Testing the suitability of three herbs as intercrops against the Allium leaf miner (Phytomyza gymnostoma Loew, Diptera, Agromyzidae) in onion production

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Abstract

During 2009 and 2010, field experiments were conducted in Ljubljana to study the efficacy of three herbs (oregano, rosemary and common lavender) as intercrops for reducing Phytomyza (Napomyza) gymnostoma damage on onion plants. Two onion cultivars (‘Holandska rumena’ and ‘Ptujska rdeča’) were involved in the experiment. Results of our research indicated that in 2009 different intercrops did not have an influence on the cultivar Holandska rumena, meanwhile cultivar Ptujska rdeča gained the highest yield in control treatment (184.2±6.6 g) and the lowest one in treatment where oregano plants were interplanted (147.2±6.1 g). Plants of common lavender proved to be the less suitable in intercropping system as the yield of both onion cultivars was lowest in 2010. Mean index of damage caused by Allium leaf miner was influenced as by onion cultivar as plant species which were used as intercrops. In 2009 we noted less damage in ‘Holandska rumena’, the lowest range of damage on onion (1.36±0.03) was in treatment with oregano as intercrop. In 2010 we did not confirm differences in the extent of damage between cultivars, similar as also between different species of intercrops. We conclude that, in 2009 and 2010, the Allium leaf miner did not reduce the yield of onion, therefore we cannot expose any intercrops tested as a suitable plant species for diminishing the damage caused by the larvae on onion.

Key words: Phytomyza gymnostoma, intercropping, Allium cepa, oregano, rosemary, common lavender.

Introduction

Onion (Allium cepa L.) is tolerant to cold and hot temperature and is grown in most parts of the world in the open. Allium crops have many pests, most important being the onion thrips (Thrips tabaci Lindeman, Thysanoptera: Thripidae), the onion maggot (Delia antiqua (Meigen), Diptera: Anthomyiidae), the leek or onion moth (Acrolepiopsis assectella (Zeller), Lepidoptera: Acrolepididae) and the leaf miners (Diptera: Agromyzidae)². There are 7 leaf miner species that have been reported as pests of Allium crops ⁹.

The Allium leaf miner Phytomyza (Napomyza) gymnostoma Loew is a pest of leek (A. porrum) and chives (A. schoenoprasum L.) and to a lesser extent of onion (A. cepa), garlic (A. sativum), shallot (A. ascalonicum L.) and of ornamental Allium plants ¹. The pest is causing extensive damage to crops in an increasing number of European countries. It has been reported as an Allium pest from Central, Eastern and, more recently, Western Europe, as well as in Asia from Turkey and Turkmenistan ⁵, ⁷, ¹⁴, ²², ²³, ²⁵. The Allium leaf miner larvae mine the leaves and bulbs, making the plants soft and susceptible to bacterial and fungal infections, such as white rot (Sclerotium cepivorum Berk). Heavy infections completely destroy plants ¹-⁷.

In order to produce healthy food, a lot of research work is directed into development of efficient environmentally friendly plant protection ¹², ¹⁷, ²⁷, ²⁸. Several sustainable methods of control have been developed in recent years for reducing insect pest damage in field vegetable crops ¹², ²⁸. This has helped to overcome some of the problems that occur when pest insects develop resistance to certain insecticides ¹⁵, ¹⁸. One of the sustainable methods of pests control is intercropping ¹⁰. Intercropping, or growing two or more crops in association, which is widely applied in developing countries, plays a minor role in high input agriculture ¹⁶, ²⁹, ³¹. However, recently intercropping gained an increasing interest in an attempt to substantiate functional biodiversity for agricultural production and to reduce pesticide use. A number of recent studies addressed weed problems and potential solutions offered by intercropping systems ³, ¹³, ²⁸. Several of the above-mentioned authors suggested intercropping specifically as a tool for pest and weed management in organic farming and minor crops. There is an increasing need for efficient non-chemical weed management techniques, particularly for the vegetable production for fresh market, because of a rapid decline in registered herbicides and consumer concerns about pesticide residues ³.

The fact that the plants of the intercrop compete directly with the main crop for light, water and nutrients ³, ¹³, ²⁸, is obviously of concern. In the current research we tested the efficacy of three herbs as intercrops for reducing the damage done to onion crops by the Allium leaf miner. The herbs tested were common lavender (Lavandula angustifolia Mill.), rosemary (Rosmarinus officinalis L.) and oregano (Origanum vulgare L.). The purpose of our research was to study the influence of intercrops on the yield of
onion and the extent of damage caused by Allium leaf miner larvae on onion bulbs, since in Slovenia we do not have any insecticides registered for controlling the pest in question.

**Materials and Methods**

**Experimental design:** During 2009 and 2010, field experiments were done at the Biotechnical Faculty in Ljubljana, Slovenia (46°04’N latitude, 14°31’ E longitude, 299 m above the sea level) to study the efficacy of three intercrops in reducing *Phytomyza gymnostoma* damage on onion plants. Two area of land, each 26 m long and 1 m wide, were divided into four blocks. The three intercrop treatments were assigned randomly to the three plots within each block. Every block was divided in 4 plots (three treatments and the control, without intercrop). Each plot covered 3.2 m². Within each treatment in a block there were two subplots (parcel of 1.6 m in length) where both onion cultivars, namely ‘Holandska rumena’ and ‘Ptujska rdeča’ were planted in planting distance of 20 cm × 20 cm. The design of the experiment was similar to the one used earlier 27 to study the efficacy of intercropping against onion thrips in onion.

In 2009 the experiment was done in a part of the experimental field in which vegetables had been grown intensively for several years. The soil was fertilized with farmyard manure at the rate 25 t ha⁻¹. Tests indicated that this soil had a pH of 6.2, an organic matter content of 2.9%, and P and K contents (ammonium lactate extraction) of 19 and 28 mg per 100 g of dry soil, respectively. In 2010, the experiment was done in the same field. Tests indicated that this soil had a pH of 5.9, organic matter content of 1.6%, and P and K contents of 12 and 9 mg per 100 g of dry soil, respectively. Fertilizer was not added to this test area.

**Agritechnique:** On 20 April 2009, we planted both cultivars of onion in row distance of 20 cm × 20 cm. On 5 May we planted symmetrical in each treatment 7 plants of oregano (0.41 seedling m⁻²), 6 plants of common lavender (0.48 seedling m⁻²) and 8 plants of rosemary (0.36 seedling m⁻²). All intercropped plants (onion, oregano, common lavender and rosemary) were planted manually on black PE mulch (thickness = 15 µm). On 15 June, the onion plants were sprayed with the fungicide Ridomil Gold MZ 68 WP (a.i. metalaxyl-M 4% + maneconazole 64%, 25 g/101 water) to reduce the spread of downy mildew of onion (*Peronospora destructor* [Berk.] Casp. and Berk.). We repeated the spraying on 7 and 9 July, during the wet weather.

On 24 April 2010 we planted onion. Intercrops were planted the same way as a year before on black PE mulch on 8 May. On 24 June, the onion plants were sprayed with the fungicide Ridomil Gold MZ 68 WP to reduce the spread of downy mildew (*Peronospora destructor* [Berk.] Casp. and Berk.). We repeated the spraying on 9 and 15 July, during the wet weather.

**Damage and yield evaluation:** Onion was harvested at technological maturity; in our case, this was on 12 August 2009 and 26 July 2010. Samples included 20 randomly selected but representative plants from each subplot. We removed abovement part of the plant and weighed the mass of bulbs. We evaluated also damage caused after the attack of the larvae of Allium leaf miner. By intersecting the bulbs, we determined the presence of larvae, which caused the rotting of bulbs due to the infection with soilborne pathogens (Table 1).

**Data analysis:** The average index of damage values for two cultivars of onion in each of the two damage classes was totalled across the four blocks; so that the effects of the three different intercrops could be compared. Prior to analysis, each variable was tested for homogeneity of variance, and those data found to be non-homogeneous were transformed to log (Y) before being subjected to analysis of variance (ANOVA). The analysis of variance was done to establish the differences between the mean values of the various parameters recorded per plot. In all comparisons, the Student-Newman-Keuls’s multiple range test (P≤0.05) was used to separate differences between the various means. The statistical analyses were done using Statgraphics Plus for Windows 4.0 (Statistical Graphics Corp., Manugistics Inc.) and the figures were generated using SigmaPlot 2002 for Windows 8.0 (Systat Software Inc.). The data are presented as the untransformed means ±SE.

**Results and Discussion**

In 2009, statistically significantly (P<0.0000) lowest average mass (g) of onion bulbs was gained in cultivar Holandska rumena (134.3±2.8), while for cultivar Ptujska rdeča average mass of bulbs was 164.2±3.2 g. Cultivar choice acted as significant factor (P = 0.0002) onto bulbs mass also in 2010, when ‘Ptujska rdeča’ averaged at 89.1±4.5 g and ‘Holandska rumena’ averaged significantly higher at 111.7±4.4 g. Anova results are presented in Tables 2 and 3.

‘Holandska rumena’ yielded in 2009 according to average bulb mass no significant differences between treatments (P = 0.3120) and its values ranged from 134.2±5.1 g (rosemary) to 137.2±5.8 g (common lavender) (Fig. 1). Meanwhile, ‘Ptujska rdeča’ gained

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**Table 1.** Scale for damage evaluation on onion due to the larvae of Allium leaf miner (*Phytomyza gymnostoma*).

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description of onion health status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Damaged (with mines) and consecutively rotting</td>
</tr>
<tr>
<td>2</td>
<td>No damage (no mines) and no succeeding rotting</td>
</tr>
</tbody>
</table>

**Figure 1.** Mean mass of bulbs of two onion cultivars in different intercrops in 2009. Capital and lower-case letters correspond to the grouping of means by Student-Keuls’s multiple range test (P≤0.05) for intercrop species and onion cultivar, respectively. The same letters do not differ significantly.
Table 2. ANOVA results for the damage rate caused by the larvae of the Allium leaf miner on the onion bulbs in 2009 and 2010.

<table>
<thead>
<tr>
<th>Source</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>df</td>
</tr>
<tr>
<td>Block</td>
<td>1.57</td>
<td>3</td>
</tr>
<tr>
<td>Intercrop</td>
<td>1.14</td>
<td>3</td>
</tr>
<tr>
<td>Onion cultivar</td>
<td>17.51</td>
<td>1</td>
</tr>
<tr>
<td>Intercrop × Onion cultivar</td>
<td>0.07</td>
<td>3</td>
</tr>
</tbody>
</table>

*a source of variation significant at p = 0.05.

Table 3. ANOVA results for the mean mass of onion bulbs in 2009 and 2010.

<table>
<thead>
<tr>
<th>Source</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>df</td>
</tr>
<tr>
<td>Block</td>
<td>5.93</td>
<td>3</td>
</tr>
<tr>
<td>Intercrop</td>
<td>5.09</td>
<td>3</td>
</tr>
<tr>
<td>Onion cultivar</td>
<td>51.69</td>
<td>1</td>
</tr>
<tr>
<td>Intercrop × Onion cultivar</td>
<td>3.41</td>
<td>3</td>
</tr>
</tbody>
</table>

*a source of variation significant at p = 0.05.

In 2010, treatment with intercrop common lavender onion yield in ‘Holandska rumena’ (86.8±8.2 g) was statistically significant (P = 0.0039) lowest, as similar conclusion (P = 0.0006) in ‘Ptujksa rdeča’ showed to be evident for treatment common lavender (69.2±7.8 g) and rosemary (68.3±6.7 g) (Fig. 2). When compared both cultivar’s yields in 2010 only treatment oregano showed no significant differences and their values ranged between 101±9.7 g (‘Ptujksa rdeča’) and 113.0±8.7 g (‘Holandska rumena’) (Fig. 2).

Average index of damage analysis on both cultivars within individual treatments in 2009 showed no statistically significant differences. In ‘Holandska rumena’ (P = 0.3120) damage index ranged between 1.23±0.04 (control and rosemary) and 1.29±0.04 (oregano). In the meantime, bulbs of ‘Ptujksa rdeča’ (P = 0.5434) were more damaged and amounted from 1.5±0.23 (common lavender) to 1.43±0.05 (oregano) (Fig. 3).

When compared average index of damage due to the larvae of leek leaf miner between both onion cultivars in 2010 we determined no statistically significant differences (P = 0.1054) on degree of damage when compared in 2010 ‘Holandska rumena’ and values amounted between 1.5±0.23 (common lavender) and 1.92±0.23 (control). Similar conclusions were drawn also for cultivar ‘Holandska rumena’ (P = 0.4028) with index values between 1.58±0.23 (oregano) and 1.94±0.24 (control).

Results of our research demonstrated that in 2009 different intercrops did not influence on the yield of ‘Holandska rumena’, meanwhile ‘Ptujksa rdeča’ gained the highest yield in control treatment (184.2±6.6 g) (Fig. 1).

In 2010, treatment with intercrop common lavender onion yield in ‘Holandska rumena’ was lower than expected, as both winters in the area where the research was conducted, were colder compared to long-term average. At the same time, summers received above long-term average amount of precipitation and both weather situations caused the decrease in population of studied insect pest. Mean index of damage due to the mining of Allium leaf miner larvae in our experiment was influenced by cultivar of onion and as well planting different intercropping plants. In 2009, we noted less damage in cultivar Holandska rumena, and influence on damage level in previously mentioned year was also run by the choice of intercropping plant as oregano as lavender in 2010 was the lowest.
intercrop acted the most effective (1.36±0.03). In 2010, we did not confirm any differences in the portion of damage between the cultivars as well as between separate intercropping treatments. We conclude that, in 2009 and 2010 in Ljubljana, the Allium leaf miner did not reduce the yield of onions.

Until the late twentieth century *P. gymnostoma* was not regarded as an organism of economic significance 24. However, since it was first recorded causing significant damage in a crop of leeks in Hungary in 1988 8, it has also been reported causing damage in the Slovak Republic 30, Serbia 21, Slovenia (where it is the most important pest on leeks and onions) 20, Austria 11, Poland 25, Germany 4, 19, Turkey 5, northern Italy (where severe damage has been seen at organic farms) 26, 31, France 5 and the UK 7. *P. gymnostoma* is capable of severely infesting almost 100% of a crop. In Serbia around 20 pupae were found per leek stem. All plants were completely destroyed. Even at lower pest densities, the presence of mines on young plants may reduce the quality and marketability of produce 23. Until now, *P. gymnostoma* was not recorded as a vector although the feeding damage it causes allow infection from secondary pests such as bacterial pathogens and pathogenic fungi 11.

In Austria, organic farmers are advised to grow leeks as far away as possible from chives. They are advised also to cover their leek crops with nets as soon as the adults of the autumn generation emerge, and to bury any plant remains containing fly pupae as deep as possible in the soil 11. In Poland, delayed planting in the spring reduces damage by *P. gymnostoma* in the autumn 21. At a commercial site, professional growers have a broad spectrum of chemical products. Treatments with a systemic insecticides base on rotenone and pyrethrins, when adults are active and females egg-laying, around March/April and October/November, could be used 4. In Austria, sprays are advised as long as larvae are found feeding in the upper parts of the leaves 11.

**Conclusions**

Results of our research do not enable setting out any of studied plant intercrop species as an effective control measure of Allium leaf miner on onion. That is why further researches are needed in which we will try to improve the efficacy of demonstrating intercrops; for example with higher seeding density, in combining with other environmentally friendly measures of control (biological control, biotechnical plant protection, plant extracts, etc.) with the intention to achieve synergistic effect and which all together form the basis for the implementation of such kind of control measures into the food production systems. Country in which above mentioned research took place and in numerous other European countries there are no registered synthetic insecticides for controlling Allium leaf miner larvae on onion and its related cultivated *Allium* species. This is why environmentally friendly control methods for this insect pest species have a great meaning for the producers of alliums to lessen its damage potential.

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