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DETERMINING THE BIOLOGICAL EFFECTS OF SOME PLANT PROTECTION PRODUCTS TO CONTROL BROWN PSEUDOBUTTERFLY, *Pochazia shantungensis* (CHU & LU, 1977) (HEMIPTERA: RICANIIDAE)

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Abstract: *Pochazia shantungensis,* an invasive pest originating from Far East Asia, poses a threat to numerous commercially significant agricultural crops and ornamental plants. This insect species was initially discovered in Istanbul province in 2019 and has since spread extensively across a significant part of the ecosystem in the Marmara Region of Türkiye. The primary strategy for managing this pest relies heavily on chemical control methods. Given the lack of a registered plant protection product (PPP) specifically for *P. shantungensis* in Türkiye, various chemical and biological formulations were evaluated in this study. The chosen preparations were those that have received official approval for use against other harmful species in Türkiye, which exhibit damage patterns similar to those caused by *P. shantungensis*. The study assessed the recommended dosage along with two sub-doses of these registered formulations for their effectiveness against this pest. Efficacy testing was conducted in pots fitted with muslin cloth cages, employing a randomized block design with three replications for each formulation at three different dosages. The findings indicated that the 0.025% concentration of the acetamiprid 20% formulation (Mospilan 20 SP) achieved the highest efficacy, resulting in a 100% effect within five days post-application. Additionally, a 0.05% concentration of deltamethrin 25 g/L (Deltharin 2.5) demonstrated an efficacy of 97.65% after seven days, while a 0.5% concentration of azadirachtin 0.3 g/L (Nimbecidine) reached an efficacy of 69.51% after eleven days. Minimal effects were noted one day after application, with recorded efficacies of 1.14% and 2.27% for the 0.05%, 0.15%, and 0.25% doses of 1.5% *Verticillium lecanii* strain bb-1 1.5% - 1x10 over 8 cfu/ml min (Nibortem SL) and the 0.2% concentration of sulfur 80-WG, respectively.

Keywords: *Pochazia shantungensis*, Ricaniidae, Chemical control, Plant protection product

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1. Introduction

The climate in the Marmara Region is described as a transitional climate, located between the Mediterranean and continental climate zones. A wide variety of fruit and vegetable species, including olives, peaches, cherries, figs, strawberries, chestnuts, quinces, kiwi fruits, grapes, tomatoes, potatoes, garlic, onions, eggplants, zucchinis, and peppers, are cultivated extensively in this region. The region's lands have significant agricultural potential, with income from agricultural products making a substantial contribution to the country's economy. Numerous biotic and abiotic elements adversely influence the quality and yield of agricultural produce. A significant factor to consider is also the presence of harmful organisms and the issues they lead. Certain detrimental organisms possess the capability to alter their environments and migrate to new locations in response to food shortages influenced by global climate change. The recent rise in international trade, along with the enhanced human-induced movement between countries, has made it feasible to transport harmful organisms across boundaries. One of the invasive species being carried is the Brown pseudobutterfly, *Pochazia shantungensis* (Chu & Lu, 1977) (Hemiptera: Ricaniidae), a new pest to the fauna of Türkiye, with its initial discovery in Istanbul Province (Hizal et al., 2019). *P. shantungensis* belongs to the Ricaniidae family. This family's species are mostly common in tropical regions. In the Palearctic region, only species from the genus Pochazia are found (Demir, 2009). The Ricaniidae family comprises a total of 45 genera and approximately 450 species across the world (Chou et al., 1985; Xu et al., 2006; Ginezdilov and Sugonyaev, 2009). Only four species are known to exist in Europe. Among these species, *Ricania hedenborgi* Stal, 1865, has been recorded in Greece and Türkiye (Demir, 2009), while *Ricania japonica* Melichar, 1898, occurs in

Türkiye, Bulgaria, and Ukraine (Demir, 2009; Gjonov, 2011). Additionally, *Ricania limbata* Lallemand, 1935, is found in France (Bourgoin, 2013), and *Ricania speculum* Walker, 185, is present in Italy (Mazza et al., 2014). Currently, three species of Ricania have been identified in Türkiye: *Ricania hedenborgi* Stal, 1865 (Lodos and Kalkandelen, 1981; Tezcan and Zeybekoglu, 2001); *Ricania simulans* Walker, 1851 (Ak et al., 2015; Göktürk and Mıhlı, 2015); and *Ricania aylae* Dlabola, 1983 (Demir and Demirsoy, 2009). Nonetheless, Demir (2009) and Öztemiz (2018) assert that *R. japonica* was incorrectly identified as *R. simulans*, while *R. aylae* is deemed a synonym of *R. hedenborgi*. This destructive insect species, first identified in China and subsequently observed in South Korea, causes significant damage to jujube, blueberry, apple, chestnut, plum, and quince (Choi et al., 2011). Brown pseudobutterflies, similar to their Far Eastern relative *Orosanga japonica*, lead wounds on the shoots during the egg-laying phase. In the nymphal stage, their feeding on plant sap results in the accumulation of honeydew on the plants (Ak et al., 2015; Altaş and Ak, 2019). Additionally, the presence of sugary materials stimulates the proliferation of mold fungus, which can further impair plant respiration and photosynthesis (Choi et al., 2011). This species, which spreads rapidly through the formation of substantial populations, has a diversified host range and is detrimental to 138 plant species in 62 families (Kim et al., 2015). This pest, similar to the Pseudobutterfly (*Orosanga japonica*) species found in the Eastern Black Sea Region, causes damage to agricultural crops and has an undesirable effect on public places such as homes, cafes, restaurants, parks, and gardens due to its high population. Accordingly, this study was conducted to find solutions to the previously mentioned issues. As no licensed plant protection product is available in Türkiye for the chemical management of this newly identified pest, a trial was carried out to determine the effective doses of some registered chemical and organic preparations that have been effective against numerous insects with similar damage characteristics. The study was supported by the General Directorate of Agricultural Research and Policies, affiliated with the Ministry of Agriculture and Forestry.

2. Materials and Methods

2.1. Material

The main materials of the study were the biological stages of *Pochazia shuntungensis*, *Ligustrum vulgare* L. (Lamiales: Oleaceae) and several plant protection products including 1.5% *Verticillium lecanii* strain bb-1 (Nibortem SL), azadirachtin 0.3 g/L (Nimbecidine), sulfur 80% WG (Diaflex 80 WG), acetamiprid 20% SP (Mospilan) and 25% G/L deltamethrin 25% G/L (Deltharin 2.5). Other supplies comprised personal protective clothing, a 2-liter hand sprayer from HP Garden Tools, drift prevention material (a cardboard box), pots and cages with muslin cloth, soil, insect repellent, black mulch (jute), sterile purified water, petri dishes, Eppendorf tubes, soft-tipped brushes, and clear polyethylene bags.

2.2. Method

The biological efficacies of plant protection products against the second and third instar nymphs of *P. shantungensis* were determined by using pot tests in net cages at the institute's field in Yalova Province.

Table 1. Plant protection products licensed against other pests in Türkiye tested in this study and their recommended dosages, in 2021

Active substance name	Trade name	Plant for which it is licensed	Pest for which it is licensed	Recommended Dosage/ Concentration
1.5% *Verticillium lecanii* strain bb-1 1.5% - 1×10^8 kob/ml min	Nibortem SL	Cucumber	*Bemisia tabaci* (Gennadius 1889) *Frankliniella occidentalis* (Pergande 1895)	2500 ml/ha larvae, pupae, adult
Azadirachtin 0.3 g/l	Nimbecidine	Tobacco, grape, peach, cultivated mushroom, olive, pepper	*Bemisia tabaci* (Gennadius 1889) *Frankliniella occidentalis (*Pergande 1895)	500 ml/100 L water
Sulphur %80	Diaflex 80 WG	A variety of fruits and vegetables	Powdery mildew and mites	400 g/l 100 L water
Acetamiprid %20	Mospilan 20 SP	Pepper, Watermelon, Cherry, Tomato, Pistachio, Peach, Tobacco, Cotton, Potato	*Myzus persicae,* (Sulzer 1776) *Bemisia tabaci* (Gennadius 1889) *Aphis pomi*, (DeGeer. 1773) *Empoasca* spp. *Leptinotarsa decemlineata*, Say,1824 *Agonoscena pistaciae* Burckhardt and Lauterer, 1989	25 g/100 L water (adult-nymph)
Deltamethrin 25 G/L	Deltharin 2,5	A variety of fruits and vegetables	*Cacopsylla pyricola*, (Förster, 1848) *Agonoscena pistaciae*, Bur. and Lau.1989 *Bemisia tabaci* (Gennadius 1889)	50 ml/100 L water

Table 2. Plant protection products and their doses tested against *Pochazia shantungensis* on common privets in Yalova province in 2021

The name of plant protection production	D/C	D/C	D/C
1.5% *Verticillium lecanii* strain bb-1 1.5% - 1×10^8 kob/ml min	0.25%	0.015%	0.05%
Azadirachtin 0.3 g/l	0.5%	0.4%	0.3%
Sulphur %80 WG	0.4%	0.3%	0.2%
Acetamiprid %20 SP	0.025%	0.02%	0.015%
Deltamethrin 25 G/L	0.05%	0.035%	0.02%

D= dosage, C= concentration.

The trial was established in a randomized block trial design with three replications using two sub-doses and the registered dose of each plant protection product against the pest for which it has a license in Türkiye. Data relating to the plant protection products utilized in the trial are provided in Table 1, along with details about the doses tested in Table 2 and the trial design in Table 3.

Table 3. Trial plan established against *Pochazia shantungensis* on common privets in Yalova province in 2021

Order	I. Block	II. Block	III. Block
1	A1	A3	A2
2	C1	B3	C2
3	E1	E3	E2
4	D1	C3	K3
5	B1	D3	B2
6	A2	A1	D2
7	C2	C1	A3
8	E2	E1	B3
9	K1	D1	E3
10	B2	B1	C3
11	D2	A2	D3
12	A3	C2	A1
13	B3	E,2	C1
14	E3	K2	E1
15	C3	B2	D1
16	D3	D2	B1

A=1.5% *Verticillium lecanii* strain bb-1 1.5% - 1×10^8 kob/ml min (Nibortem SL), B=Azadirachtin 0.3 g/l (Nimbecidine), C=Sulphur 80% WG (Diaflex 80 WG), D=Acetamiprid 20% SP (Mospilan), E=Deltamethrin 25 G/L (Deltharin).

2.2.1. Cultivation of common privets

The biological effects of PPPs were determined on second- and third-instar nymphs feeding on leaves and shoots of common privets. Therefore, the plants required for the experiment were cultivated in 300 x 300 mm pots. Firstly, the pots were filled with a mixture of sterile soil, peat, and barnyard manure (1:1:1, v/v/v), and then rooted plant cuttings were planted in these pots in pairs. The plants were left to grow naturally, and they were placed in 40 x 40 × 80 cm net cages when they reached a height of 70 cm and had grown enough leaves and shoots for the nymphs to feed on. The floor of the cage was covered with black mulch (jute).

2.2.2. The collection of *Pochazia shantungensis* nymphs

The nymphs for the experiment were gathered using an insect aspirator from heavily identified locations from May to June. The collected nymphs were placed using an insect aspirator on the 50-60 cm tall common privets in the cages. Following the introduction of 30 nymphs into each cage, the plants in the cage were sprayed with the recommended dosages and two sub-doses of the plant protection agents listed in Table 2, which are registered against pests comparable to *P. shantungensis* in Türkiye, using a hand sprayer (2 L). Prior to the experiment's setup, an ant repellent insecticide was applied on the ground and surrounding area. Nymphs in control plots (cages) were only applied sterilized water. The pots used in the study were spaced 70 cm apart in rows, 30 cm apart in rows, and a 1 m wide safety strip was between plots. In addition, a 50 x 50 x 100 cm spray screen (cardboard box) was placed inside the cages in order to prevent the sprayed water from drifting during application to the plot. The application involved 300 milliliters of the plant protection product mixed with water for every individual plant. The counts and evaluations of nymphs, both alive and dead, were executed on the 1st, 3rd, 5th, 7th, 9th, and 11th days after the spraying occurred. Throughout the trial period, temperature and humidity data were provided from the Provincial Directorate of Meteorology.

2.2.3. Statistical analysis

The percentage efficacy of plant protection products was calculated by using the Abbot (1925) formula given in Equation 1 on the data obtained from counting and evaluation.

$$\% \text{ Mortality} = \frac{\text{LC} - \text{LT}}{\text{LC}} \times 100 \quad (1)$$

Where, LC is % of living individuals in the control plot and LT is % of living individuals in the treated plot.

In addition, variance analysis (ANOVA) and multiple comparisons were performed using the JMP 5 statistics program, and differences between means were compared using the Tukey ($P<0.01$) test (Genç and Soysal, 2018).

3. Results

Under natural conditions, nymph emerging occurred on 1 May 2021, from 10 egg clusters, which were detected on the annual shoots of common privets a year ago (15-20 November 2020) and marked with colored raffia, and monitored daily from April the following year. Subsequently, the nymphs were gathered out of various outdoor ornamental plants in May and June, when they were in their second and third stages, and placed in trial cages. The trial was established on 18 June 2021, when nymphs transferred to potted common privets in muslin cages began consuming leaves and shoots, and the results obtained in the trial are shown in Table 4, and the percentage effects of the PPPs included in the trial are given in Table 5. Meteorological data on the dates when the experiment was established and when counts were conducted to assess the experiment are presented in Table 6.

Table 4. Counting results from the plant protection products trial conducted against *Pochazia shantungensis* on the common privets in Yalova provinces in 2021

				1. Day		3. Day		5. Day		7. Day		9. Day		11. Day	
Active ingredient name		D. / C.	Rep.	19.06.2021		21.06.2021		23.06.2021		25.06.2021		27.07.2021		29.06.201	
				D.	A.	D.	A.	D.	A.	D.	A.	D.	A.	D.	A.
1.5% *Verticillium lecanii* strain bb-1 1.5% - 1×10^8 kob/ml min	Nibortem SL	500 ml/ha	I.	1	29	1	29	2	28	4	26	5	25	5	25
			II.	1	29	1	29	3	27	4	26	4	26	4	26
			III.	1	29	1	29	2	28	3	27	5	25	5	25
			Ave.	1	29	1	29	2.3	27.7	3.7	26.3	4.7	25.3	4.7	25.3
		1500 ml/ha	I.	1	29	1	29	3	27	6	24	6	24	8	22
			II.	1	29	2	28	4	26	5	25	6	24	7	23
			III.	0	30	1	29	3	27	4	26	4	26	5	25
			Ave.	0.67	29.3	1.33	28.7	3.33	26.7	5	25	5.3	24.7	6.7	23.3
		2500 ml/ha	I.	1	29	1	29	3	27	8	22	10	20	10	20
			II.	1	29	2	28	5	25	7	23	9	21	9	21
			III.	0	30	1	29	5	25	6	24	8	22	8	22
			Ave.	0.67	29.3	1.3	28.7	4.3	25.7	7	23	9	21	9	21
Azadirachtin 0.3 g/l	Nim.	300 ml/100 L W.	I.	7	23	8	22	8	22	10	20	11	19	12	18
			II.	6	24	8	22	9	21	10	20	10	20	12	18
			III.	6	24	10	20	11	19	13	17	13	17	13	17
			Ave.	6.3	23.7	8.7	21.3	9.3	20.7	11	15.7	11.3	18.7	12.3	17.6
		400 ml/100 L W.	I.	9	21	11	19	12	18	14	16	16	14	17	13
			II.	7	23	9	21	11	19	14	16	16	14	17	13
			III.	7	23	10	20	12	18	13	17	15	15	18	12
			Ave.	7.7	22.3	10	20	11.7	18.3	13.7	16.3	15.7	14.3	17.3	12.7
		500 ml/100 L W.	I.	10	20	14	16	19	11	19	11	19	11	20	10
			II.	7	23	10	20	17	13	20	10	22	8	23	7
			III.	8	22	10	20	15	15	19	11	21	9	22	8
			Ave.	8.3	21.7	11.3	18.7	17	13	19.3	10.7	20.7	9.3	21.7	8.3
Sulphur 80 % WG	Dia. WG 80%	200 g/100 L W.	I.	2	28	2	28	4	26	4	26	4	26	4	26
			II.	1	29	2	28	3	27	3	27	3	27	4	26
			III.	1	29	3	27	5	25	5	25	5	25	5	25
			Ave.	1.3	28.7	2.3	27.7	4	26	4	26	4	26	4.3	25.7
		300 g/100 L W.	I.	2	28	3	27	4	26	4	26	5	25	5	25
			II.	2	28	2	28	3	27	3	27	4	26	5	25
			III.	1	29	3	27	3	27	4	26	5	25	6	24
			Ave.	1.7	28.3	2.7	27.3	3.3	26.7	3.7	26.3	4.7	25.3	5.3	24.7
		400 g/100 L W.	I.	3	27	5	25	5	25	5	25	5	25	6	24
			II.	2	28	4	26	5	25	6	24	6	24	6	24
			III.	3	27	6	24	6	24	7	23	7	23	7	23
			Ave.	2.7	27.3	5	25	15.3	24.7	6	24	6	24	6.3	23.8
Acetamiprid 20%	Mospi. 20 SP	15 ml/100 L W.	I.	9	21	19	11	22	8	24	6	24	6	24	6
			II.	10	20	21	9	23	7	25	5	25	5	25	5
			III.	11	19	22	8	23	7	24	4	24	6	24	6
			Ave.	10	20	20.7	9.3	22.7	7.3	24.3	5	24.3	5.7	24.3	5.7
		20 ml/100 L W.	I.	12	18	21	9	25	5	27	3	27	3	27	3
			II.	14	16	20	10	26	4	28	2	28	2	28	2
			III.	16	14	21	9	26	4	28	2	28	2	28	2
			Ave	14	16	20.7	9.3	25.7	4.3	27.7	2.3	27.7	2.3	28.3	2.3
		25 ml/100 L W.	I.	20	10	26	4	30	0	30	0	30	0	30	0
			II.	24	6	28	2	30	0	30	0	30	0	30	0
			III.	22	8	29	1	30	0	30	0	30	0	30	0
			Ave.	22	8	27.7	1.7	30	0	30	0	30	0	30	0

Table 4. Counting results from the plant protection products trial conducted against *Pochazia shantungensis* on the common privets in Yalova provinces in 2021 (continue)

Active ingredient name		D. / C.	Rep.	1. Day		3. Day		5. Day		7. Day		9. Day		11. Day	
				19.06.2021		21.06.2021		23.06.2021		25.06.2021		27.07.2021		29.06.201	
				D.	A.	D.	A.	D.	A.	D.	A.	D.	A.	D.	A.
Deltamethrin 25 G/L	Delth. 2.5	20 ml/100 L W.	I.	4	26	9	21	18	12	19	11	21	9	22	8
			II.	5	25	11	19	20	10	20	10	20	10	20	10
			III.	5	25	10	20	19	11	20	10	19	11	19	11
			Ave.	4.7	25.3	10	20	19	11	19.7	10.3	20	10	20.3	9.76
		35 ml/100 L W.	I.	9	21	18	12	25	5	25	5	25	5	26	4
			II.	11	19	20	10	23	7	24	6	24	6	24	6
			III.	10	20	20	10	21	8	23	7	24	6	24	6
			Ave.	10	20	19.3	10.7	23	6.7	24	6	24.3	5.7	24.6	5.3
		50 ml/100 L W.	I.	14	16	22	8	27	3	28	2	28	2	28	2
			II.	16	14	24	6	29	1	30	0	30	0	30	0
			III.	17	13	24	6	29	1	30	0	30	0	30	0
			Ave.	15.7	14.3	23.3	6.7	28.3	1.7	29.3	0.7	29.3	0.7	29.3	0.7
Control			I.	0	30	0	30	1	29	1	29	2	28	3	27
			II.	1	29	1	29	1	29	2	28	3	27	3	27
			III.	1	29	1	29	1	29	2	28	2	28	2	28
			Ave.	0.66	29.3	0.66	29.3	1	29	1.66	28.3	2.33	27.6	2.66	27.3

D. / C.= dosage /concentration, D= dead, A= alive, Ave.=average, Delth.= deltamethrin, Dia.= Diaflex, Mospi.= Mospilan, Nim.= Nimbecidine, W.= wate.

Table 5. Effects of plant protection products tested against *Pochazia shantungensis* on common privets in Yalova province in 2021

Tested plant protection product		Efficiacy (%)					
		1. Day	3. Day	5. Day	7. Day	9. Day	11. Day
1.5% *Verticillium lecanii* strain bb-1 1.5% - 1×10^8 kob/ml min	Nibortem SL 500 ml	1.14 G	1.14 F	4.60 HI	7.06 GH	8.43 FG	7.32 HI
	Nibortem SL 1500 ml	1.14 G	2.27 F	8.05 GHI	11.76 FG	10.84 F	14.63 GH
	Nibortem SL 2500 ml	1.14 G	2.27 F	11.49 GH	18.82 F	24.10 E	23.17 G
Azadirachtin 0.3 g/l	Nimbecidine 300 ml	19.32 DE	27.27 D	28.74 F	32.94 E	32.53 E	35.37 F
	Nimbecidine 400 ml	23.86 CDE	31.82 D	36.78 F	42.35 D	48.19 D	53.66 E
	Nimbecidine 500 ml	26.14 CD	36.36 D	55.17 E	62.35 C	66.27 C	69.51 CD
Sulphur 80% WG	Diaflex WG 80 200 g	2.27 G	5.68 EF	10.34 GH	8.24 GH	6.02 FG	5.80 HI
	Diaflex WG 80 300 g	3.41 FG	6.82 EF	8.05 GHI	7.06 GH	8.43 FG	9.76 HI
	Diaflex WG 80 400 g	6.82 FG	14.77 E	14.94 G	15.29 FG	13.25 F	13.41 H
Acetamiprid 20%	Mospilan 20 SP 15 ml	31.82 C	68.18 BC	74.71 D	79.52 B	79.52 B	79.27 BC
	Mospilan 20 SP 20 ml	45.45 B	68.18 BC	85.06 BC	91.76 A	91.57 A	91.46 A
	Mospilan 20 SP 25 ml	72.73 A	92.05 A	100.00 A	100.00 A	100.00 A	100 A
Deltamethrin 25 G/L	Deltharin 2.5 20 ml	13.64 EF	31.82 D	62.07 E	63.53 C	63.86 C	64.63 D
	Deltharin 2.5 35 ml	31.82 C	63.64 C	77.01 CD	78.82 B	79.52 B	80.49 B
	Deltharin 2.5 50 ml	51.14 B	77.27 B	94.25 AB	97.65 A	97.65 A	97.65 A
Control	Control 1	0.00 G	0.00 F	0.00 I	0.00 H	0.00 G	0.00 I
	Control 2	0.00 G	0.00 F	0.00 I	0.00 H	0.00 G	0.00 I
	Control 3	0.00 G	0.00 F	0.00 I	0.00 H	0.00 G	0.00 I
P<0.01; CV =%32							

* Means containing the same letter are not statistically different according to the Tukey test (P<0.01).

Table 6. Meteorological data relating to the experiment conducted against *Pochazia shantungensis* on the common privets in Yalova province in 2021

Counts	Date	Average temperature (˚C)	Maximum temperature (˚C)	Minimum temperature (˚C)	Average humidity (%)
Date of trial setup	18.06.2021	21.0	23.9	16.5	82.4
1. Day	19.06.2021	20.4	22.8	19.1	85.5
3. Day	21.06.2021	21.7	25.1	19.9	82.1
5. Day	23.06.2021	22.9	26.7	18.4	82.1
7. Day	25.06.2021	24.6	28.3	19.8	82.0
9. Day	27.06.2021	25.0	29.2	20.3	79.4
11.Day	29.06.2021	24.8	29.4	19.7	77.1

The results presented in Table 4 indicate that various statistical groups formed regarding the effects observed among the trial characters in the days following application. In the trial, the most effective experimental character was acetamiprid 20% (Mospilan 20 SP), which was applied at a concentration of 25 ml per 100 L and achieved a complete effect within five days of application. The second strongest effect was recorded at 97.65% within 7 days following the application of deltamethrin 25 g/l (Deltharin 2.5) at a concentration of 50 ml per 100 L. Subsequently, 11 days after the application of azadirachtin 0.3 g/L (Nimbecidine) at a concentration of 500 ml per 100 L, the third highest effect was achieved, resulting in an efficacy of 69.51%. In contrast, the least effects were recorded in the evaluations performed one day after the treatment with 1.5% *Verticillium lecanii* strain bb-1,110 CFU/ml (Nibortem SL), and sulfur 80% WG (Diaflex WG 80). Namely, the 1.5% *Verticillium lecanii* strain bb-1,110 CFU/ml (Nibortem SL) demonstrated an efficacy of 1.14% at application rates of 500, 1500, and 2500 ml/ha, whereas sulfur 80% WG (Diaflex WG 80) exhibited an effect of 2.7% at a concentration of 200g per 100 L (Table 5). Throughout the experiment, the average temperature fluctuated between 20.4 °C and 24.8 °C. The minimum temperatures were recorded between 16.5 °C and 20.3 °C, while the maximum temperatures ranged from 22.8 °C to 29.4 °C. Additionally, the average relative humidity varied from 77.1% to 85.5% (Table 6).

4. Discussion

The trial results indicate that the use of acetamiprid 20% (Mospilan 20 SP) at a concentration of 25 ml per 100 liters, deltamethrin 25 G/L (Deltharin 2.5) at 50 ml per 100 liters, and azadirachtin 0.3 g/L (Nimbecidine) at 500 ml per 100 liters of water can be recommended for the management of this pest. Among the three preparations that exhibited effectiveness, two were chemical formulations: Acetamiprid at 20% and deltamethrin at 25 g/L. Furthermore, azadirachtin, an organic plant protection product at a concentration of 0.3 g/L, was also effective. As this research represents the first investigation in Türkiye focused on the chemical management of this pest, a comparison was performed with studies on *Ricania simulans*/*Orosanga japonica* (Walker, 1851), a species from the same family that inflicts comparable harm on its hosts. In Türkiye's Eastern Black Sea Region, azadirachtin (Neem-azal) demonstrated a 30% effectiveness against *R. simulans/O. japonica* when utilized at a concentration of 400 ml per 100 L, according to the findings of (Ak et al. 2013). Furthermore, another study indicated that Neem-azal achieved more than 40% efficacy against nymphs of the same species in two consecutive years (Öztemir, 2014). On the other hand, in this study, Nimbecidine, a commercially available formulation of azadirachtin at a concentration of 0.3 g/l, demonstrated a higher efficacy of 69.5%. In another study, utilizing Nimbecidine at the same concentration on *R. simulans/O. japonica* in the Eastern Black Sea Region demonstrated an efficacy rate of 75% (Göktürk, 2020). Likewise, another investigation revealed that neem extract -1 and neem extract -2, both at the same concentration, exhibited effectiveness rates of 70% and 76.9% against *P. shantungensis*, respectively (Choi. et al., 2012). Deltamethrin EC was found to be 100% effective against nymphs on the 3rd day at a concentration of 0.1% of the recommended dosage (Choi et al., 2012), an another research conducted using permethrin (Restron), a synthetic pyrethroid belonging to the same category as deltamethrin, revealed an effectiveness rate of 100% (Öztemir, 2014). Due to the preference of sunflowers as plants to lay *P. shuntengensis*'s eggs, the application of a 0.1% concentration of acetamiprid SL 20% resulted in a 90.3% effectiveness (Choi et al., 2017). In the present study, using this formulation as a spray against 3rd and 4th stage nymphs resulted in 100% efficacy. On the other hand**,** the findings of the study reveal that the biological preparations (Nibortem SL) had the minimal biological effect as detailed in Table 5. Conversely, *Beauveria bassiana* isolates extracted from *Orosanga japonica* adults in the Black Sea Region, where it was prevalent, were assessed as effective and have been noted to significantly support the biological control of this species (Erper et al., 2022).

5. Conclusion

The study's findings led to the conclusion that the following concentrations can be suggested for the control of the pest: Acetamiprid 20% (Mospilan 20 SP) preparation at 25 ml/100 L, deltamethrin 25 G/L (Deltharin 2.5) at 50 ml/100 L, and azadirachtin 0.3 g/l (Nimbecidine) at 500 ml/100 L. Since *Pochazia shantungensis* (Brown pseudobutterfly), an invasive species originating from Far East Asia, was first discovered in Türkiye in 2019, the application of chemical and organic preparations plays an important role in its short-term solution. Therefore, the determination of chemical and organic insecticides and their effective doses that can be recommended in the control of the pest formed the basis of this study. In addition, the removal and pruning of annual shoots that contain egg clusters on the primary host plants of the pest in the spring and autumn, prior to the hatching of the eggs, could be an effective pest control method and should not be overlooked as a topic for further investigation. This is due to the fact that the pest overwinters within the annual shoots of the host plants during the egg stage.

Author Contributions

The percentages of the authors' contributions are presented below. All author reviewed and approved the final version of the manuscript.

	G.Ç.	Ki.A.	Ka.A.
C	50	30	20
D	60	30	10
S		80	20
DCP	70	10	20
DAI	60	20	20
L	60	20	20
W	60	20	20
CR	60	20	20
SR	60	20	20
PM	60	20	20
FA	60	20	20

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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