Intercropping against onion thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae) in onion production: on the suitability of orchard grass, lacy phacelia, and buckwheat as alternatives for white clover


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Summary
During 2004 and 2005, field experiments were done to compare the effectiveness of four different intercrops in reducing onion thrips (*Thrips tabaci* Lindeman) damage on onion plants. The four intercrops were lacy phacelia (*Phacelia tanacetifolia* Benth.), buckwheat (*Fagopyrum esculentum* Moench.), orchard grass (*Dactylis glomerata* L.) and white clover (*Trifolium repens* L.). The experiment was done in a fertile soil in 2004 and a relatively infertile soil in 2005. In both years, the thrips population was lower than expected due to two cold springs and wet summers. The amount of damage on the two onion varieties tested, 'Rdeči baron' and 'Holandska rumena', exceeded the 20% leaf damage threshold only on some onion plants. In both years, white clover was the least attractive intercrop for onion thrips, and orchard grass was only slightly more attractive. Although the damage to the onion leaves was the highest in these two intercrops, these plots still produced the highest yield of onions. In contrast, lacy phacelia, buckwheat and orchard grass should not be used in onion production to replace white clover, the intercrop used currently. In the current experiments, intercropping with white clover resulted in the highest yield of onions in both high and low fertility soils.

Key words: intercropping, IPM, onion, onion thrips, *Thrips tabaci*

Zusammenfassung


Stichwörter: integrierte Bekämpfung, *Thrips tabaci*, Zwiebel, Zwiebelthrips, Zwischensaat

1 Introduction
Throughout Europe, onion thrips, *Thrips tabaci* Lindeman, causes considerable damage on onion crops (NAWROCKA 2003; TRDAN et al. 2005), leek (DEN BELDER et al. 2002) and cabbage (HEROLD and STENGEL 1993; GARAVOLGYI et al. 2004). Although some authors claim that damage by thrips does not reduce the yield of onions, other authors disagree (FOURNIER et al. 1995; TRDAN et al. 2005).

Several sustainable methods of control have been developed in recent years for reducing thrips damage in field vegetable crops. As a result, more selective insecticides are now being introduced into crop production. This has helped to overcome some of the problems that occur when pest insects develop resistance to certain insecticides (MARTIN et al. 2003; RUEDA and SHELTON 2003). One sustainable method of control is 'intercropping' (FINCHI and KARPELENSTEIN-MACHAN 2002), a system in which a plant species (the intercrop) is grown specifically to reduce pest insect damage on a main crop, in this case onions. Earlier work has shown that intercropping with clover (*Trifolium*) reduces damage by onion thrips in fields of both leek (THEUINNISSEN and SCHELLING 1998) and onion (HILDENHAGEN et al. 1995).

The fact, that the plants of the intercrop compete directly with the main crop for light, water and nutrients (WEBER et al. 1999), is obviously of concern. In the current research we tested the efficacy of four intercrops for reducing the damage done to onion crops by the onion thrips. White clover (*Trifolium repens* L.) was used as the control or 'standard' intercrop. The other intercrops tested were, orchard grass (*Dactylis glomerata* L.), buckwheat (*Fagopyrum esculentum* Moench.), and lacy phacelia (*Phacelia tanacetifolia* Benth.), three plant species that are considered common in Slovenia. Throughout Europe, lacy phacelia and buckwheat are grown quite regularly as 'honey' plants (BECKER and HEDTKE 1995; SCHRAMM et al. 2003), and orchard grass is used widely as a forage crop (YAHAYA et al. 2002). Until now, lacy phacelia has not been tested as an intercrop in onion production. However it has been shown that while phacelia did not compete well with the...
maize plants in maize crops, it regularly out competed the weeds growing in such crops (JORGENSEN and MÖLLER 2000). Phacelia used as an intercrop also reduced thrips damage on peas (WILK 1998). The second test intercrop, buckwheat, is not only attractive to thrips (NICHOLS et al. 2000) but has an allelopathic effect which suppresses the growth of weeds (KHAN et al. 2005). Orchard grass was chosen as the final intercrop, as it is highly attractive to onion thrips during July, one of the months of rapid onion growth in continental Europe (WADYKO and ŻURANSKA 1991).

Our aim was to determine if any of the three intercrops mentioned above could replace the current intercrop, white clover, to reduce onion thrips damage in onion crops.

2 Materials and methods

During 2004 and 2005, 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 four intercrops in reducing Thrips tabaci damage on onion plants. Two area of land, each 26 m long and 1.5 m wide, were divided into four blocks. The four intercrop treatments were assigned at random to the four plots within each block (Fig. 1). Each plot covered a total area of 4.8 m² and was divided into two equal sub-plots so that the effect of the intercrop on two varieties of storage onion, ‘Holandska rumena’ and ‘Rdeči baron’, could also be compared. The design of the experiment was similar to the one used earlier (TRDAN et al. 2005) to study the efficacy of light blue sticky boards for trapping onion thrips.

In 2004, 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 of 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 mg and 28 mg per 100 g of dry soil, respectively. In 2005, the experiment was done in the same field but in a part which had been grassland until it was ploughed for the first time in the spring of 2004. During 2004, sweet fennel (Foeniculum vulgare Mill.) was sown to delay the development and flowering of these two varieties of storage onion sets, spaced 15 cm apart both within and between the rows. In 2005, the experiment was done in 2004. However, in 2005, instead of sowing all four intercrops on the same day, only the plots of white clover and orchard grass were sown during the first drilling, on 23 March. The onion sets were planted on all plots also on 23 March. The plants of lacy phacelia and buckwheat were sown about 4 weeks later, on 18 April, by which time the onion plants had reached the developmental stage BBCH 12-13 (from the 2nd to the 3rd leaf clearly visible) (BBA, 2001). The later drilling was done to delay the development and flowering of these two

2.1 Year 2004

On 20 April, the four plant species used as the intercrops; white clover (Trifolium repens L.), variety ‘Milka’ (12-15 kg ha⁻¹), orchard grass (Dactylis glomerata L.) variety ‘Fala’ (20-25 kg ha⁻¹), buckwheat (Fagopyrum esculentum Moench.) variety ‘Darja’ (60-90 kg ha⁻¹) and lacy phacelia (Phacelia tanacetifolia) (10-16 kg ha⁻¹), were sown by hand into their respective plots. On the following day, rows of onion sets, spaced 15 cm apart both within and between the rows, were planted in all plots. On 22 April, the plots were covered with white polypropylene fleece to enhance the growth of the intercrops. Five weeks later, on 24 May, the fleece was removed and light blue sticky traps were placed in the plots to monitor onion thrips.

The first flowers were seen on buckwheat and lacy phacelia on 1 and 14 June, respectively. At this time, the white clover and the orchard grass were only about 10 cm high and were not in flower. On 15 June, the onion plants were sprayed with the fungicide Antracol (a.i. propineb 70%, 25 g/10 l water) to reduce the spread of downy mildew (Peronospora destructor [Berk.] Casp. in Berk.)

On 23 June, the first onion thrips were seen on the flowers of buckwheat and slight damage was also noticed on some onion leaves. On the following day, the plots were sprayed with Ridomil Gold MZ 68 WP (a.i. metalaxyl-M 4% + mancozeb 64%, 25 g/10 l water), as the onion plants had been infected with downy mildew during the wet weather. The sticky traps were renewed again on 7 July, even though only a few thrips had been caught. Reasonable high number of thrips remained, on both the traps and the plants, were noted for the first time on 13 July. Due to the wet weather at this time, the onions were sprayed again with the fungicide Ridomil Gold MZ 68 WP.

The appearance of the plants in the different treatments was recorded on 22 July and again on 3 August. On 8 July and 4 August, records were taken also of plant height, the developmental stage of the plants and the area of ground covered by each intercrop (Table 1). By 10 August, the foliage of the onion plants in most of the plots had senesced and withered and so the onions were harvested.

2.2 Year 2005

The experiment done in 2005 was largely a repeat of the one done in 2004. However, in 2005, instead of sowing all four intercrops on the same day, only the plots of white clover and orchard grass were sown during the first drilling, on 23 March. The onion sets were planted on all plots also on 23 March. The plots of lacy phacelia and buckwheat were sown about 4 weeks later, on 18 April, by which time the onion plants had reached the developmental stage BBCH 12-13 (from the 2nd to the 3rd leaf clearly visible) (BBA, 2001). The later drilling was done to delay the development and flowering of these two

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![Fig. 1: Plan of the experimental field design used in both 2004 and 2005.](image-url)
plants. On all plots, the seeding rates and the plant spacings were similar to those used in 2004.

On 23 May, light blue sticky traps were put out for the first time and the mollusces Mesurol granulate (a.i. methiocarb 45% + 25% profenofos) was applied to reduce the heavy infestation of slugs (Gastropoda). All large weeds were removed mechanically from the plots on 25 May and again on 9 June. As some thrips adults were caught on the sticky traps on 9 June, the traps were renewed. Heavy rain during the last two weeks of June and the first week of July allowed downy mildew to establish, and so the onions were sprayed with the fungicide Ridomil Gold MZ 68 WP on 6 July. The sticky traps were renewed for the second time on 8 July.

The appearance of the plants was recorded on both 13 and 25 July. The height, developmental stage of the plants and amount of ground covered by the intercrop were recorded on 4 July and again on 5 August (Table 1). The onions were harvested from all plots on 10 August.

2.3 Damage and yield evaluation

On both days on which onion thrips damage was assessed (22 July and 3 August 2004, 13 and 25 July 2005), ten onion plants were selected at random from the central part of each sub-plot. To avoid ‘edge effects’, all of the plants selected were more than 20 cm away from the edge of the plots. The percentage of the leaf surface damaged was estimated on a scale of 1-5 (RICHTER et al. 1999), in which: 1 = no damage, 2 = up to 20%, 3 = 21-33%, 4 = 34-50%, and 5 = over 50% damage. In both years, yield was recorded at the time of the final harvest by weighing 20 onion bulbs, selected at random, from the central part of each sub-plot.

2.4 Data analyses

The percentage values for the two varieties of onion in each of the five different damage classes were totalled across the four blocks so that the effects of the four different intercrops could be compared. Prior to analysis, each variable was tested for homogeneity of variance and those data found to be nonhomogeneous were transformed to log (Y) before being subjected to analysis of variance (ANOVA). The analyses of variance were 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.

3 Results

3.1 Height and ground cover of the intercrops

The data shown in Table 1 are the mean values calculated from the four replications of each treatment done in each year. They show that lacy phacelia (60 cm tall) grew about three times as tall as white clover (20 cm tall) in 2004 but only about twice as tall (45 cm) in 2005, probably because the 2005 plots were on a less fertile part of the experimental field. On the day (22 July) of the first assessment, the differences in height between the four intercrops were less pronounced (Table 1).

At the time of the first assessment in both years, least ground (mean area 42.5%) was covered by white clover and most (mean area 77.5%) by lacy phacelia. The other two intercrops, orchard grass and buckwheat, had a value (mean area 53.7%) that came between the other two. By the time of the second assessment, the differences between the four intercrops were less pronounced (Table 1). The best ground cover was in the middle of the white clover plot (35% to 15 flower heads per plot in 2004: 16 to 20 flower heads per plot in 2005), as this plant uses stoloniferous growth to spread. The results from both assessments showed clearly that buckwheat and lacy phacelia grew much faster and larger than the other two intercrops and so covered more of the available ground.

3.2 Damage evaluation

In 2004, an analysis using the combined results from both varieties of onion showed differences (P < 0.0001) in the thrips damage recorded in the four intercrops on the two dates (22 July and 3 August) the plants were assessed. In 2005, there were time of the second assessment, the differences between the four intercrops treatments on the two dates the plants were assessed and also between the two varieties of onions (P < 0.0459 on 13 July, and P < 0.0003 on 25 July). At the time of the first assessment (22 July) in 2004, most thrips damage was recorded in the plots intercropped with buckwheat and lacy phacelia. During the first assessment, similar levels of thrips damage were recorded on the onion variety ‘Rdeči baron’ intercropped with buckwheat and lacy phacelia. During the time of the second assessment, the levels of damage were similar in all intercrops. On the day (22 July) of the first assessment in 2004, more than 70% of the onion plants intercropped with buckwheat and lacy phacelia were not damaged, compared to 50% of the onion plants intercropped with white clover and orchard grass (Fig. 3). At the time of the second assessment (3 August), although more plants had class 2 damage, less than 10% of the plants had class 3 damage.

On the day (13 July) of the first assessment in 2005, most thrips damage on both varieties of onion was recorded on the plots intercropped with white clover. The onion intercropped with buckwheat were the least damaged. The levels of damage recorded on the onions intercropped with both lacy phacelia and orchard grass were similar. At the time of the second assessment (25 July), the damage on both varieties of onion was highest in the plots intercropped with white clover. Least damage was recorded on the onions grown amongst buckwheat and lacy phacelia.
The first assessment in 2005 showed that thrips damage on both varieties of onion was similar to that recorded in 2004. However, unlike 2004, the levels of thrips damage had not increased by the time of the second assessment (Fig. 4).

### 3.3 Yield evaluation

A group analysis of the yield of onion bulbs in both years showed differences between the four intercrops \((P < 0.0001)\) and between the two onion varieties \((P < 0.0001)\) in 2004, and \(P < 0.0459\) in 2005. The yield from the variety ‘Holandska rumena’ was higher than from ‘Rdeči baron’ (Fig. 5).

Analyses of the yield data from both years indicated that there were differences in yield from the four intercrops \((P < 0.0001)\) and from the two varieties \((P < 0.0001)\) (Fig. 6). In 2004, the highest yield of onion bulbs was recorded from the plots intercropped with white clover and orchard grass. Lacy phacelia and buckwheat were not suitable intercrops for use with the variety ‘Rdeči baron’, as the yield of onions from these two intercrops was too low. Lacy phacelia was also the least suitable intercrop to use with the variety ‘Holandska rumena’, as lacy phacelia was much too competitive and so greatly reduced the yield of onions. The yield of onions from the buckwheat plots was higher than from the lacy phacelia plots but still much lower than from the plots of white clover and orchard grass. In 2005, the yield of onions was lower than in 2004. For both varieties, the highest yields of onion bulbs were obtained from the white clover plots.

### 4 Discussion

Although lacy phacelia and buckwheat were both highly attractive to thrips, these two intercrops grew too quickly and too tall, and so were much too competitive to be used as intercrops in onion production. The competitive nature of these intercrops took light, water and nutrients away from the onion crop. Hence, neither plant was suitable for use as an intercrop, as apart from causing difficulties during crop production (LOTZ et al. 1997; GRISLEY et al. 1997), both plants reduce considerably the yield of onions. Orchard grass proved a more appropriate intercrop, but only in fertile soil, where there were sufficient nutrients for both the intercrop and the main crop.
In the second year of this project, when the experiment was done in relatively infertile soil, the yield of onions was acceptable only from the plots intercropped with white clover. We assume this was due to the ability of clover to fix nitrogen from the air (Gamper et al. 2005) and make it available to the main crop. In soils of low fertility, plants use this nitrogen more intensively (Karpenstein-Machan and Stuelpnagel 2000).

During the two years of this project, the population of thrips was lower than expected (Trdan et al. 2005), as both years had cold springs and wet summers. The mean index of damage on the onion leaves exceeded 2 only at the time of the second assessment in 2004, and then only in the plots of white clover and orchard grass. From our results and those published earlier on thrips damage to onion (Fournier et al. 1995; Richter et al. 1999) we conclude that, in 2004 and 2005 in Ljubljana, the thrips infestation did not reduce the yield of onions.

Onion thrips is an important pest of field-grown vegetables throughout Europe and many other parts of the world. Models of the potential effect of climate change on the life-cycles of pest insects indicate that more generations of thrips could occur in future (Bergant et al. 2005). Biological control agents that could help to 'control' onion thrips are not well understood, unlike the agents that feed on (Sengonca and Saleh 2002) or parasitize (Kavalleratos et al. 2005) aphids. Nevertheless, some potential biological control agents of onion thrips have been identified in recent years. These include predators (Schade and Sengonca 1995), parasitoids (Murai and Loomans 2001) and entomopathogenic fungi (Hudak and Penzes 2004), though how these biological control agents can be of use in practice still needs to be determined. At present, using intercrops to reduce pest insect damage is a much more reliable method of crop protection than methods based on biological control.

In the present experiments, lacy phacelia and buckwheat were too competitive to be intercropped with onions. However, they could be useful if sown at a lower plant density or if low-growing cultivars could be found. Both alternatives should make the intercrop less competitive with the main crop, onions. Another possibility might be to sow lacy phacelia and buckwheat in field margins and use them as 'trap crops' for onion thrips. Trap crops have been tested against other pest insects (Ramert et al. 2001) but not against onion thrips. Finally, lacy phacelia and buckwheat are particularly valuable both as 'honey' plants and for maintaining populations of natural enemies (Patt et al. 1997). In addition, during flower-
ing, these plants make an aesthetically pleasing addition to the general landscape.

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Literature


