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Application strategy for the chemical control of pea (*Pisum sativum* L.) crops against *Thrips tabaci* LINDEMAN, 1889 (Thysanoptera)

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ABSTRACT. In Poland chemical control of thrips in pea crops currently relies on insecticides with several modes of action, including pyrethroids (deltamethrin, cyhalothrin, cypermethrin) and neonicotinoids. The first insecticide treatment is recommended to be applied during the full bloom of pea plants and the second two repeated at intervals of 7 days. Field experiments were carried out at the Experimental Station in Mydlniki (near Kraków, southern Poland) over two years (2011 and 2012). Acetamiprid (neonicotinoid) (trade name Mospilan 20 SP) was used to control thrips on peas in the experiment. The results suggest that the conventional spray regime consisting of one weekly application of Mospilan 20 WP starting at full flowering can be replaced by one treatment at the beginning of flowering.

KEY WORDS: acetamiprid, damage index, thrips, pea.

INTRODUCTION

Poland enjoys favourable conditions for growing many species of food legume plants, but one of the most common among them is the pea (*Pisum sativum* L). Its cultivation area currently amounts to 14.3 thousand ha, which makes up 38.2% of the total cultivation area for edible crops. Pea production accounted for 44.0% of the total production of edible legumes in 2011. The yield of peas in Poland in 2011, depending on the growing region, ranged from 1.9 to 2.6 t / ha; it was the highest in the province of Małopolska (CSO 2011).

Peas are attacked by a large number of pests, the most important of which are thrips. In Hungary (JENSER et al. 2012) and England (WILLIAMS 2008), pea thrips (*Kakothrips* *pisivorus* [WESTWOOD, 1880]) cause bud and flower loss, deformation and discoloration of the pods and prevent seed setting. *Caliothrips indicus* (BAGNALL, 1913) is a serious pest of peas in Pakistan (SAHITO et al. 2013). In Germany, VON OETTINGEN (1951) lists *Thrips tabaci* LINDEMAN, 1889 as a pea pest already in the middle of the last century. In Slovenia, TRDAN (2003) mentions peas as host plants for onion thrips. *T. tabaci* was also observed in Poland on peas, beans, lentils and soybeans. POBOŻNIAK (2011) defines it as a species that emerges and develops on legumes, with an evident preference for peas. It is a serious threat to pea cultivation (POBOŻNIAK 2013). In the USA, moreover, GASKELL (1997) mentions *T. tabaci* as a serious pest infesting pea pods. Its feeding punctures may also be a point of entry for fungal disease organisms such as *Ascochyta* sp. From India, PATEL et al. (2013) report that onion thrips feeding on peas and beans contribute to large losses in the yields of these crops. Although insect pests are controlled by diverse measures, chemical control of insect pests is still considered more effective than other methods (SHELTON et al. 2008).

In Poland control of thrips in pea crops currently relies on insecticides with several modes of action, including pyrethroids (deltamethrin, cyhalothrin, cypermethrin) and neonicotinoids (ROBAK et al. 2014). Neonicotinoids are a unique chemical class of compounds for sucking-insect pest control owing to their broad spectrum of activity. Acting as agonists on nAChR, they control pest populations resistant to conventional insecticides and exhibit long-lasting residual effects (ELBERT et al. 2008, LAZNIK et al. 2010).

The major control strategy for onion thrips is the frequent use of insecticides (TRDAN et al. 2007), and growers may apply treatments weekly, resulting in several applications per crop (BROUGHTON & HERRON 2006). Overuse and misuse of pesticides adversely affect the environment and can lead to health risks to humans and the danger of pesticide residues remaining on produce (NDERITU et al. 2010). The negative effects of using synthetic pesticides have stimulated the ongoing search for alternative pest control approaches, among which are a reduced application frequency of pesticides (GOMBAČ & TRDAN 2014). Therefore, from a research perspective, it is important to determine not just which insecticides are effective, but when and how many times to apply them during the season (REITZ 2014). For this reason, the aim of the present study was to reduce the use of synthetic pesticides against *Thrips tabaci* on peas by limiting the amount of spraying and selecting the optimum date for their application.

MATERIALS AND METHODS

Study sites and experimental plots

The present experimental work was conducted at the Experimental Station of the Faculty of Biotechnology and Horticulture, Kraków Agricultural University, situated in

Mydlniki (near Kraków, southern Poland, 50°04’ N, 19°51’ E, 207 m amsl) during 2011 and 2012. Pea (*Pisum sativum*) seeds of the medium early and sugar cultivar ‘Hetman’ were sown in rows, 0.3 m apart, on 7th April 2011 and 30th March 2012. This variety is highly susceptible to thrips infestation and its feeding on pods causes a reduction in their quality and weight (POBOŻNIAK 2013).

The field was fertilized according to the recommendations for food legumes and based on soil test results carried out at the Plant Nutrition Unit of the Faculty of Biotechnology and Horticulture, Kraków Agricultural University (70 kg P_2O_5 and 100 kg K_2O in autumn and 35 kg N in spring). No fungicides or herbicides were applied, and weeds were removed mechanically.

In the experiment to control thrips on peas, acetamiprid insecticide (trade name Mospilan 20 SP) was used at a dose of 0.2 kg / ha with adjuvant Slipp 0.2 l / ha. In Poland it is recommended to apply this insecticide three times at 7-day intervals as a spray (ROBAK et al. 2014). Mospilan 20 WP was sprayed three times on to the crop: the first application when the first flowers appeared, the second during pod formation and the third during early pod ripening. The applications were done in the late evening. The experiment was designed in RCBD (Randomized Complete Blocks Design) with six combinations and four replicates (24 plots). The plot size was 12m^2 (4×3 m), and plots were separated by 1 m wide paths. Further details of each combination are given in Table 1. The phenological growth stages of the pea cultivars in all seasons were recorded at each sampling date and were classified according to FELLER et al. (1995) and WEBER & BLEIHOLDER (1990), as shown in Table 2.

Table 1. Dates of chemical treatments in Mydlniki (Kraków region) in 2011-2012.

Chemical treatment	**Combination**					
	A control	**B**	**C**	**D**	**E**	**F**
2011						
1st spray	–	02.06	02.06	02.06	–	–
2nd spray	–	12.06	12.06	–	12.06	–
3rd spray	–	–	20.06	–	–	20.06
2012						
1st spray	–	24.05	24.05	24.05	–	–
2nd spray	–	02.06	02.06	–	02.06	–
3rd spray	–	–	08.06	–	–	08.06

Table 2. Development phenology of the 'Hetman' pea cultivar in Mydlniki (Kraków region) in 2011-2012.

Year	Month and day								
	May				June				July
2011	12	19	24	30	06	11	18	27	06
	L	L	L	I/F	F	F/P	P	P	P
2012	13	19	23	30	07	16	21	27	07
	L	L	I/F	F	F/P	P	P	P	P

L – development of main shoot and leaves (BBCH 35–39); I – inflorescence emergence (BBCH 50–59); F – flowering (BBCH 60–69); P – development and ripening of pods (BBCH 70–85)

Assessment of the thrips population

The sampling period in all seasons started in May and lasted until the third week of July. Thrips were caught using a standard entomological sweep net. A single sample consisted of 25 sweeps within each plot at intervals of 5–9 days, and the resulting catch was stored in a plastic bag. In the laboratory, thrips adults and larvae were extracted and kept in a conservation fluid (60% alcohol with glycerol). To determine the species, microscope preparations were made according to ZAWIRSKA (1994)**.** Adult individuals of thrips were identified according to ZAWIRSKA (1994). Thrips larvae were determined to species level according to VIERBERGEN et al. (2010).

Determination of pod yield and quality

In order to determine the effect of larvae and adult thrips feeding on the quality of pea pods, 1000 pea pods were randomly collected during the harvesting maturity of each plot. They were then divided according to a six-point scale: I – no damage to the pods, II – ≤ 5% of the pod surface damaged, III – 5.1 – 10% of the pod surface damaged, IV – 10.1–25% of the pod surface damaged, V – 25.1–50% of the pod surface damaged, VI –> 50.1% of the pod surface damaged.

On this basis, the index of pod damage was calculated for each cultivar according to the Townsend-Heuberger formula (PÜNTENER 1981).

$$damage = \frac{\sum_0^i (n \cdot v)}{i\,N} \cdot 100\ \%$$

where: v = class of damage, i = the highest class of damage, n = number of plants (or parts thereof) in the class, N = total number of plants (or parts thereof).

Statistical analysis

For the field data one-way ANOVAs and the Duncan test (P ≤ 0.05) were performed to test for differences between the numbers of *Thrips tabaci*. Similarly, the damage index, weight and the increase in pod weight were compared using one-way ANOVAs. Statistical analyses were performed using PASW Statistics 10.0 software.

RESULTS

Effect of insecticide spraying on the thrips population

The phenology of pea development and the population dynamics of onion thrips during the growing season are shown in Table 1 and Figures 1-2, respectively. During both years of the study, the first *Thrips tabaci* individuals were observed in the pea plots of all combinations as soon as the plants were emerging, e.g. around 20th May. In mid-May, when the pea plants were still at the stage of main shoot and leaf development, the number of feeding onion thrips gradually increased. In the control plots (combination A), where no chemical treatments were applied, the number of thrips reached a maximum on 11th June 2011 and 7th June 2012, when the pea plants were in full bloom and during pod development. Then, the onion thrips population clearly decreased towards the end of June or in early July (Fig. 1, 2). In the chemically treated plots, each application of insecticide resulted in a significant reduction of the thrips population compared to the unsprayed plots. The application when the flowers first appeared caused a decrease in the number of thrips of about 10 thrips / plot to about 2 thrips / plot (combinations B, C and D). The second spray during pod formation (combination B and C) and the third during early pod ripening (combination C) led to a further decrease in the number of onion thrips. In plots of combination D, the populations of pests increased slightly two weeks after spraying but remained at a low level until the peas stopped growing. Combinations E and F were characterized by high *T. tabaci* infestation until spraying, which took place during the formation of the first pods (combination E) and during early pod ripening (combination F). Thereafter, the number of *T. tabaci* rapidly decreased from about 40 (2011) and 25 (2012) specimens / plot to just a few specimens / plot (Fig. 1, 2).

All the spray regimes reduced the onion thrips population in comparison to the plots without any thrips management measures. Plots in combinations B, C and D belonged to the group with significantly smaller numbers of collected thrips compared with the control and combinations E and D. In 2011, the mean number of thrips collected from combinations B, C and D ranged from 32.0 to 42.0 individuals / plot and was more than two times less than in the control plots. In 2012 the differences were even greater (Table 3).

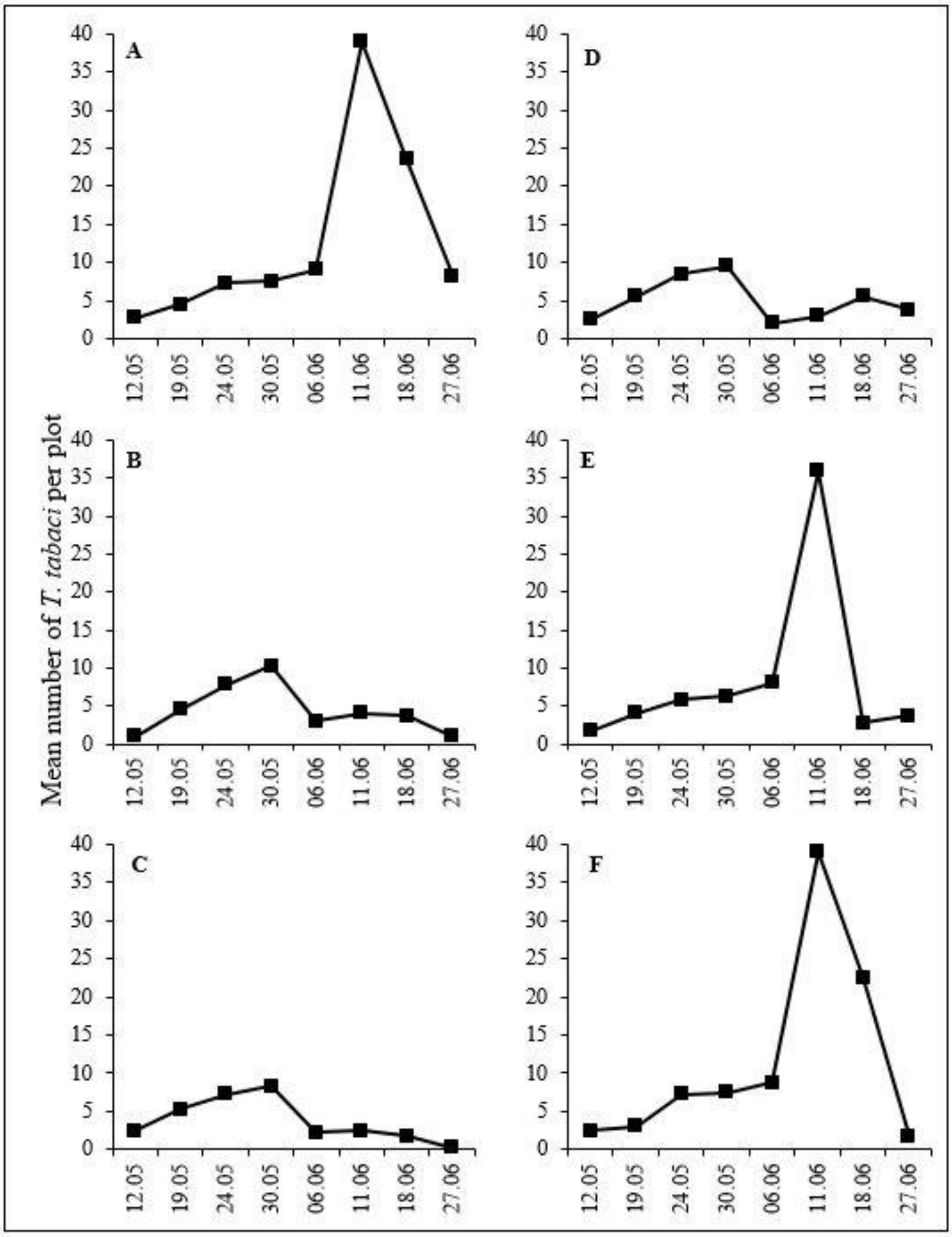

Fig. 1. Effect of insecticide treatment on the population dynamics of *Thrips tabaci* in peas Mydlniki (Kraków region, Poland) in 2011. Combination A – control; Comb. B – 1st application on 02.06 and 2nd appl. on 12.06; Comb. C – 1st appl. on 02.06, 2nd appl. on 12.06 and 3rd appl. on 20.06; Comb. D – 1st appl. on 02.06; Comb. E – 1st appl. on 12.06; Comb. F – 1st appl. on 20.06.

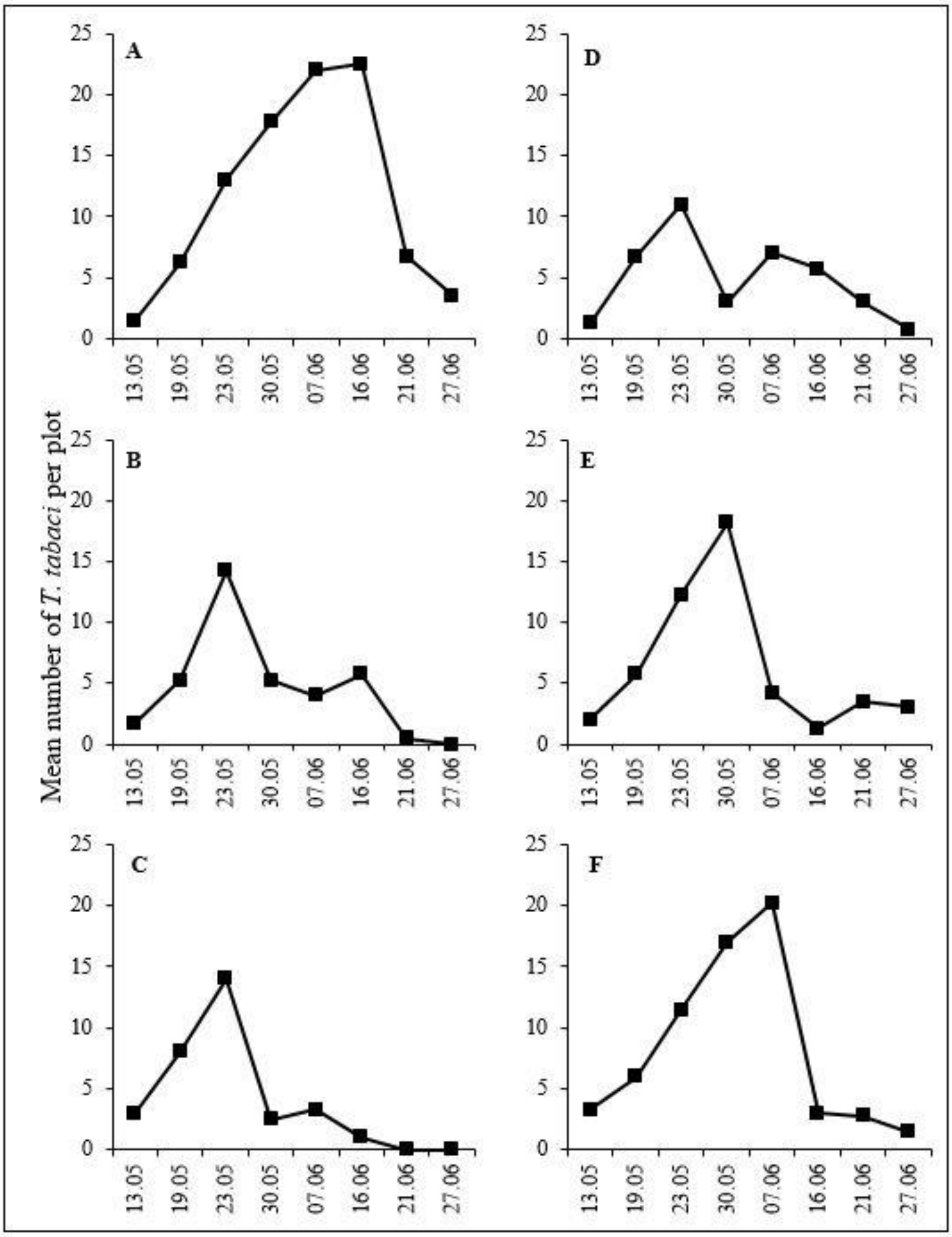

Fig. 2. Effect of insecticide treatment on the population dynamics of *Thrips tabaci* in peas Mydlniki (Kraków region, Poland) in 2012. Combination A – control; Comb. B – 1st application on 24.05 and 2nd appl. on 02.06; Comb. C – 1st appl. 24.05, 2nd appl. on 02.06 and 3rd appl. on 08.06; Comb. D – 1st appl. on 24.05; Comb. E – 1st appl. on 02.06; Comb. F – 1st appl. on 08.06.

Table 3. Mean numbers of thrips (mean ± SE) in pea crops subjected to a different number and frequency of insecticide applications in Mydlniki (Kraków region) during 2011-2012.

Year	Combination					
	A*	**B**	**C**	**D**	**E**	**F**
2011	116.0 ± 2.6 a	38.5 ± 2.6 c	35.0 ± 2.1 c	44.5 ± 3.8 c	80.8 ± 4.4 b	104.0 ±5.1 a
2012	93.3 ± 1.8 a	36.8± 1,9 c	32.3± 5.9 c	38.5± 2.7 d	50.3 ± 3.4 b	68.3 ± 4.8 b

Mean values followed by different letters are significantly different; one-way ANOVA at $P \leq 0.05$.
*see Table 1

Table 4. Pod damage index [%] (mean ± SE) in pea crops subjected to a different number and frequency of insecticide applications in Mydlniki (Kraków region) during 2011–2012.

Year	Combination					
	A*	**B**	**C**	**D**	**E**	**F**
2011	57.3 ± 1.6 a	33.8 ± 1.3 c	32.1 ± 1.6 c	33.7 ± 0.5 c	44.4 ± 0.5 b	56.9 ± 1.6 a
2012	41.5 ± 0.8 a	31.6 ± 1.1 c	31.7 ± 0.9 c	30.2 ± 1.0 c	36.1 ± 2.5 b	40.4 ± 1.9 a

Mean values followed by different letters are significantly different; one-way ANOVA at $P \leq 0.05$.
*see table 1

Table 5. Weight and increase in weight of pea pods in pea crops subjected to a different number and frequency of insecticide applications in Mydlniki (Kraków region) during 2011–2012.

Combination	Mean weight of 1000 pods [g± SE]	Mean increase in weight [% ± SE]	Mean weight of 1000 pods [g± SE]	Mean increase inweight [% ± SE]
	2011		**2012**	
A	2336.4 ± 43.4 c	–	2359.0 ± 40.6 c	–
B	2882.2 ± 98.4 ab	23.3 ± 2.4 a	2487.0 ± 59.2 abc	5.6 ± 1.6 ab
C	2936.2 ± 62.6 a	24.7 ± 1.7 a	2564.1 ± 66.3 ab	5.6 ± 1.4 a
D	2815.0 ± 138.7 ab	21.3 ± 6.9 ab	2606.4 ± 64.0 a	10.4 ± 1.3 a
E	2553.5 ± 177.6 bc	9.0 ± 5.6 b	2529.5 ± 43.1 abc	7.3 ± 1.7 ab
F	2624.8 ± 39.0 abc	12.4 ± 1.6 ab	2377.6 ± 67.0 bc	0.8 ± 0.3 c

Mean values followed by different letters are significantly different; one-way ANOVA at $P \leq 0.05$.
*see table 1

Effect of insecticide spraying on pod weight and quality

In both years of the study the damage index of the pods was significantly higher (57.3% and 41.5% respectively in 2011 and 2012) in the control plots and significantly lower in combinations B, C and D (33.8%, 32.1% and 33.7% respectively in 2011 and 31.6%, 31, 7% and 30.2% respectively in 2012). Table 4 shows that insecticide spraying in combinations B, C and D in 2011 and C and D in 2012 led to significantly greater mean weights of pods when compared with the untreated control. This was especially evident in combinations B, C and D in 2011, where the insecticide caused a more than 20% increase in pod weight than the untreated control (Table 5).

DISCUSSION

The pea is a suitable host plant for *Thrips tabaci* (POBOŻNIAK & KOSHIER 2013). ÁBRAHÁM (2008), JENSER et al. (2012) and POBOŻNIAK (2013) state that onion thrips feeds on the leaves, flowers and pods of both peas and other food legume plants. The results indicate that pea plants are inhabited by number of *T. tabaci* throughout the growing season. The population density of onion thrips underwent particularly strong fluctuations in the successive phases of the phenological development of pea plants and was the highest during flowering and pod development. According to POBOŻNIAK (2013), *T. tabaci* is the primary pest of pea pods. As a result of this species' feeding, young pods became deformed and twisted, as a result of which many withered and dropped off the plant. Silvery spots, later turning brown, often formed on older pods, which became deformed primarily from the sprout and at the base (POBOŻNIAK 2013).

It was established that *Aeolothrips intermedius* BAGNALL, 1934 reduces population densities of herbivorous thrips in open areas (FRANCO et al. 1999). According to TRDAN et al. (2005) *A. intermedius* is very probably an effective predator only in an environment where it does not lack alternative food; only a single specimen of the predator was found on vegetative plant parts in spite of the large populations of its potential prey. A study by POBOŻNIAK (2013) indicates that the predatory species *A. intermedius* occurs and reproduces on pea, but its population is not sufficient to reduce the number of herbivorous thrips species to a level below which their damage is minimal. For this reason, chemical treatments are the main method used by pea growers for controlling thrips.

The results of the present study demonstrated that Mospilan 20 SP performed well in reducing the population of *Thrips tabaci* on pea crops. This is in line with the findings of KHATTAK et al. (2004), who evaluated the efficacy of Mospilan 20 SP against thrips on mungbeans and on peas (SAHITO 2013). Tests conducted with acetamiprid (Assail 70 WP) showed that it led to >85% mortality of thrips at the field rate (SHELTON et al. 2006). The maximum decrease in the mean number of *T. tabaci* after spraying was recorded in all plots treated with insecticide when the first flowers appeared. The thrips population was not significantly different in plots where the treatment was repeated during the development and maturation of the pods in comparison with the plots with no repeated spraying. The tested insecticide gave effective control of thrips up to several days, and as long as two weeks after spraying, the pest population was lower than in the control plots. These results are in conformity with those of ASLAM (2004) and SOLANGI & LOHAR (2008), who reported that Mospilan 20 WP gives satisfactory control up to seven and even fourteen days after application. Because of this, repeated treatments according to the pea protection programme in Poland (ROBAK et al. 2014) against thrips was unnecessary. Also, the studies by TRDAN et al. (2007) confirmed that one application of deltamethrin was enough to control *T. tabaci* in an early cabbage cultivar.

A spray regime consisting of one insecticide application during early pod ripening had a significant effect on the thrips population compared to the control plots only in 2012. The results show that the spraying was carried out after the thrips population had increased (i.e. after the pea plants had flowered) and caused more damage to the pods. For example, there was no significant difference in the pod damage index and the mean weight of pods between the combinations sprayed only during pod formation or early pod ripening and the unsprayed plots. Spray regimes with one insecticide application at the beginning of flowering was sufficient to ensure pods of better quality and greater mass in comparison to untreated plots and later spraying. This form of thrips management was the most cost effective, leading to a similar or even greater increase in pod weight compared to spray regimes with two and three sprayings. Also, the pod damage index and mean weight of pods harvested from plots with only one spraying at the start of flowering significantly differed from the plots with one spraying during pod formation and early pod ripening. The results suggest that the conventional spray regime consisting of one weekly application of Mospilan 20 WP starting at full flowering should be replaced by one treatment at the beginning of flowering.

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