Ph.D. thesis

The role of plant characteristics in the resistance of white cabbage varieties to onion thrips

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1. INTRODUCTION AND RESEARCH OBJECTIVES

Since being identified 30 years ago on white cabbage, the damage caused by onion thrips has become an ever-present threat requiring continuous management of cabbage crops. A damage free crop can only be obtained by the use of resistant cabbage varieties. During the head forming period, chemical management of onion thrips has not proven satisfactory, and pesticide uses can lead to much higher production costs.

Therefore, a very important issue in white cabbage production is the resistance of varieties against onion thrips. Unsolved problems still exist concerning white cabbage resistance to this threat. During the 1980s, experiments carried out in the USA revealed that antixenotic resistance plays a significant role in the fight against onion thrips. Previous studies carried out in the Entomology Department of the Corvinus University of Budapest revealed that the resistance of white cabbage varieties may differ according to leaf reflection. Therefore it is possible that clay minerals can change leaf reflection properties and induce resistance within susceptible varieties.

However several other factors may also influence these mechanisms; the epidermal thickness or other morphological and physiological parameters may combine to determine the resistance.

Therefore my main objective was to assess the leaf reflection of white cabbage varieties. By using clay minerals to change leaf reflection, the host plant choice of the onion thrips was assessed. One other important question was whether any correlation exists between the epidermal thickness of the different varieties and the damage caused by onion thrips.

2. MATERIALS AND METHODS

Field Location

Between 2008 and 2010 the susceptibility of the tree onion thrips resistant (Balashi', 'Bloktor', 'Riana') and tree susceptible ('Green Gem', 'Hurricane', 'Quisor') white cabbage varieties were tested. My assessment was based on previous work of Fail et al. (2008) and the following parameters were assessed to assess antixenotic resistance against onion thrips: the abundance of colonizing thrips, the thrips damage on white cabbage varieties, the UV-A and visible reflection of the outer and head forming leaves, the epidermal thickness of the cultivars and the weight of the cabbage heads. Assessments were carried out on both untreated and clay minerals treated (Surround® WP respectively Kolloidizált Mikromeliorit®) plants in the Research Station of the National Food Chain Safety Office at Tordas, Hungary.

Clay minerals used for manipulating the leaves reflection

Clay minerals were used in both 2008 and 2009. In 2008 the Surround® WP respectively Kolloidizált Mikromeliorit® were used, in 2009 only the Surround® WP was tested. The Surround® WP contained 95% kaolin and 5% other minerals. After treatment a fine film substrate was observed on plants. The Kolloidizált Mikromeliorit® contains 40-50% zeolite, 30-40% volcanic silicates and 20% other minerals.

Treatments were applied in the morning, because the application was affected by precipitation therefore, after the rain, a new application of clay minerals was carried out. Furthermore, to obtain a uniform substrate the Silwet® L-77 was used together with clay minerals.

Antixenotic Evaluation

Antixenotic evaluation was made in both years by assessing the number of colonizing adults. In 2008 after the sample collection, all plant material was carried to the university and thrips assessment carried out on the same day. In 2009 and 2010 plant materials were collected together from all six varieties and kept refrigerated at 4ºC pending assessment. Forty-eight samples from each variety were collected, the data from sample collections were always correlated with the time elapsed between the first thrips adult presence respectively degree-days needed for the next generation.

Firstly the head weight of each variety was measured, then from each head forming leaf up to ten, the number of onion thrips were assessed under a stereomicroscope. The number of thrips found in the 10 leaves were counted and these values then used for antixenotic evaluation. In assessing the antixenotic resistance of the cultivars, the relative abundance of the individuals was considered. This was done because the relativity of the resistance is better represented, and the year effect is reduced.

Onion Thrips Damage Assessment

In each years damage assessment was carried out at harvesting in in the Plant Cultivars Research Station of the National Food Chain Safety Office at Tordas, Hungary. Similarly with the antixenotic resistance 48 plants were assessed. The head weight and the damage level on the leave's abaxial sides were determined according to the procedures developed by Fail et al. (2006).

For damage assessment an approximation method was used between 0 and 1. For this the percentages of the damaged surfaces were determined and approximated with the most appropriate decimal value.

In this way the value 0 indicated no damage, value 1 indicated 100% damage. Intervening values were expressed in increments of 0.1. The damage values thus obtained for each leaf were recorded and taken to represent a damage value for the individual plant. The number of damaged leaves were also taken into consideration.

Statistical analyses were ten carried out on damage values and number of leaves damaged for each variety.

Leaves Reflection Measurements

Leaf reflection assessment of each white cabbage variety was made at the Technical University of Budapest, Department of Optics and Mechanic Informatics under the supervision of Balázs Vince Nagy PhD.

Assessments were made three times in 2008, according to the number of samples collected, while only one reflection measurement was made in 2009

The UV-A and visible reflection of the outer and head forming leaves were measured. From each cultivar 12 outer and 24 head forming leaves were collected. Because the shape heterogeneity of the leaves, four measurements on outer leaves and two measurements on head forming leaves were carried out. For visible reflection a Konica Minolta CM-2500d was used, while for UV-A reflection a special tool made by Balázs Vince Nagy PhD was manufactured.

Epidermal thickness evaluation

The epidermal thickness was assessed three times in 2008 and once in 2009, during which the number of thrips were also assessed. Samples were taken from the second head forming leaf of each variety, and 48 replicates per variety were used.

For epidermal thickness assessment, a Leica DM LB HC stereomicroscope was used and a total number of 288 samples from leaf abaxial and 288 from leaf adaxial parts were measured.

Data Analysis

First all data were analysed in terms of distribution using the Kolmogorov-Smirnov test. When data showed normal distribution,

parametric testing was used, then the homogeneity of variances were tested with the Levene test. The Tukey HSD test was used for homogenous variances and the Games-Howell test when no homogeneity of variance was detected. For these data bar charts were used as figures and confidence intervals of 95% were used.

If data was not normally distributed the Kruskal-Wallis test and then the Mann-Whitney U test was used to compare variables. For each pair of values the Bonferroni corrections were used. For these data boxplots were used for figures. All analyses were made with IBM SPSS version 20.

3. RESULTS

Antixenotic Evaluation

Assessing the antixenotic resistance of the cultivars allowed the relative abundance of the individuals to be considered. This was done because the relativity of the resistance is better represented, and the year effect is reduced. Analyses revealed that there were significant differences between varieties on the colonising onion thrips. Treatments with clay minerals Surround® WP and Kolloidizált Mikromeliorit® however did not influenced the rate of colonization.

By considering our yearly results separately, we observed that in 2008 the highest number of thrips was detected on Green Gem, followed by Hurricane and Quisor. The lowest number of thrips were detected on resistant varieties (Balashi, Bloktor and Riana) with no significant differences between them.

In 2009, at the beginning of head formation, the highest number of thrips was again detected on Green Gem, followed by Hurricane with no significant differences between cultivars. A much lower number of thrips were detected on susceptible Quisor. Significantly higher number of thrips were detected on Bloktor than on Balashi and Riana.

In 2010 the highest number of thrips was detected on Green Gem, followed by Quisor and Hurricane and again no significant differences between resistant varieties were detected. Altogether more thrips were counted on susceptible than on resistant varieties.

In 2008 the highest thrips abundance was detected on Hurricane treated with Surround® WP than on plants with Kolloidizált Mikromeliorit®. More thrips on clay treated Riana were detected than on the control. No effects of treatments on other cultivars were detected.

In 2009 on Balashi and Bloktor varieties with Surround® WP the relative number of thrips was higher than on the control, while on susceptible Green Gem the thrips abundance on control plants was much higher than on treated plants.

Onion Thrips Damage Assessment

The highest damage was recorded on Hurricane and Green Gem varieties. Highly significant positive correlations were detected between the onion thrips abundance inside the cabbage heads and the extent of damage. Again no effects due to mineral treatments on damage were detected.

Leaves Reflection

Leaf reflectance in both UV-A, and the visible range has significant effects on thrips colonisation, i.e. higher reflectance means lower colonization rates. Even if the leaves reflectance increases in absolute range by the use clay minerals, this has no influence on colonization.

No direct relationship between white cabbage leaves reflection intensity and onion thrips colonization has been detected. In spite of these results our observations is not in contradiction with the negative effects

of higher reflection on thrips colonization because several other factors may influence the rate of colonisation.

Considering each year separately, in 2008 the highest reflection was detected on plants treated with Surround® WP on both outer and head forming leaves. Lower reflection was detected on plants treated with Kolloidizált Mikromeliorit®. The lowest reflection was detected on untreated plants. A similar trend was detected in 2009.

Epidermal thickness evaluation

The epidermal thicknesses in both abaxial and adaxial parts of the second head forming leaves were assessed. Based on these result, we can conclude that epidermal thickness has no effect on antixenotic resistance of white cabbage to onion thrips.

Again, considering each year separately, in 2008 the highest epidermal thickness was detected on Riana, while in 2009 the highest was on Hurricane. We consider that the higher the epidermal thickness, the higher the detected resistance to thrips.

Our results however show that white cabbage varieties cannot be classified as susceptible or resistant according to their epidermal thickness. No correlations between both abaxial and adaxial epidermal thickness and resistance against onion thrips were found.

Association between the weight of the cabbages and onion thrips damages

In 2008 at the beginning of the head formation, no correlation between the colonising thrips populations and cabbage weight were detected. Also no correlation between damage and head weights at harvest were detected.

In 2009 and 2010 a significantly high positive correlation was detected between the number of thrips and cabbage weight, and again similar positive correlation between thrips damage and head weight at harvest. The same trend was observed in 2009 under clay mineral treatments.

4. NEW SCIENTIFIC RESULTS

1. Leaf reflection of three resistant (‘Balashi’, ‘Bloktor’, ‘Riana’) and three susceptible white cabbage varieties (‘Green Gem’, ‘Hurricane’, ‘Quisor’) were detected at UV-A (360-400 nm) and visible (401-650 nm) range.

2. The leaf reflection of the resistant varieties was generally higher than for susceptible varieties.

3. Treatment with clay minerals (Surround® WP and Kolloidizált Mikromeliorit®) increased at absolute level the lea reflection of the white cabbage varieties at two-fold level.

4. No effects of clay minerals on onion thrips damage has been detected.

5. No effects of white cabbage epidermal thickness on onion thrips resistance can be detected.

5. DISCUSSION

Based on these results further connections are highlighted in the attempt to understand relationships between onion thrips colonization, damage and leaf reflections of white cabbage varieties. Our assessment has revealed that the highest number of thrips were detected on susceptible varieties. The lowest number on resistant varieties.

In 2008 the highest thrips abundance was detected on Hurricane treated with Surround® WP compared to plants with Kolloidizált Mikromeliorit®. In 2009 on varieties Balashi and Bloktor with Surround® WP the relative number of thrips was higher than on the control.

Highly significant positive correlations were detected between onion thrips abundance inside the cabbage heads and the extent of damage. Again no effects of mineral treatments on damage were detected.

No direct relationship between white cabbages leaves' reflection intensity and onion thrips colonization has been detected. In spite of these results our observations are not in contradiction with the negative effects of higher reflection on thrips colonization because several other factors may influence the rate of colonisation.

In 2008 the highest reflection was detected on plants treated with Surround® WP on both outer and head forming leaves. Lower reflection was detected on plants treated with Kolloidizált Mikromeliorit®. The lowest reflection was detected on untreated plants. Similar trends in 2009 were detected.

Epidermal thickness has no effect on white cabbage antixenotic resistance to onion thrips. We considered that the higher the epidermal thickness, the

higher the resistance against thrips. Our results however show that white cabbage varieties cannot be classified as susceptible or resistant according to their epidermal thickness. There were no associations between the weight of the cabbages and onion thrips damage. However, comparing the varieties, a highly significant positive correlation between the extent of damage and the weight of the cabbages was detected.

Several other factors influencing white cabbage varieties however, may be responsible for this resistance, such as the reproduction biology of onion thrips. Finally, the clarification of the true relationship between white cabbage and onion thrips could be the key for a successful resistance breeding.

PUBLICATIONS IN THE SUBJECT OF THIS STUDY

BÁLINT, J., NAGY, B.V., FAIL, J. (2013): Correlations between colonization of Onion Thrips and leaf reflectance measures across six cabbage varieties, PLoS ONE 8(9): 1-8, e73848. (IF. 3,534)

BÁLINT, J., BURGHARDT, N., HÖHN, M., PÉNZES, B., FAIL, J. (2013): Does epidermal thickness influence white cabbage resistance against onion thrips (Thrips tabaci)? Not Bot Horti Agrobo (41)2: 444-44. (IF. 0,476)

BÁLINT, J., CSÖMÖR, ZS., PÉNZES, B., FAIL., J. (2010): The effect of silicate minerals on the head weight of white cabbage and on the colonization and damage of onion thrips, University of Agronomical Sciences and Veterinary Medicine, Scientifical Papers, 54: 22-30, ISSN 1222-5312, index BDI-CABI.