests of the few leaf stage plants, the characteristics of the lower epidermis (on which thrips were isolated) were measured by a penetrometer (Texture Analyser, Stable Microsystems) using a simple cylindrical probe (0,9 mm in diameter). Data were analysed by Texture Expert software and analysis of variance tests were performed on the thickness and the firmness of the epidermis.

Another antibiotic resistance test was carried out to assess egg mortality. For 24 hours 10 living adults were confined into each leaf-cage set on the plants in order to lay eggs. 10 days after the removal of the adults the cages were opened and the number of emergence holes and unhatched eggs were counted. Stochastic homogeneity tests were performed on the number of eggs laid and on egg mortality.

## Results

### Field screening

Although no varieties were found absolutely resistant to thrips injury, there were significant differences in the degree of susceptibility (Table 2-4). 'Golden Cross', 'Balashi', 'Riana', 'Autumn Queen', 'Leopard', 'Ama-Daneza' and 'Galaxy' suffered the lowest damage. In these cases, it was only by careful examination that injury could be detected. The symptoms were

always confined to a few outer leaves. On the other hand, 'Bejo 1860', 'SG 3164', 'Quisto', 'Green Gem' and 'Ramada' were injured the most by thrips. The outer 6-10 leaves were severely injured and slight damage could be still observed deep in the head (25-30. leaves).

### Antixenosis test

In the extent of feeding injury and the number of adults found on plants no differences were observed between the four varieties at the few leaf stage (Table 5). However, the number of eggs laid on 'Szentesi Lapos' was significantly higher than that on 'Quisto' ( $p<0,01$ ) and 'Coronet' ( $p<0,05$ ).

Although the counting of adults was difficult when plants have started cupping (that is why the number of adults found was extremely low), more adults were observed on 'Histona' than on the other three varieties ( $p<0,01$ ). The extent of feeding injury ( $p<0,01$ ) and the number of eggs laid ( $p<0,05$ ) on 'Histona' were also higher than that on 'Quisto' and 'Szentesi Lapos'.

### Antibiosis tests

At the few leaf stage, the mortality of thrips were considerably high on all four varieties but it was lower on 'Histona' ( $p<0,01$ ) than on 'Quisto' and 'Coronet' (Table 6). Although the susceptibility values were negative for all four varieties, it was the lowest also on 'Histona' ( $p<0,05$ ). The characteristics of the lower epidermis are presented in Table 8. Weak but significant

Variety Group 1.	Date of maturity	Injury <sup>a</sup>	Variety Group 4.	Date of maturity	Injury <sup>a</sup>
Patron	19. June	20,05a	Bejo 1860	8. August	83,57a
Speedon	14. June	18,11a	Quisto	8. August	75,61a
Alpha 3010	19. June	17,74ab	Pruktor	15. August	36,21b
Santorino	19. June	17,3a	Bronco	8. August	27,61bcd
Gonzales	19. June	17,01a	Rotan	15. August	25,18bc
Parel	14. June	16,98a	Frontor	15. August	24,96bc
Resistor	19. June	16,94a	Morris	8. August	23,74c
Elisa	14. June	12,88abc	Gloria	15. August	22,16c
Jetma	14. June	9,608abcd	Satelite	8. August	21,70c
Pandion	14. June	5,579bcd	Autumn Queen	15. August	9,10d
Surprise	14. June	4,557cd	Riana	15. August	4,61d
Golden Cross	14. June	4,504d	Balashi	15. August	4,59d

<sup>a</sup> Means with similar letters are not significantly different at 5% level, by analysis of variance.

Table 2. Relative susceptibility of varieties to onion thrips, group 1 and 4, Tordas, 2000.

Variety Group 2.	Date of maturity	Injury <sup>a</sup>	Variety Group 3.	Date of maturity	Injury <sup>a</sup>
Green Gem	19. July	70,43a	Minoris	27. June	35,21a
Balbro	26. July	39,84b	Charmant	27. June	27,66a
Gollma	19. July	29,81bc	Juno	5. July	25,85ab
Castello	14. July	26,39bc	Histona	5. July	22,74ab
Guardian	26. July	22,45cd	Estron	27. June	22,34ab
Suprema Vantage	19. July	22,05cd	Juniusi Orias	27. June	15,62b
Marcello	19. July	21,97cd			
Consul	14. July	21,96cd	Group 5.		
Admiral	19. July	21,86cd	Ramada	22. August	60,18a
Drummer Girl	26. July	16,12cd	Cecile	22. August	26,87b
Faroo	19. July	11,32d	Coronet	5. September	18,34b

<sup>a</sup> Means with similar letters are not significantly different at 5% level, by analysis of variance.

Table 3. Relative susceptibility of varieties to onion thrips, group 2, 3 and 5, Tordas, 2000.

Variety Group 6.	Date of maturity	Injury <sup>a</sup>	Variety Group 7.	Date of maturity	Injury <sup>a</sup>
Octoking	21. September	24,40ab	SG 3164	12. October	76,35a
Hinova	21. September	19,67a	Burton	12. October	17,09b
Ramco	21. September	15,94abc	Dialog	12. October	14,40bc
Erdeno	21. September	12,75abcd	Upton	12. October	13,15bc
Score	5. October	10,89bc	Avalon	12. October	11,97bc
Mentor	5. October	7,11cd	Ancoma	25. October	10,37bc
Leopard	21. September	4,23d	Agressor	25. October	7,97bc
			Ama-Daneza	25. October	5,73c
<b>Group 8.</b>					
Scandic	16. November	30,82a			
Amager	16. November	21,64a			
Desmond	16. November	12,01ab			
Saratoga	16. November	10,52ab			
Galaxy	23. November	6,882b			

<sup>a</sup> Means with similar letters are not significantly different at 5% level, by analysis of variance.

Table 4. Relative susceptibility of varieties to onion thrips, group 6 - 8, Fertod, 2000.

Variety	Few leaf stage			Cupping – heading stage		
	Adults <sup>b</sup>	Feeding injury <sup>b</sup>	Eggs laid <sup>b</sup>	Adults <sup>b</sup>	Feeding injury <sup>b</sup>	Eggs laid <sup>b</sup>
Quisto	5a	26,39a	7,4a	0a	2,879a	1a
Histona	8,2a	26,14a	11,6ab	2b	30,68b	15,9b
Szentesi Lapos	7,5a	25,2a	37,7b	0,1a	1,132a	0,8a
Coronet	7a	43,09a	15a	0,1a	18,51ab	4,6ab

<sup>b</sup> Means with similar letters are not significantly different at 5% level, by stochastic homogeneity tests.

Table 5. Antixenotic resistance of varieties to onion thrips at the few leaf stage (January, 2001.) and at heading stage (May, 2001.), Budapest.

negative correlation was found between the susceptibility values, the thickness (Kendall tau-b value: -0,208,  $p < 0,01$ ) and the firmness (Kendall tau-b value: -0,135,  $p < 0,05$ ) of the epidermis respectively. In the other antibiotic set-up, egg mortality (Table 7) was lower on 'Szentesi Lapos' than on 'Quisto' ( $p < 0,01$ ) and 'Histona' ( $p < 0,05$ ).

At harvest maturity, no significant differences were found between the varieties except in the number of eggs laid in the second antibiotic set-up (Table 7). More eggs were laid on the head leaves of 'Quisto' and 'Coronet' than that on 'Histona' ( $p < 0,05$ ).

## Discussion

In the field screening test, there were differences in the severity of injury observed on the cabbage varieties. The injury occurred as a result of natural infestation. Assuming that the onion thrips pressure was uniform in each section at the venues, we must conclude that this phenomenon was due to varietal resistance. Since there were adjacent onion fields to our cabbage plots (some of them were overwintering), we could expect a great number of thrips invading to the cabbage field. We were justified by the severe damage occurring on some of the varieties. Although the

Variety	Few leaf stage			Harvest maturity		
	Thrips <sup>b</sup>	Susceptibility <sup>b</sup> 'SV'	Mortality <sup>b</sup> %	Thrips <sup>b</sup>	Susceptibility <sup>b</sup> 'SV'	Mortality <sup>b</sup> %
Quisto	3,8a	-64,12a	79,8a	6,4a	24,16a	4,2a
Histona	5,5a	-26,9b	53,3b	5,3a	-2,625a	13,7a
Szentesi Lapos	4,2a	-58,98a	76,6ab	3,6a	4,454a	15,0a
Coronet	4,5a	-78,82a	96,1c	3,8a	-17,67a	34,2a

<sup>b</sup> Means with similar letters are not significantly different at 5% level, by stochastic homogeneity tests.

Table 6. Antibiotic resistance of varieties to onion thrips and thrips mortality at the few leaf stage (February-March, 2001.) and at heading stage (January-February, 2001.), Budapest.

Variety	Few leaf stage		Harvest maturity	
	Eggs laid <sup>b</sup>	Egg mortality <sup>b</sup> %	Eggs laid <sup>b</sup>	Egg mortality <sup>b</sup> %
Quisto	6,3a	39,7a	10,8a	16,4a
Histona	10,8a	18,8a	5,3b	37,4a
Szentesi Lapos	10,5a	1,4b	5,8ab	23,8a
Coronet	8,0a	18,6ab	12,4a	16,6a

<sup>b</sup> Means with similar letters are not significantly different at 5% level, by stochastic homogeneity tests.

Table 7. Egg mortality of onion thrips and number of eggs laid in a non-choice set-up at the few leaf stage (February, 2001.) and at heading stage (January-February, 2001.), Budapest.

Variety	Thickness <sup>c</sup> (µm)	SD (µm)	Firmness <sup>d</sup> (N)	SD (N)
Quisto	23,4a	6,1	0,208ac	0,0729
Histona	12,7b	3,7	0,172b	0,0476
Szentesi Lapos	22,6a	5,8	0,183ab	0,0639
Coronet	22,8a	5,9	0,234c	0,0639

<sup>c</sup> Means with similar letters are not significantly different at 1% level, by analysis of variance.

<sup>d</sup> Means with similar letters are not significantly different at 5% level, by analysis of variance.

Table 8. Characteristics of the epidermis measured by a penetrometer (March, 2001.), Budapest.

onion thrips pressure was more or less uniform in space, it was not in time. According to the general experience of growers, the local migration period of onion thrips lasts from the middle of June until the middle of September. Generally, in this period the onion thrips pressure is considered to be high, but not uniformly high. When planting the same varieties later in New York State, USA, Stoner observed lower damage (Stoner and Shelton, 1988a). Therefore, sampling data were divided into 8 groups based on the date of the observation. Varieties assessed at the same time (with no larger deviation than two weeks) were mounted into one group. The susceptibility of varieties was compared only within groups (Table 2-4).

During harvest the removal of the highly damaged outer leaves of the head is general practice amongst the growers. Not only does this procedure mean loss in yield but it also makes the harvest less efficient. The more leaves are damaged the more shall be removed. For this reason and because varieties with injury deep in the head are considered more susceptible, the damage ratings for each leaf were not only summarised but multiplied by the square root of the leaf-number on which damage was observed. This modification method was chosen arbitrarily. With the use of this method, the susceptibility of a variety could be consequently expressed by one value based on not only a few sample leaves but all the damage that occurred on a particular plant. The greater the value, the more susceptible the variety, and vice versa. With this method, the extent of the damage could be better identified than with the examination of a few outer leaves.

Our studies have confirmed that there is significant difference in susceptibility to onion thrips between the tested varieties. The value of cumulated damage ratings for 'Bejo 1860' for example exceeded twenty fold the value calculated for 'Balashi' or 'Riana'. This characteristic could be utilised to reduce damage significantly. However, yet the purpose of field monitoring for the resistance of cabbage varieties against onion thrips was not only to gain useful data for the growers but to find promising candidates for further resistance evaluation tests. 11 varieties - 'Balashi', 'Riana', 'Autumn Queen', 'Pandion', 'Surprise', 'Golden Cross', 'Ama-Daneza', 'Mentor', 'Leopard', 'Aggressor' and 'Galaxy'

were appointed as candidates. 'Quisto' was chosen as a control variety for detailed examination of the mechanisms of the resistance that contributed to the overall results of the 11 varieties mentioned above. 'Quisto' is not only one of the most susceptible varieties, but it is also highly regarded by Hungarian growers thanks to its good quality. Due to its susceptibility and wide acceptance it seems to make a good basis for comparison.

The preliminary resistance evaluation tests provided useful experience for further experiments. The antixenotic resistance test of young plants could be accomplished without meeting considerable problems. The counting of adults was relatively easy, considering the size and the number of leaves, and the agricultural plastic worked rather well preventing invasion or escape of thrips without altering the climate of the arena. The counting of eggs laid was also easily executable in case of the young thin and green leaves by using a microscope (12-90X magnification) with translucent illumination. The pale kidney shaped eggs meant quite a contrast on the dark background of the leaf. The assessment of the damaged area of leaves could have been more accurate. The use of a device measuring directly the size of the feeding spots could have given a better comparison than the values of the damage rating scale modified by plant size (assessed by another scale). However, the evaluation was done by one person, which probably reduced the effect of subjectivism.

Although there was no preference of thrips for shelter or feeding site for any variety, 'Szentesi Lapos' seemed to be the most suitable for egg laying. Concerning the replication of the test, in May the latter sown 'Histona' was only at the beginning of cupping, whereas the other three varieties had already started heading. Despite of the physiological difference the test was carried out but it distorted the results. Although the counting of adults produced extremely low values, more thrips were collected from the leaves of 'Histona' than from the other three varieties. The low values were probably due to the delayed counting. All leaves (including the head) were initially removed from the plant and put in plastic bags then the thrips were counted in the laboratory. During the procedure thrips received great disturbance and most likely

escaped without being noticed. The immediate wash of the whole plant with 70% alcohol as described by Stoner (Stoner and Shelton, 1988b) could have resulted in higher figures. Regardless of the number of adults, 'Histona' was preferred for feeding and for egg laying site as well. In our opinion, this outcome could be attributed to the physiological difference amongst the varieties. Based on our general experience, thrips prefer young plant tissue for feeding. The tender leaves of 'Histona' offered better feeding and oviposition sites for the onion thrips.

The varieties used for the first antibiotic set-up (thrips mortality, susceptibility) of the young plants were not exactly at the same physiological age either, because the test was carried out on the latter sown 'Histona'. This reflects in the lowest mortality and in the highest susceptibility values calculated for 'Histona'. However, even on 'Histona' the thrips mortality was quite high and the susceptibility value was negative on plants that had already grown to a premature age with thick leaves. There was significant negative correlation found between thrips-susceptibility, the thickness and the firmness of the epidermis respectively. Since the correlation between the characteristics of the epidermis and thrips mortality was not significant, therefore the lower susceptibility values could not be explained by only the higher thrips mortality due to greater difficulties of feeding. Instead, the cumulative effect of the epidermis characteristics and other factor(s) is suspected. What exactly the other factor(s) could be remains unclear. Although the number of thrips found in the leaf cages did not differ between the varieties, the low figures indicate the necessity for further improvement of the sealing or rather the requirement of greater care for handling. It is suspected that thrips could escape when mounting the larvae into the cage or when fastening the cage onto the leaf. The same test on head leaves of the mature plants produced no significant differences, notwithstanding that the values of susceptibility and thrips mortality were like they could be expected based on the results of field monitoring. This might mean that the increase of replicates could reduce standard deviation to such an extent, that differences became significant. The use of a better susceptibility evaluation method – for example differentiation between  $L_1$  and

$L_2$  instars or mounting thrips individuals being much closer to a certain age into the leaf cages – could also result in more accurate evaluation. The assessment of the egg mortality on 'Quisto' and 'Histona' showed significantly higher values than on 'Szentesi Lapos' in case of the young plants. In this non-choice set-up no egg laying preference was found but testing the varieties at the same growth-stage in the antixenotic set-up revealed strong preference for 'Szentesi Lapos'. The negative correlation between egg mortality and the number of eggs laid in the antixenotic set-up was significant (Kendall tau-b value: -0,284,  $p < 0,05$ ). The same test on head leaves resulted more eggs laid on 'Quisto' and 'Coronet' than on 'Histona', although the egg mortality values did not differ significantly. For accurate assessment the increase of replicates is needed.

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