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THRIPS (THYSANOPTERA) ASSOCIATED WITH NARROW-LEAFED LUPIN (*LUPINUS ANGUSTIFOLIUS* L., 1753) INTERCROPPED WITH SPRING TRITICALE (X *TRITICOSECALE* WITTM. EX A. CAMUS, 1927)

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ABSTRACT

The aim of this study was to determine thrips abundance, species composition and seasonal dynamics on narrow-leafed lupin intercropped with spring triticale in different growing conditions. Thrips were studied at the Experimental Research Station at Pawłowice, near Wrocław, Lower Silesia, Poland, during the period 2010-2012.

The experiment was designed as a split-plot with four replicates for each mixture of plants. Lupin and triticale were sown in three different proportions. For determination of thrips species composition narrow-leafed lupin plants were collected from the central part of each plot when plants were at the full blooming stage. In the laboratory larvae and adults were identified to species level. During the whole lupin growing season, insects were also counted weekly on 10 consecutive plants in the middle row of each plot.

In two of the three years of the study, significantly more thrips were collected from lupin plants grown as single crop. There were no significant differences in the number of these insects between lupin-triticale mixtures. In the three years of the study a total of 2247 thrips individuals were collected on lupin plants at the full blooming stage (BBCH 65); 2237 belonging to 17 species, and 10 individuals, because of damage, were classified to the genus range.

In each treatment *Frankliniella intonsa* and *Aeolothrips intermedius* were the dominant species. *Thrips tabaci* also occurred in great numbers on lupin plants. *Aeolothrips intermedius*, a predatory species, was found mainly in the first or second instar larvae. The percentage of this predatory species in the total number of thrips recorded in each treatment was much higher in lupin-triticale mixtures than in the single crop.

Key words: intercropping, narrow-leafed lupin, species composition, thrips, abundance.

INTRODUCTION

Intercropping, also referred to as mixed cropping or polyculture, is an important cultural practice in crop production, which may lead to several benefits (Andrews and Kassam, 1976). Intercropping can positively affect biological interactions between the crops, can increase grain yields and stability, more efficiently use available resources, reduce weed pressure, and sustain plant health (Altieri and Letourneau, 1982; Risch et. al., 1983; Šarūnaitė et al., 2010). In pest management intercropping is based on the principle of reducing insect pests by increasing the diversity of the ecosystem (Willey, 1979; Altieri and Letourneau, 1982; Risch et al., 1983; Andow, 1991; Altieri, 1994; Risch, 2005). In fields with a mixture of crops a given pest will find fewer acceptable hosts to feed or lay eggs on, in comparison to fields with a single crop. However, reviews of the literature indicate that insects that have a broad host range may not be reduced by diversifying crops (Andow, 1991).

Thrips are mostly known as insects living in flowers, but many species live only on leaves, a few are predatory, and probably

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about half of the species, mainly of Phleothripidae family, feed on fungi (Palmer et al., 1989; Mound, 2002). Of 6000 thrips species recorded worldwide, only about 1% are known to be economically harmful (Mound and Teulon, 1995). Thrips can affect plants both through direct feeding and through virus transmission. Visible direct feeding damage caused by these insects may involve silvering or streaking of leaves, distortion or even galling of leaves, or scarring of young fruits (Ananthakrishnan, 1984). A large population of thrips may induce premature flower loss, and possible reduction of available pollen (Kirk, 1984a; Sampson and Kirk, 2012; Tommasini and Maini, 1995).

Because of the hidden lifestyle of thrips, chemical control is inefficient against them, so intercropping is one of the methods used to reduce their population densities on host plants. According to Hurej and Twardowski (2004), intercropping of yellow lupin (*Lupinus luteus* L.) (Markiz var.) and spring triticale (x *Triticosecale* Wittm. ex A. Camus) (Wanad var.) decreased pest populations feeding on lupin plants. The greatest reducing effect was observed in the case of the black bean aphid, and partially in the case of thrips. On the other hand, they also found more beneficial organisms in such diverse habitats, for example carabid beetles (Hurej and Twardowski, 2006). Some studies have been conducted on thrips occurring on vegetables. Theunissen and Schelling (1996, 1998) have shown that intercropping with clover strongly reduces damage by onion thrips in field crops of leek. Similar results were achieved in the case of onion and clover (Trdan et al., 2006). The results of research conducted by Legutowska et al. (2003) and by Kucharczyk and Legutowska (2002) showed that carrot intercropped with leek decreased the number of *T. tabaci* more effectively than clover and French bean sown between rows of leek. However, it is necessary to be very careful with the selection of plant species for intercropping. Trdan et al. (2006) indicated that lacy phacelia, buckwheat and orchard grass should not be used in onion production because of their high attractiveness for onion thrips. Contradicting these authors, it was found that phacelia used as an intercrop reduces thrips damage in peas (Wnuk, 1998).

To date no studies on thrips feeding on lupin plants grown in pure stands, and lupin grown in a mixture with cereals have been conducted in Poland. In the available world literature there are also no specific data concerning this problem. The aim of this study was to determine thrips abundance, species composition and seasonal dynamics on narrow-leafed lupin intercropped with spring triticale in different growing conditions.

MATERIAL AND METHODS

Thrips in mixed crops of narrow-leafed lupin (cv. Graf) and spring triticale (cv. Dublet) were studied at the Experimental Research Station at Pawłowice, near Wrocław, Lower Silesia, Poland (51°1737' N, 17°1176' E), during three vegetation seasons (2010-2012). The mixtures and the pure stands of lupin were grown in plots of 15 m^2 (10 m x 1.5 m) on sandy soil. The 0.3 m wide space between the experimental plots was maintained mechanically as bare soil and the plots were weeded regularly. The experiment was designed as a split-plot with four replicates for each mixture of plants. Lupin and triticale were sown in three different proportions (Table 1).

Table 1. Number of narrow-leafed lupin and spring triticale seeds sown per 1 m^2 in the different treatments of the experiment

Treatment	Narrow-leafed lupin	Spring triticale	% of narrow-leafed lupin seeds in mixture
1	100	0	100
2	60	160	27
3	40	240	14

For determination of thrips species composition, 10 narrow-leafed lupin plants were collected from the central part of each plot (40 plants for treatment), when plants were at the full blooming stage (BBCH 65). In the laboratory plants were shaken over a sheet of white paper.

Larvae and adults were counted, preserved in 75% ethyl alcohol and then identified according to Strassen (2003), Schliephake and Klimt (1979) and Vierbergen et al. (2010). During the whole lupin growing season, through three years of the research, insects were also counted weekly on 10 consecutive plants in the middle row of each plot.

For comparison of the number of thrips collected at the full blooming stage in three different treatments of the experiment, analysis of variance (ANOVA) followed by Tukey's HSD (post-hoc) were used. Statistical significance was evaluated at $P \leq 0.05$. For statistical analysis Statistica 9.0 software was chosen.

RESULTS AND DISCUSSION

Abundance and species composition

In 2010, a total of 334 thrips belonging to 11 species were collected from the narrow-leafed lupin plants which were at the full blooming stage (BBCH 65) (Table 2).

Table 2. Species composition of thrips collected in 2010

Species	1*			2			3			total thrips	%
	total	inc. larvae	%	total	inc. larvae	%	total	inc. larvae	%		
Frankliniella intonsa (Trybom, 1895)	104	14	61.5	42	2	45.2	26	4	36.1	172	51.5
Aeolothrips intermedius Bagnall, 1934	30	21	17.7	42	41	45.2	32	32	44.4	104	31.1
Thrips major Uzel, 1895	12	5	7.1	4	2	4.3	4		5.5	20	6.0
Thrips fuscipennis Haliday, 1836	13	1	7.7	2		2.1	2		2.8	17	5.1
Thrips tabaci Lindeman, 1889	6	1	3.6	1	1	1.1	2		2.8	9	2.7
Haplothrips aculeatus Fabricius, 1803	2	1	1.2	2		2.1	3		4.2	7	2.1
Frankliniella tenuicornis Uzel, 1895	1		0.6							1	0.3
Limothrips cerealium Haliday, 1836							1		1.4	1	0.3
Limothrips denticornis Haliday, 1836							1		1.4	1	0.3
Thrips atratus Haliday, 1836	1		0.6							1	0.3
Chirothrips manicatus Haliday, 1836							1		1.4	1	0.3
Total	169a**	43	100.0	93b	5	100.0	72b	36	100.0	334	100.0
No. species	8			6			9			11	

*treatment (Table 1);
**values followed by different letters are significantly different ($P \leq 0.05$).

This was the lowest number of determined Thysanoptera during the three years of the study. Significantly more thrips occurred on plants grown in the pure stands of lupin (169) than in the mixture with a lower proportion of lupin (72) or in the mixture with a higher proportion (93) ($F=3.99$, $df=2$, $p=0.020646$). The number of identified species ranged from 6 in treatment 2, to 9 in treatment 3. In each treatment the most numerous species were *Frankliniella intonsa* and *Aeolothrips intermedius*. The first species made up 51.5%, and the second one 31.1% of all identified insects. *F. intonsa* was the most numerous in the pure lupin crop and occurred mainly in the adult stage. The tendency for

numbers of this species was to decrease with decreasing proportions of lupin in the mixture. Predatory species *A. intermedius*, contrary to phytophagous *F. intonsa*, occurred in greater numbers in mixtures of narrow-leafed lupin and spring triticale. In mixtures this species made up about 45% of all identified thrips, while in the pure stand of lupin only 17.7%. *A. intermedius* was found mainly in the first or second instar larvae. In 2010 *Thrips major* and *T. fuscipennis* were also more numerous. Both species occurred mainly on plants grown in pure stand. Only in treatment 3, with the greatest share of triticale, were single individuals of graminicolous species: *Limothrips cerealium*, *L. denticornis* and *Chirothrips manicatus* noted. All of them feed in florets, and the two former also on the leaves of grasses, and may be treated as a vagrant on lupin plants (Rao et al., 2010).

In 2011, a total of 787 thrips were found in the material from the narrow-leafed lupin plants (Table 3). As in the previous year they were the most numerous in the pure lupin crop (367). Significantly fewer insects occurred in the lupin-triticale mixtures: 60:160 (238) or 40:240 (182) (F=5.14, df=2, P=0.007101). All the collected insects were identified into 10 species, and a few of them, due to the incomplete specimens, into 2 genera levels. Eight species and 2 genera were identified in the pure stand of lupin, 10 species and 1 genus in the higher proportion of lupin in the mixture, and only 6 species and 2 genera in the lower proportion of narrow-leafed lupin in the mixture. In all treatments *F. intonsa* and *A. intermedius* were the most numerous species, making up 54.5% and 24.6% of all found thrips, respectively. In this year *Thrips tabaci* also occurred in greater numbers, comprising 10.6% of all insects. Its greatest numbers were noted in pure lupin stands (13.1%). There were many more individuals of *F. intonsa* collected from the pure stand crop than from both mixtures. In the case of this species adult insects were most frequently recorded. *A. intermedius* occurred in similar numbers in the three studied treatments. Taking into consideration the percentage of this species in the total number of thrips in each treatment, it should be emphasized that *A. intermedius* was more numerous in mixtures then in the pure lupin crop.

Table 3. Species composition of thrips collected in 2011

Species	1*			2			3			total thrips	%
	total	inc. larvae	%	total	inc. larvae	%	total	inc. larvae	%		
Frankliniella intonsa (Trybom, 1895)	222	52	60.5	126	9	52.9	81	10	44.5	429	54.5
Aeolothrips intermedius Bagnall, 1934	62	58	16.9	54	48	22.8	78	69	42.8	194	24.6
Thrips tabaci Lindeman, 1889	48	9	13.1	23	2	9.7	12	3	6.6	83	10.6
Thrips fuscipennis Haliday, 1836	8	1	2.1	6		2.5	3		1.6	17	2.1
Thrips major Uzel, 1895	15		4.1	2		0.8				17	2.1
Thrips angusticeps Uzel, 1895	3		0.8	9		3.8	2		1.1	14	1.8
Thrips atratus Haliday, 1836				11		4.6				11	1.4
Aeolothrips fasciatus (Linnaeus, 1761)	1		0.3	1		0.4	4		2.3	6	0.8
Thrips spp.	4		1.1				2		1.1	6	0.8
Anaphothrips obscurus (Muller, 1776)				4	2	1.7				4	0.5
Haplothrips spp.	3	1	0.8	1	1	0.4				4	0.5
Odontothrips loti (Haliday, 1852)	1	1	0.3	1		0.4				2	0.3
Total	367 a**	122	100.0	238 b	62	100.0	182 b	82	100.0	787	100.0
No. species	10			11			7			12	

*treatment (Table 1); **values followed by different letters are significantly different P≤0.05).

In 2012 a total of 1126 thrips belonging to 11 species were collected (Table 4). This was the highest number of determined Thysanoptera during the three years of the study. No significant differences in the number of recorded insects were found between treatments (F=2.31, df=2, P=0.102485). Six species were identified in the mixture with the lower proportion of lupin, and 8 in the pure stand crop and in the mixture with the higher proportion of lupin. *F. intonsa* and *A. intermedius*, as in the previous years, were the most numerous species in each treatment, making up 35.6% and 45.5% of all identified thrips. In the case of the first species mainly adult insects occurred on lupin plants. The tendency for numbers of *F. intonsa* was to decrease with decreasing proportions of lupin in the mixture. Contrary to *F. intonsa, A. intermedius* occurred mainly as larvae, and was almost twice as numerous in mixtures as in the pure stand of lupin. Also, the percentage of this species in the total number of thrips recorded in each treatment was higher in the lupin-triticale mixtures (47.0% in treatment 2; 68.0% in treatment 3) than in the single crop (25.1%). In 2012 *Thrips atratus* and *T. tabaci* were also more numerous species, and had shares in pure lupin stands of 14.2% and 12.6%, respectively. These species were also more numerous on the plots mixed with triticale. The remainder of the identified species occurred individually in the collected material and not in each treatment.

Table 4. Species composition of thrips collected in 2012

Species	1*			2			3			total thrips	%
	total	inc. larvae	%	total	inc. larvae	%	total	inc. larvae	%		
Aeolothrips intermedius Bagnall, 1934	94	80	25.1	208	200	47.0	210	201	68.0	512	45.5
Frankliniella intonsa (Trybom, 1895)	172	9	46.0	165	2	37.2	65	1	21.1	402	35.6
Thrips atratus Haliday, 1836	53		14.2	41		9.3	10		3.2	104	9.2
Thrips tabaci Lindeman, 1889	47	3	12.6	22	5	5.0	21	6	6.8	90	8.0
Thrips major Uzel, 1895	3		0.8	3	1	0.7				6	0.5
Thrips flavus Schrank, 1776	1	1	0.3	2	1	0.4				3	0.3
Thrips angusticeps Uzel, 1895	2		0.5	1		0.2				3	0.3
Frankliniella tenuicornis Uzel, 1895							2		0.6	2	0.2
Thrips fuscipennis Haliday, 1836	2		0.5							2	0.2
Haplothrips aculeatus Fabricius, 1803							1	1	0.3	1	0.1
Haplothrips subtilissimus (Haliday, 1852)				1	1	0.2				1	0.1
Total	374 a**	93	100.0	443 a	210	100.0	309 a	209	100.0	1126	100.0
No. species	8			8			6			11	

*treatment (Table 1); **values followed by the same letter are not significantly different (P≤0.05).

In the three years of the study a total of 2247 thrips belonging to 17 species (and, due to body damage, unidentified species of 2 genera) were collected on lupin plants at the full blooming stage. In each treatment *Frankliniella intonsa* and *Aeolothrips intermedius* were the dominant species. *Thrips tabaci* also occurred in greater numbers. The majority of world communities of thrips are described as herbivorous. Lewis (1997) gives 90 species of economic importance, including species capable of vectoring plant viruses. In our research only *A. intermedius* and *A. fasciatus* are predators. Most of the others,

among them the dominant *F. intonsa* and *T. tabaci*, are floricolous or herbivorous, and are connected with dicots. The graminicolous species were represented by single individuals in treatments with cereals mainly. The predatory *A. intermedius*, commonly occurring in our trials, was recorded as a predator of 44 species of the order Thysanoptera (Riudavets, 1995). Predatory larvae and adults feed on the larvae of other thrips, on aphids, and also on the larvae and eggs of other insects. In Poland the presence of this species has been recorded in the flowers of many plant species, including herbs (Kucharczyk et al., 2006). According to Trdan et al. (2005) *A. intermedius* spends much of its life in the flowers of the host plants, where it feeds on pollen and arthropods. Additionally, pollen and the blue colour of narrow-leafed lupin flowers could be attractants for these insects (Andjus et al., 2001; Kirk, 1984b). Nevertheless, in our trials *A. intermedius* was more numerous on plants collected in treatments with triticale.

The most abundant species in our research, *F. intonsa*, is a highly polyphagous flower-dwelling thrips, infesting many flowering plants belonging to different orders and families (Murai, 1988; Raspudič et al., 2009; Wang et al., 2010; Pobożniak and Sobolewska, 2011). In Poland it is the most common and the most numerous species (Zawirska, 1999). It very often feeds in the flowers of leguminous plants. It is not generally considered as a pest in Polish conditions, but its very numerous individuals feeding in seed crops of alfalfa, and red and white clover can cause severe flower damage. Discoloration and deformation of *Rosa* sp. and *Peonia* sp. flowers caused by large population densities of *F. intonsa* were observed by the second author. This species is considered to be a serious pest in Asian-Pacific areas and in Turkey, where it is harmful on cotton plantations (Atakan and Özgür, 2001; Wang et al., 2010). In laboratory conditions *F. intonsa* was shown to transmit tospoviruses: TSWV, TCSV, GRSV and INSV (Wijkamp et al., 1995).

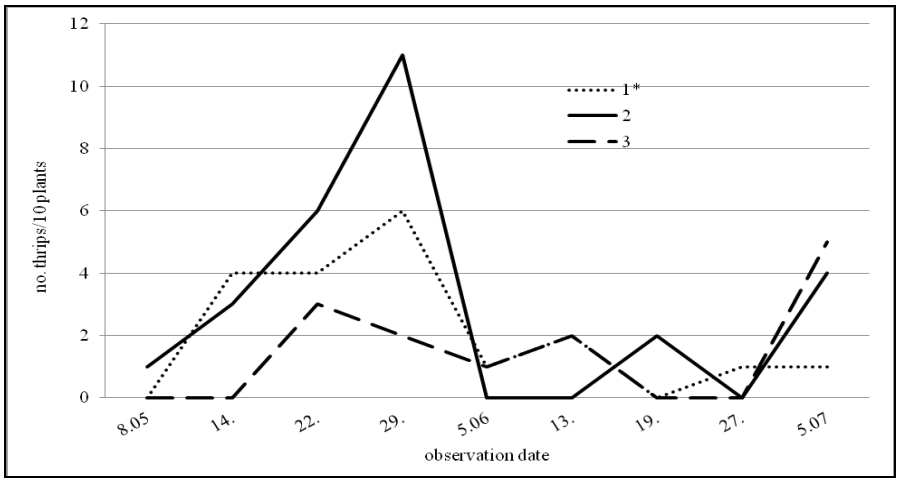
The third in the number of collected individuals, and occurring in all treatments, *T. tabaci*, has a broad host range that includes grasses and broadleaves. It is a pest of agricultural crops, home gardens, landscapes, and greenhouses. *T. tabaci* infests about 300 plant species. Among them the primary vegetable hosts include onion, garlic, leek, cabbage, cauliflower, bean, tomato, cucumber, and asparagus. Common field crop hosts include alfalfa, small grains, and cotton. *T. tabaci* can cause damage to bedding plants and some flowers. *T. tabaci*, in contrast to *F. intonsa*, feeds mainly on leaves, and its capacity to transmit plant viruses is very high (Tommasini and Maini, 1995). Both the larvae and adults of this species were collected in all treatments; however, they were more numerous on plots with pure lupin.

Plants of the Fabaceae family are the main hosts for species of the genus *Odontothrips.* They are typical flower-feeding species and are even regarded as pollinators. *O. loti* was sporadically recorded in our experiment in 2011. However, according to the literature lupin is not a preferred host plant for this species (Pitkin, 1972). Six species regarded as graminicolous: *Frankliniella tenuicornis*, *Limothrips cerealium*, *L. denticornis*, *Anaphothrips obscurus*, *Chirothrips manicatus* and *Haplothrips aculeatus* were also noted sporadically but, as expected, more often in treatments with triticale. Similar research was carried out in 2001-2003 on thrips fauna in spring triticale intercropped with yellow lupine. The species mentioned above dominated in ears, and among them *H. aculeatus* and *L. cerealium* were the most numerous. As in the present experiment, thrips were more abundant in mixed treatments than in pure ones (Hurej and Twardowski, 2004). In the latter case, the yellow colour of lupin flowers could act as a trap, luring more insects (Kucharczyk, 1998; Kirk, 1984b; Andjus et al., 2001).

Seasonal changes. In the conducted trials, the number of thrips observed during the growing season on narrow-leafed lupin was low in each year. On the other hand, the number and seasonal changes of these insects were similar in the three studied treatments, and because of this, only the results of 2012

are presented in Figure 1. In this year, the higher number of thrips was observed in the second half of May, with the maximum of their population at the end of this month. At the maximum of thrips population, plants were at the full blooming stage (BBCH 65). Insects occurred on lupin plants till mid July (BBCH 87). No significant differences in thrips numbers occurring on plants grown in the single crop or in mixtures with spring triticale, at any date, were found (F=0.67, df=2, P=0.514536).

In temperate climates polyphagous species of thrips show two peaks of abundance in their seasonal dynamics. The first, lower peak occurs in spring, and is caused mainly by wintering adult individuals which colonize crops and intensively feed as plants begin to flower. According to the weather conditions, at the end of May and in early June after laying eggs the population of adults decreases. The second, higher peak of abundance is usually recorded in July, and is formed by both the larvae and adults of a new generation (Lewis, 1973; Kobro et al., 2000; Hurej and Twardowski, 2004; Kucharczyk et al., 2011; Bereś et al., 2013; Kucharczyk unpublished research). In our research, thrips occurring in lupin plants in studied treatments had slightly different seasonal population patterns. In treatment 3 the spring peak was observed a week earlier, and was the lowest in comparison with the other two. While the population of thrips in the single crop decreased after flowering, it started to increase at the end of June in both of the mixture treatments. The spring peak was mainly created by floricolous species; the summer one by herbivorous and graminicolous species.



*treatment (see Table 1).

Figure 1. Seasonal dynamics of thrips recorded on narrow-leafed lupin intercropped with spring triticale in 2012

CONCLUSIONS

In two of the three years of the study significantly more thrips were collected from lupin plants grown as single crop. There were no significant differences in the number of these insects between lupin-triticale mixtures.

In the three years of the study a total of 2247 thrips individuals were collected from lupin plants at the full blooming stage (BBCH 65); 2237 belonging to 17 species, and 2 genera, because of damage, were classified to the genus range.

In each treatment *Frankliniella intonsa* and *Aeolothrips intermedius* were the dominant species. *Thrips tabaci* also occurred in greater numbers on lupin plants.

Aeolothrips intermedius, a predatory species, was found mainly in the first or second instar larvae. The percentage of this species in the total number of thrips recorded in each treatment was much higher in lupin-triticale mixtures than in the single crop.

In seasonal dynamics, higher numbers of thrips were observed at the full blooming stage of lupin. No significant differences in

the number of these insects occurring on plants grown in the single crop or in mixtures with spring triticale, at any date, were found.

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