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TABLE OF CONTENTS

VEGETABLE GROWING

Code	Title	Authors	Page number
VG 01	Future material for the sweet pepper breeding, created at VRDS - Bacău	Silvica Ambăruş Creola Brezeanu P. M. Brezeanu Maria Călin Tina Oana Cristea	015-018
VG 02	Determination of the production performance of new carrot cultivars in Constanta area	I. Anagnoste Gh. Câmpeanu N. Atanasiu Gabriela Neața	019-021
VG 03	The effect of silicate minerals on the head weight of white cabbage and on the colonization and damage of onion thrips	J. Bálint Zs. Csömör, B. Pènzes J. Fail	022-030
VG 04	Comparative study on total polyphenolics and flavonoids content at artichoke and cardon	Eleni Balomenou Liliana Bădulescu Eugenia Iobi	031-036
VG 05	Changes of some biochemical and agrochemical characteristics of tomatoes storage	Daniela Barcă Manuela Costache Ghiorghița Fiscuci	037-041
VG 06	Iulica, a new variety of *Salvia officinalis* L. obtained at V.R.D.S. Bacău	Brezeanu Creola Brezeanu P. M. Ambăruş Silvica	042-045
VG 07	Verdana, a new *Phaseolus vulgaris* L. variety obtained at V.R.D.S Bacău	P. M. Brezeanu Creola Brezeanu Silvica Ambăruş	046-050
VG 08	Organic vegetable growing on ecological practice	Elena Catană Gh. Câmpeanu N. Atanasiu Gabriela Neață Vasilica Manea	051-056
VG 09	The study of eggplant ability for cultivations in tunnels in ecological agriculture conditions	Maria Călin L. Stoian Tina Oana Cristea Silvica Ambăruş D.I. Avasiloiei Creola Brezeanu P.M. Brezeanu	057-060
VG 10	New technological elements in setting up an asparagus plantation (*Asparagus officinalis L.*)	Andreea Ciotlos N. Atanasiu Gh. Câmpeanu Diana Chetreanu	061-065
VG 11	Comparative study regarding the agronomic performance and mitotic activity at *Capsicum annuum* L. plants regenerated *in vitro* versus seed-born plants	Tina Oana Cristea Silvica Ambăruş Maria Prisecaru Maria Călin Creola Brezeanu M. Brezeanu	066-072
VG 12	The effect of organic products in the approving process on eggplant seed germination	Elena Maria Drăghici Dorotheus Wisman Andi Bratosin Luchian Viorica Lagunovschi Elena Dobrin	073-077

The effect of silicate minerals on the head weight of white cabbage and on the colonization and damage of onion thrips

J. Bálint[1,2], Zs. Csömör[1], B. Pénzes[1] and J. Fail[1]
[1]Corvinus University Budapest, Hungary
[2]Sapientia University Târgu Mureş, Romania
balint.janos@yahoo.com

Keywords: white cabbage, *Thrips tabaci*, onion thrips, antixenosis, kaolin, silicate minerals

ABSTRACT

In the last few decades onion thrips has become a major pest of white cabbage in the summer production period. Although the most effective control measure is the use of resistant varieties, little is known about the resistance mechanism(s) involved. In 2008, a study was carried out with 6 cultivars to confirm that antixenosis is at least partly responsible for the resistance of white cabbage against onion thrips. The number of adult thrips was counted on the outer ten head leaves twice during head formation. Onion thrips damage was also assessed at full maturity of cabbage. Cabbage head weight was recorded at each assessment. Two different silicate mineral products Surround® WP and Kolloidizált Mikromeliorit® was applied as foliar spray treatments several times during head formation. Antixenosis was found to be responsible for the resistance of 'Balashi', 'Bloktor' and 'Riana' cultivars, since the number of colonizing onion thrips adults found on head leaves was significantly lower than that of 'Green gem', 'Hurricane' and 'Quisor'. The resistant cultivars ('Balashi', 'Bloktor' and 'Riana') similarly suffered significantly lower damage than the susceptible ones ('Green gem', 'Hurricane' and 'Quisor'). The foliar spray treated cabbage heads were usually significantly bigger, than the untreated ones. The increased growth of cabbage was most likely caused by the positive effects of the silicate minerals on the development of cabbage. The foliar spray treatments in general had no effect on thrips colonisation and in consequence on thrips damage but it seemed to increase the number of colonizing thrips adults and in consequence the damage of thrips in 3 cases (out of 12).

INTRODUCTION

White cabbage is one of the oldest cultivated vegetable plants. In the Middle East Europe its field cultivation has been known for more than 500 years. It has a major role in the world, especially in the Far East. It represents 10 percent of the world's vegetable production and 20 percent of the total cultivation area (Zatykó, 2004). In the last two decades the onion thrips has become a major pest of white cabbage in the summer production period (Fail, 2002).

The onion thrips – ***Thrips tabaci*** **LINDEMAN, 1889** – belongs to Order Thysanoptera, Suborder Terebrantia, Family Thripidae (Jenser 1988), syn.: *Thrips allii* GILETTE, *Thrips communis* UZEL, *Thrips solanaceorum* WIDGALM, *Thrips bicolour* KARNY, *Thrips debilis* BAGNALL, *Thrips hololeucus* BAGNALL (Jenser, 1982). Thrips damage on white cabbage was reported for the first time in the United States of America in the late 19th century (Lintner, 1892). In the 1950's in the south east part of Iowa State's cultivation area Wolfenbarger and Hibbs (1958) found bronze discolouration on the surface of white cabbage head forming leaves, and the symptoms were attributed to the damage of onion thrips. In 1983 Kretschmer (1984) confirmed with his experiment that similar symptoms like the ones described above were caused by thrips damage.

Silicate minerals and their utilization

The utilization of kaolin for fruit and vegetable cultivation is mostly studied in the United States of America. Surround® WP (NovaSource, Tessenderlo Kerley Inc., Phoenix, AZ, USA) - 95% kaolin clay - proved to be efficient against several insect pests, especially against those that damage fruit crops including pear, apple, grape, berries and some vegetables. It is excellent against sunburn and heat stress damages (Anonymous 2004). The particles reflect infrared and ultraviolet rays, cooling the surface of the fruit. Additionally decreases the foliage temperature of the treated trees. According to USDA studies photosynthesis is increased with 30 percent (Heacox, 2001). A recent study confirmed the effectiveness of kaolin against flower thrips (*Frankliniella* spp.) damaging rabbiteye blueberry (*Vaccinium ashei* READE). Although the treatment decreased the flower thrips population with 50%, it did not influence the yield (Spiers et al. 2003). In South Africa thrips cause severe damage in mango plantations. In field trials kaolin based Surround® WP (a registered product in South Africa) was used in two ways: by itself and combined with sulphur. It was applied once or twice at the beginning of the season. It proved to be effective against thrips, while combined with sulphur it was efficient against other pests (Joubert et al. 2004). The kaolin based Surround® WP is used against heat stress and sunburn in pineapple plantations. Several trials have proven that the early use of kaolin before any major temperature changes reduces the occurrence of inner or outer sunburn. Under hot and dry climatic conditions it prevents leaf damage, resulting in a significant yield increase (Bell et al. 2006). In the southern United States of America the biggest yield loss in tomato is caused by TSWV. The virus is exclusively spread by thrips. In a two years field trial the effectiveness of essential oils (geraniol, lemongrass oil and tea tree oil), kaolin clay and traditional insecticides against thrips were compared. The treatments did not clearly affect the insect populations, but kaolin combined with essential oils decreased the occurrence of TSWV. Kaolin treatments increased the yield by over 26% (Reitz et al. 2008). Larentzaki et al. (2008) observed a negative effect of kaolin on the biology of onion thrips. In untreated onion plots significantly more adults and larvae were captured then in kaolin treated plots.

The Kolloidizált Mikromeliorit® (Geoproduct Healing Minerals Ltd., Mád, HU) is a mineral crop protectant and foliar fertilizer, most frequently used in ecological farming. Its main ingredients are silicate minerals - clinoptilolite 40-50%, clay minerals (montmorillonite, illite, etc.) 20% -, and volcanic glass 30-40%. It is recommended against paprika and tomato blossom rot and damping off, apple sunburn, and against downy- and powdery mildew in several crops.

The aim of this study is to test the effect of two different foliar spray silicate minerals on the yield of white cabbage. There is an important question to be answered as well: do silicate minerals affect the colonization and damage of onion thrips on white cabbage?

MATERIALS AND METHODS

The experiment was carried out at the Tordas Station of the Central Agriculture Office, Tordas, Hungary. Greenhouse grown seedlings of 6 cultivars, ('Balashi', 'Bloktor', 'Green Gem', 'Hurricane', 'Quisor' and 'Riana') were transplanted outdoors on the 15th of May 2008. Plots were composed of 7 rows of 13 plants, spaced 0.6 by 0.6 m apart. These plots were replicated six times in a randomized block design with an alleyway of 3 m separating replicates. Standard herbicide, fertilization and irrigation practices were employed. Plants were treated with pesticides against pest and disease. Two plots received no further treatments and served as control, two were treated with Surround® WP and two with Kolloidizált Mikromeliorit®.

The time and methods of foliar spray treatments

Treatments were first applied as soon as cupping began. During head formation plants were sprayed altogether 10 times, from 24th of June until 29th of August. The frequency of applications was influenced by natural rainfalls. Surround® WP was always applied in a dose of 20kg/ha. Kolloidizált Mikromeliorit® was applied in the same dose at the time of the first two treatments but from its third application onwards the dose was doubled to 40kg/ha, because of inappropriate coverage on the cabbage foliage in the lower dose. A surfactant (Silwet L-77, in a dose of 15ml/l) was added to both silicate minerals at every application.

The measurement of cabbage yield

The weight of sampled cabbage heads was measured with a digital scale. This was carried out before any further assessment.

Antixenotic evaluation

In order to assess the antixenotic resistance of cabbage cultivars the number of colonizing thrips adults was counted on cabbage head leaves two times, at the beginning and in the second half of head formation. For every treatment 24 randomly selected cabbage heads were removed and placed in plastic bags from each plot (dates are given in Table 1 under the 'Antixenotic evaluation' column). The samples were immediately transported to the laboratory and kept in plastic bags at room temperature until the antixenotic evaluation was completed. The first ten outer head leaves were removed one after the other and the number of adult thrips on both sides was counted under a stereomicroscope. The combined number of adult thrips on all ten leaves was used in statistical analysis describing the number of colonizing adults in a given cabbage head.

Damage assessment

Onion thrips damage assessment was carried out at harvest maturity of the varieties (exact dates are given in Table 1 under the 'Damage assessment' column). 24 randomly selected cabbage heads were taken from each plot. For the assessment of thrips damage (the result of spontaneous thrips infestation) an evaluation method was developed (Fail, 2006). Cabbage head leaves were evaluated and peeled off the head one after the other until four consecutive leaves showed no damage. For every examined head-forming leaf the extent of damage was noted (only on the underside of the leaves) in the form of the proportion of damaged surface to the entire surface of the leaf: from 0 to 1 with an accuracy of 0.1. Resistance is represented by the sum of these values describing the rate of damage observed in the whole head. A given figure expresses the size of the total damaged leaf surface in the entire cabbage head in proportion to the size of the underside of the first head-forming leaf.

Data Analyses

Data were analyzed with PASW Statistics 18, release 18.0.0 (July 30, 2009). When the original data met the assumptions of normality (tested by Kolmogorov-Smirnov test), treatments and cultivars were compared by Tukey's test or Games-Howell test depending on the homogeneity of variances (tested by Levene test). When the original data of colonizing thrips adults and thrips damage did not meet the assumption of normality, Tukey's test or Games-Howell test was performed on the normalized square root and log transformed data. When normality was not achieved after data transformation, the nonparametric Kruskal-Wallis test was used, followed by Mann-Whitney U tests for comparisons of treatments and cultivars. All data are reported as original means and 95 % confidence interval of means on figures 1-5. Means with different letters are significantly different from each other according to the applied statistical test ($P \leq 0.05$). On figures 2-5, the letters right next to the confidence intervals show the differences between the applied treatments within a cultivar. Those letters situated in a coloured box above figure 1-5 show the differences between cultivars within treatments.

RESULTS AND DISCUSSION

Cabbage yield

At the time of the first evaluation cabbage head weight was between 34 and 117 gram. By the time of the second measurement the cabbage heads almost reached harvest maturity; head weight was between 1800 and 2600 gram. At the time of the final evaluation head weight varied between 2300 and 3500 gram.

Evaluating cabbage yield in the control treatment in the second half of head formation it was found that ‘Quisor’, ‘Riana’ and ‘Balashi’ cultivars had the biggest head weight (Fig. 4.). In contrast to this, the cultivars ‘Bloktor’, ‘Green Gem’ and ‘Hurricane’ produced considerably smaller heads. The head weight of ‘Bloktor’, ‘Green Gem’ and ‘Quisor’ cultivars in the Surround® WP treatment was equal to that of in the control treatment (Fig. 4.). But in case of ‘Balashi’, ‘Hurricane’ and ‘Riana’ cultivars the mean weight of sampled cabbage heads was significantly bigger in the Surround® WP treatment than in the control treatment. The mean head weight of ‘Bloktor’ cultivar in the Kolloidizált Mikromeliorit® treatment was equal to that of in the control treatment (Fig. 4.). But the mean weight of the collected cabbage heads in case of ‘Green Gem’ and ‘Quisor’ was slightly bigger, in case of ‘Balashi’, ‘Hurricane’ and ‘Riana’ cultivars was significantly bigger in the Kolloidizált Mikromeliorit® treatment than in the control treatment.

At harvest maturity a similar result was found than in the second half of head formation regarding cabbage yield. The cultivars ‘Quisor’, ‘Green Gem’ and ‘Balashi’ had the biggest head weight (Fig. 5.). In contrast to this, the cultivars ‘Bloktor’, ‘Riana’ and ‘Hurricane’ produced smaller heads. The mean head weight of ‘Bloktor’ and ‘Quisor’ cultivars in the Surround® WP treatment was equal to that of in the control treatment (Fig. 5.). But in case of ‘Green Gem’ slightly bigger, in case of ‘Balashi’, ‘Hurricane’ and ‘Riana’ cultivars significantly bigger cabbage heads were harvested in the Surround® WP treatment than in the control treatment. The head weight of ‘Green Gem’ cultivar in the Kolloidizált Mikromeliorit® treatment was equal to that of in the control treatment (Fig. 5.). In case of ‘Bloktor’ slightly bigger, in case of ‘Balashi’, ‘Hurricane’ and ‘Riana’ cultivars significantly bigger cabbage heads were harvested in the Kolloidizált Mikromeliorit® treatment than in the control treatment. However, ‘Quisor’ produced slightly smaller heads in the Kolloidizált Mikromeliorit® treatment than in the control treatment (Fig. 5.). We assume that this phenomenon was due to biased sampling since the contrary was observed for ‘Quisor’ when head weight was measured in the second half of head formation (Fig. 4.).

When considering all six cultivars in both yield assessments, the Surround® WP treated cabbage heads were 7 times bigger and 5 times equal in weight, than the untreated ones. Similarly, the Kolloidizált Mikromeliorit® treated cabbage heads were 9 times bigger, twice equal and once smaller in weight, than the untreated ones. The observed higher yield of cabbage was most likely caused by the positive effects of the silicate minerals on plant growth, which has been reported in other crops (Heacox, 2001, Anonymous, 2004, Bell et al. 2006, Reitz et al. 2008).

There seemed to be a difference between the cultivars in their yield response to the silicate mineral foliar spray treatments. The mean head weight of ‘Balashi’, ‘Hurricane’ and ‘Riana’ cultivars was always bigger in both silicate mineral foliar spray treatments than in the control. At the same time, the yield of ‘Bloktor’, ‘Green Gem’ and ‘Quisor’ increased in the silicate mineral foliar spray treatments once, twice and once, respectively.

Antixenotic evaluation

Significant differences were found between the 6 cultivars in the number of adult thrips counted in cabbage heads. At the time of the first antixenotic evaluation the most thrips were found on the cultivar ‘Green Gem’ (Fig. 1.). Equally less number of thrips colonised the cultivars ‘Quisor’ and ‘Hurricane’. Concerning those cultivars (‘Bloktor’, ‘Riana’ and ‘Balashi’) that were categorised as resistant in previous studies (Fail, 2005, 2006, Fail at al. 2002, 2008) even less thrips colonised the small cabbage heads (Fig. 1.). At the time of the second assessment a drastic increase in the number of colonising thrips was observed on the susceptible cultivars. The most adult thrips were again counted on ‘Green Gem’ in the control treatment (Fig. 2.). Significant difference was observed between ‘Quisor’ and ‘Hurricane’, the latter one supporting a thrips population three times the size then ‘Quisor’. The resistant cultivars were again colonised by the least number of thrips, although there were no significant differences in between them (Fig. 2.).

The silicate mineral foliar spray treatments did not seem to affect the thrips colonisation of cabbage in 9 cases out of 12 (Fig. 2.). The mean number of thrips found in heads was slightly more only on 'Hurricane' and 'Riana' cultivars in the Surround® WP treatment compared to the control treatment. Similarly, slightly more thrips were found on 'Riana' only in the Kolloidizált Mikromeliorit® treatment than in the control treatment (Fig. 2.).

This study further confirms that antixenosis does play a role in the resistance of cabbage to onion thrips. The silicate mineral foliar spray treatments had very little or no effect on thrips colonising cabbage.

Damage assessment

The most intensive damage was noticed on 'Hurricane' cultivar in the control treatment (Fig. 3.). 'Green Gem' and 'Quisor' was damaged to a considerably less extent. Concerning the resistant cultivars, they only suffered insignificant damage but amongst them the highest mean value of the damage rating scale was calculated on 'Bloktor'. The damage on 'Balashi' and 'Riana' was absolutely negligible (Fig. 3.).

The silicate mineral foliar spray treatments in comparison with the control did not seem to affect the extent of damage in cabbage in 9 cases out of 12 (Fig. 3.). 'Riana' was damaged slightly more in both silicate mineral foliar spray treatments than in the control treatment (Fig. 3.). This is most likely the direct consequence of the increased number of colonising thrips observed previously in both treatments (Fig. 2.). Although the same number of thrips colonised the cultivar 'Bloktor' in all three treatments, slightly more damage was observed on this cultivar in the Surround® WP than on the other two treatments (Fig. 3.). On the contrary, more thrips colonised the cultivar 'Hurricane' in the Surround® WP treatment than in the control, this did not lead to greater damage in the Surround® WP treatment at final harvest (Fig. 3.).

There was a positive correlation between the number of colonising adult thrips and the thrips damage assessed at harvest maturity. The value of the calculated Spearman rank correlation coefficient between the two variables was 0.541 ($P \leq 0.000001$) in case of the first antixenotic assessment. At the time of the second antixenotic evaluation an even stronger correlation ($\varrho = 0.702$, $P \leq 0.000001$) was observed between the two variables.

CONCLUSIONS

Based on this trial it was concluded that the use of Surround® WP and Kolloidizált Mikromeliorit® in a foliar spray treatment series more often than not increased the yield of cabbage. The cultivars 'Balashi', 'Hurricane' and 'Riana' better responded to the treatments than the other three studied cabbage cultivars. The silicate mineral foliar spray treatments had very little or no effect on thrips colonising cabbage and in consequence on the thrips damage assessed at harvest maturity.

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TABLE AND FIGURES

Table 1

Timetable of evaluations

Variety	1st Antixenotic evaluation		2nd Antixenotic evaluation		Damage assessment	
	date	**d.a.t.**	**date**	**d.a.t.**	**date**	**d.a.t.**
Balashi	25th of June	41	24th of July	70	11th of August	88
Bloktor	25th of June	41	04th of August	81	10th of October	148
Green Gem	19th of June	35	21th of July	67	12th of August	89
Hurricane	24th of June	40	31th of July	77	17th of September	125
Quisor	19th of June	35	29th of July	75	19th of August	96
Riana	24th of June	40	28th of July	74	21th of August	98

*: d.a.t. = days after transplantation

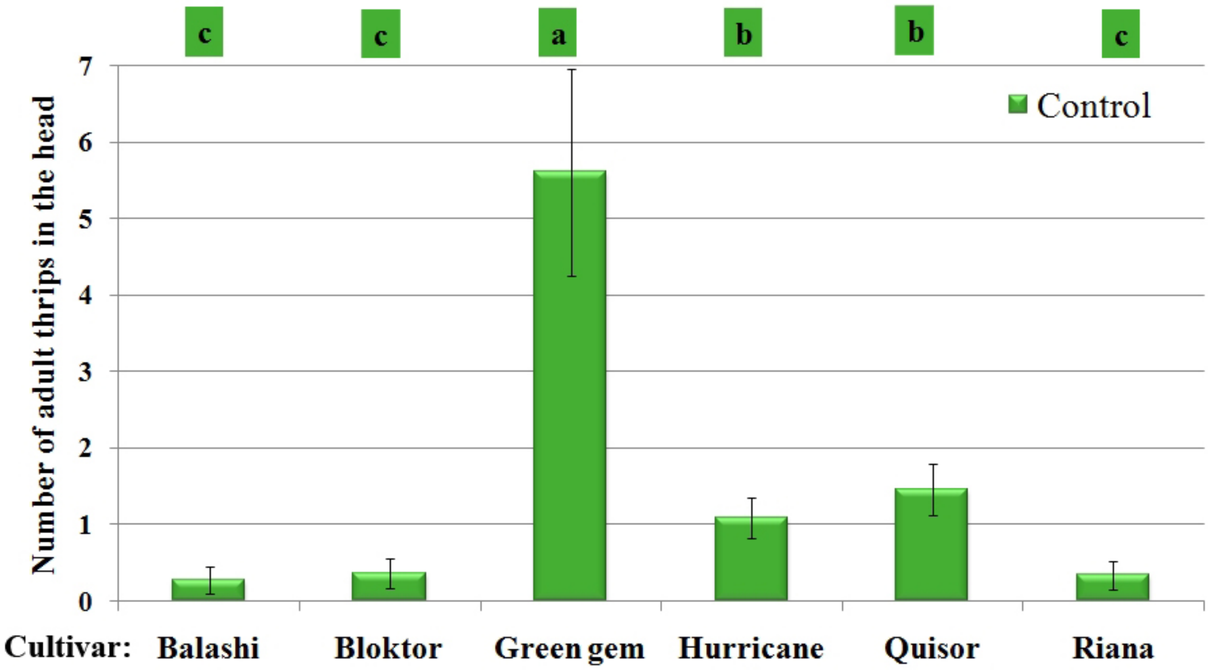

Fig. 1. Number of colonizing adult thrips at the beginning of cabbage head formation (P≤0,05)

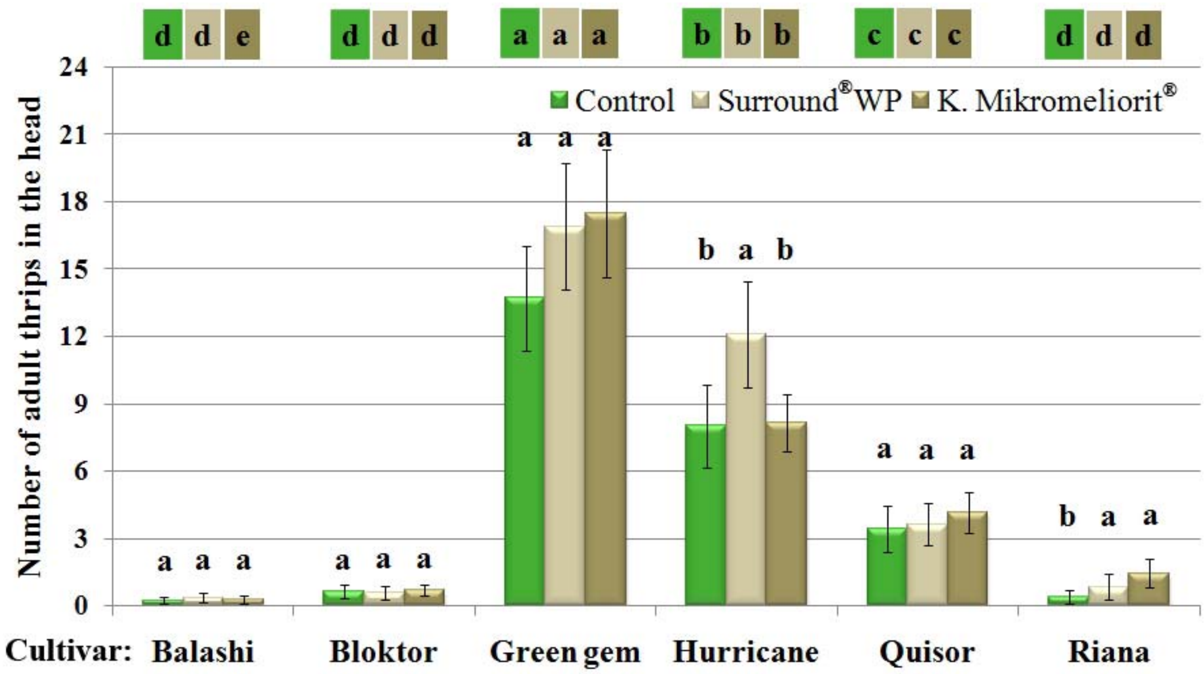

Fig. 2. Number of colonizing adult thrips in the second half of cabbage head formation (P≤0,05)

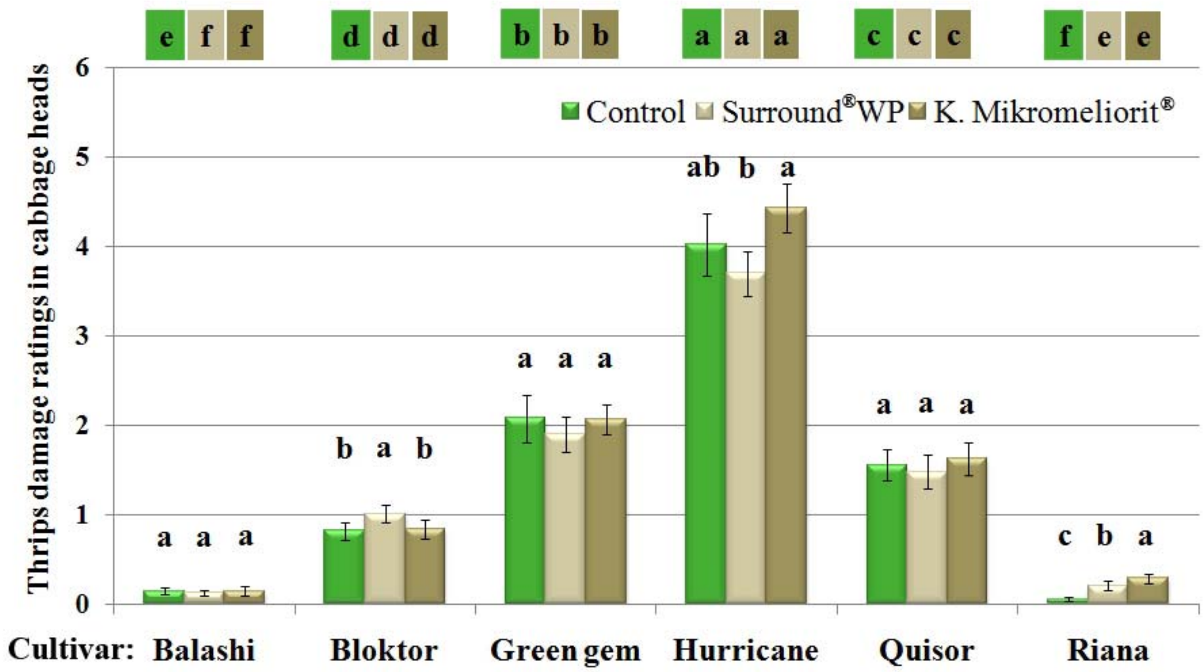

Fig. 3. Thrips damage ratings at harvest maturity of cabbage heads (P≤0,05)

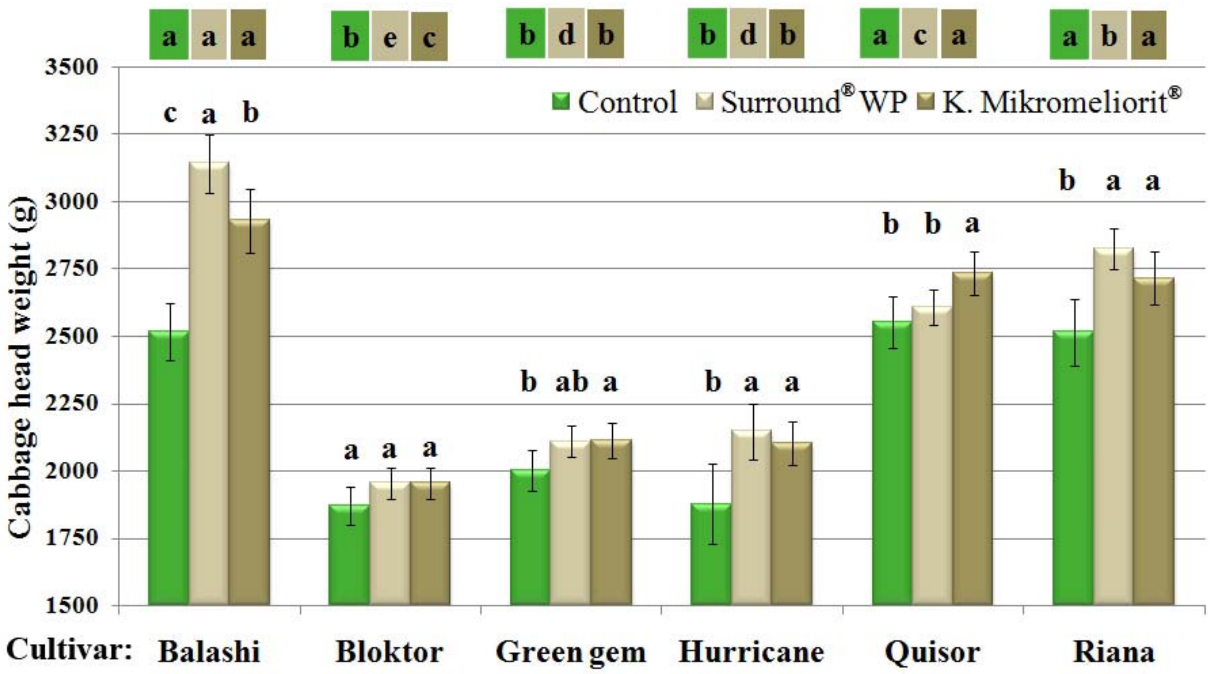

Fig. 4. White cabbage head weight in the second half of head formation (P≤0,05)

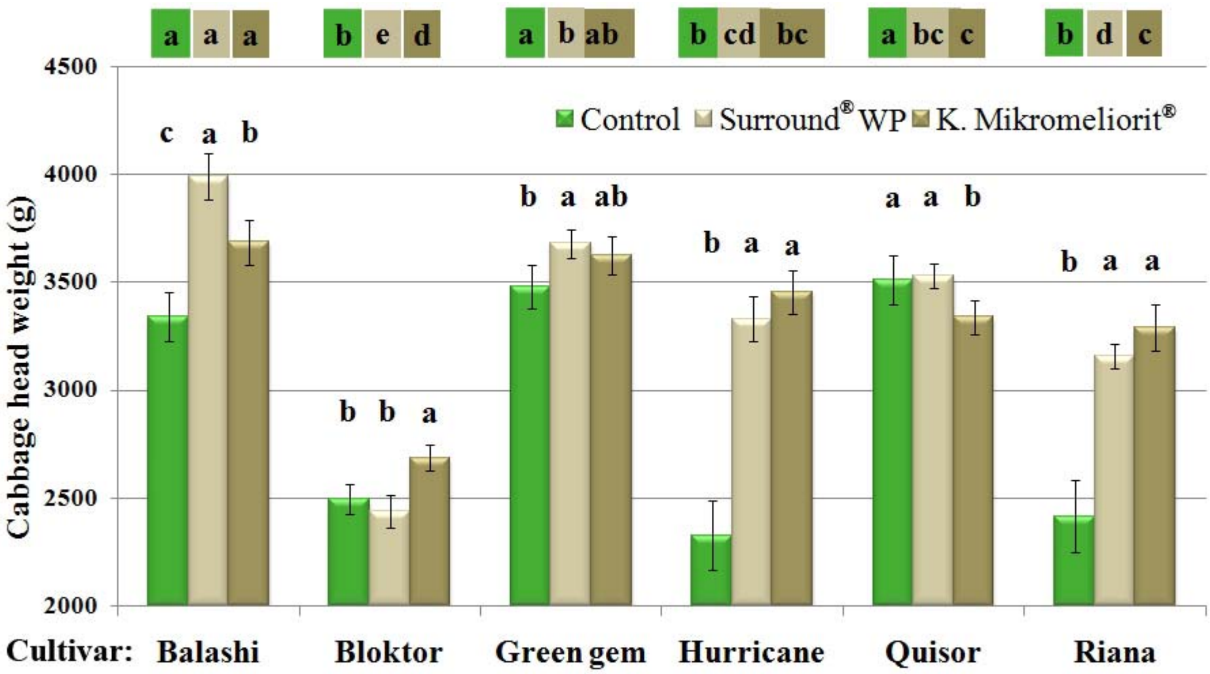

Fig. 5. White cabbage head weight at harvest maturity (P≤0,05)