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Investigation of The Effects of Yellow Sticky Traps Placed at Different Heights, on Catching Predatory Insects in Cotton Field

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ABSTRACT

This study was carried out to determine the efficacy of yellow-colored traps with different heights on capturing of predatory insect species in cotton field in Adana Province, Türkiye during 2010-2011. Traps were placed at vertically positions of 60, 80, 100, and 120 cm heights. Plant phenology was classified as vegetative, boll forming, and boll maturation. Traps were kept in the cotton field for one day and then, replaced with new ones. Nine predatory insect species were identified on the traps. Most numbers of *Orius niger* Wolff (Hemiptera: Anthocoridae) were captured, accounting for 77.62% of the total adults. This species was followed by the *Deraeocoris pallens* Reut. (Hemiptera: Miridae) constituting 11.03% of total adults on yellow-colored traps. Numbers of *D. pallens* captured were significantly higher on traps placed at 60 cm height than numbers captured on other trap heights when plant phenology was at the vegetative, and fruit forming stages. While *Orius* numbers were similar on traps with 60, 80, and 100 cm heights but significantly greater than that number found at 120 cm height ($P<0.05$). Numbers of the predatory thrips *Aeolothrips collaris* Priesner (Thysanoptera: Aeolothripidae) were similar on all trap heights when plants were at vegetative stage. Less numbers of beneficial insects were captured as the trap level exceed the upper level of plants. With respect to the results obtained, this study suggests that 60 cm or less trap heights at the early stage of plants and 60 or 80 cm trap height as plant phenology developed (June-August period) may be deployed to estimate more accurately beneficial insect population densities in cotton.

Keywords: Predatory insects, cotton, height, yellow sticky trap

Pamuk Tarlasında Farklı Yüksekliklerde Yerleştirilen Sarı Renkli Yapışkan Tuzakların Avcı Böcekleri Yakalamadaki Etkilerinin Araştırılması

ÖZ

Bu çalışma 2010 ve 2011 yıllarında Adana İli'nde pamuk tarlasında farklı yükseklikteki sarı yapışkan tuzakların avcı böcekleri yakalamadaki etkilerini araştırmak amacıyla yürütülmüştür. Tuzaklar pamuk tarlalarına dikey konumda olmak üzere 60, 80, 100 ve 120 cm yüksekliklerde yerleştirilmiştir. Bitki fenolojisi vejatative, koz oluşturma ve olgunlaştırma şeklinde sınıflandırılmıştır. Tuzaklar bir gün süreyle pamuk tarlasında bırakılmış olup, sonra yenileriyle değiştirilmiştir. Tuzaklarda 9 predatör böcek türü saptanmıştır. Toplam ergin bireylerde en yüksek sayıda *Orius niger* Wolff (Hemiptera: Anthocoridae) saptanmış olup, toplam erginlerin % 77.62'isini oluşturmuştur. Bu türü % 11.03 ile *Deraeocoris pallens* Reut. (Hemiptera: Miridae) Reuter izlemiştir. Bitki yükseklikleri 60-80 ve 81-100 olduğunda en fazla sayıda *D. pallens* 60 cm tuzak yüksekliğinde yakalanırken, *O. niger* 60, 80 ve 100 cm tuzak yüksekliklerinde benzer, ancak, 120 cm tuzak yüksekliğine göre önemli sayıda kaydedilmiştir ($P<0.05$). Bitkiler vegetative dönemde olduğunda görülen avcı thrips *Aeolothrips collaris* Priesner (Thysanoptera: Aeolothripidae) tüm yüksekliklerde benzer sayılarda kaydedilmiştir. Tuzak seviyesi bitki seviyesinin üzerinde olduğunda daha az sayıda predatör böcek toplanmıştır. Bu sonuçlara dayanarak, bitkinin erken gelişme döneminde 60 cm ve daha düşük tuzak yükseklikleri, bitki fenolojisinin geliştiği dönemde (haziran-ağustos dönemi) 60 cm veya 80 cm tuzak yüksekliklerinin, avcı böceklerin popülasyon yoğunluklarını daha doğru bir şekilde tahmin etmek için kullanılabileceği kanaatine varılmıştır.

Anahtar kelimeler: Predatör böcekler, pamuk, yükseklik, sarı yapışkan tuzak

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Introduction

Various sampling methods are used for sampling harmful and beneficial insects in cotton fields. Many products also use sticky traps to monitor insect populations. According to the response of insects to color, sticky traps are widely used in integrated control programs in various products (Gerling and Horowitz, 1984; Hill and Hooper, 1984; Chandler, 1985; Meyerdirk and Oldfield, 1985; Heizn et al., 1992). Yellow sticky traps capture more fruit flies (Bateman, 1976; Cyrtrynowicz et al., 1982), aphids (Broadbent, 1948), whiteflies (Webb ve Smith, 1980; Hart et al., 1978; Melamed-Madjar et al., 1979), and leafhoppers (Welch and Kondratieff, 1993; Mensah, 1996; Chancellor et al., 1997). Western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) were mostly caught in white (Moffit, 1964; Baevers et al., 1971; Roditakis et al., 2001) and acrylic blue (Brodsgaard, 1989) colored traps. In addition to the color factor, the trap height is also important in the mass capture and follow-up of populations of some insects (Ladd et al., 1984; Meyerdirk and Moreno, 1984, Chander, 1985, Byrne and ark., 1986). In a study conducted on cotton in Çukurova, it was reported that the number of whiteflies caught in yellow sticky traps at 60 cm height was higher than at 20 cm height and similar at other 40, 80, 100 cm heights in only one sampling date (Göçmen et al., 1988). Gerling ve Horowitz (1984) reported that whitefly was caught more effectively in yellow sticky traps placed at ground level (0 cm height) in cotton fields, while trapping effects were similar in traps above 2 m. In a previous study (Atakan and Bayram, 2011), the trapping effects of different colored traps placed were investigated for *F. occidentalis* and predatory bugs, *Orius* spp. (Hemiptera: Anthocoridae) in cotton.

There are different factors that affect the population dynamics of pests such as pest thrips in cotton (Atakan and Özgür, 2000). One of them is natural enemies. In the study of harmful and beneficial insects in cotton fields, mostly plant and sweep-net sampling are used. In the cotton fields in Adana Province, the populations of the beneficial insects were followed up with the flower thrips in yellow sticky traps, and the relationships between the populations of the harmful and beneficial insects were investigated (Atakan and Özgür, 2001). Difficulties may be encountered in estimating populations of motile pests (eg leafhoppers) and hemipterian predatory insects (species belonging to families, Anthocoridae and Miridae) during the plant samplings. Plant sampling takes more time during the developmental phenology of cotton plants in late season. The use of sweep-net is difficult in the advanced phenological period of the plant, and effective insect sampling can not be done well.

In this study, the effects of yellow sticky traps placed at different heights in different phenological periods of plants on catching beneficial insects were investigated. The results obtained may be evaluated in more accurate estimation of populations of beneficial insects as well as pest populations.

Materials and Methods

Establishing the Field Trials

Experiments were carried out at the Cotton Research and Application Centre (CRAC) (378 000 N, 358 210 E) of the Faculty of Agriculture, University of Çukurova located in Adana Province, Türkiye, during 2010 and 2011. In the preparation of yellow sticky traps, 15 × 20 × 0.3 cm sized yellow-colored plexiglass sheets were used. A special adhesive (stickem special, tanglefood) with the trade name Heller Raupenleium was applied on these plates. Traps are placed vertically in cotton fields at 60, 80, 100, and 120 cm heights. In the placement of the traps, "T" shaped laths with a 3 mm thick channel on the horizontal edge were used. On the same row, the traps were placed 3 meters apart from each other. The direction of the traps was in the east-west direction. The experiment was carried out for 4 repetitions according to the randomized blocks design. The plot sizes were determined as 120 m^2 (0.80 m row spacing × 15 rows × 10 m row length). The blocks are separated by 20 meters. No pesticides were used to control pest insects, mites, disease agents, or weeds during the trial.

Sampling of Predatory Insects

Sampling was started on 10 July 2010 and 25 July 2011, and was completed in mid-August. Field experiments were repeated twice a week, 10 times in 2010 and 10 times in 2011. Sampling was carried out between 10 July and 20 August in 2010 and between 181 July and 14 August in 2011. The traps were left in the experimental field for 24 hours. Traps were replaced with new ones at hours 9:00-10:00. Traps were counted in the laboratory under a stereo-binocular microscope. For the identification of insects on the traps, the sticky liquid was dissolved with the kerosene when necessary, and the samples were kept in different alcohol degrees for a while to remove the glue.

Plant Phenology

The heights of 15 plants selected randomly were measured and their generative organs (square, flower and bolls) were counted and recorded in all trials, which traps were placed at different heights according to the plant phenology. Plant phenology was classified as vegetative, boll forming, and boll maturation.

Evaluation of Data

Adult insect species and numbers caught in yellow sticky traps at different heights are given in Tables (Table 1). *Orius niger* and *Deraeocoris pallens* as common predators, as well as the predator thrips *Aeolothrips collaris* were taken into consideration because they were caught in relatively large numbers. Individuals of *D. pallens* and predatory thrips were not included in the evaluation, because they were caught in very low numbers in 2011. Adult Individuals of coccinellids were not included in the evaluation because they were caught in small numbers on traps in both experimental years. However, the species list of Coccinellidae is shown in Table 1.

Obtained data were evaluated at $P<0.05$ significance level using a two-way analysis of variance (ANOVA-Univariate). Thus, the effects of trap height, plant phenology, and interactions between them on insect densities captured on the traps were investigated. In order to determine the effects of different altitudes on catching insects, the data were subjected to analysis of variance (ANOVA) and the comparison of the averages was done in the Tukey test at the $P<0.05$ level. Logarithmic transformation [Ln $(x + 1)$] was applied to the data to reduce the variance between the means. Data using logarithmic transformation were used to compare the means (Table 3). All analyzes were made in SPSS (SPSS, 2006) Software Package Program.

Identification of Predatory Insects

Önder (1982) was used to identify Anthocoridae species. The identification key published by Çakır and Önder, (1990) was used for the identification of Lygaeidae, Geocorinea species (*Geocoris* and *Piocoris* genera). Coccinellidae species were identified by Prof. Dr. Nedim Uygun (Adana), Identifications of other insect species captured were done by comparison with samples previously identified by the experts and stored in the entomology laboratory. Predatory thrips were identified by the author.

Results and Discussion

List of Predatory Insect Species

In this study, 10 predatory insect species were detected in the traps (Table 1). *Orius niger* was the most common species in total adult individuals and it constituted 77.62% of total adult individuals.

Table 1. Numbers of predatory insects species and their total numbers caught on yellow sticky traps with various heights, during 2010-2011

Order	Family	Predatory insects	No of insects				Total	%
			Trap height (cm)					
			60	80	100	120		
Coleoptera	Coccinellidae	*Adonia variegata* Goeze	1	3	2	0	6	0.16
Coleoptera	Coccinellidae	*Symnus levillanti* Mulsant	22	6	6	3	37	1.03
		Stethorus sp.	16	2	6	9	33	0.89
Hemiptera	Anthocoridae	*Orius niger* Wolff	753	794	726	596	2869	77.62
Hemiptera	Miridae	*Deraeocoris pallens* Reut.	142	231	31	4	408	11.03
Hemiptera	Lygaeidae	*Geocoris arenarius* (Jakovlev)	1	1	0	0	2	0.05
Hemiptera	Lygaeidae	*Piocoris erythrocephalus* (Lep & Serv.)	3	0	2	1	6	0.16
Neuroptera	Chrysopidae	*Chrysoperla carnea* (Stephens)	36	29	16	13	94	2.54
Thysanoptera	Aeolothripidae	*Aeolothrips collaris* Priesner	73	72	55	71	241	6.52

Deraeocoris pallens ranks second in this species (11.03%). *Chrysoperla carnea* a common predator in cotton fields, was caught only at a rate of 2.54%. While the number of *O. niger* was similar at 60, 80, and 100 cm heights, lower numbers were collected at 120 cm heights (Table 1). *Deraeocoris pallens* was mostly caught in traps with 80 cm high. *Chrysoperla carnea* was recorded in relatively higher numbers at heights of 60 and 80 cm. Predatory thrips, numbers of *Aeolothrips collaris* were relatively higher in traps at 60, 80 and 120 cm heights than at 100 cm trap height. In this study, *O. niger* was the most common species and was recorded in higher numbers. In previous studies conducted in the cotton field, *O. niger* has found to be the most common species and it feeds on thrips, inhabiting in cotton flowers, and also on nectars and pollens in the absence of its preys (Atakan, 2000). *Orius niger* is one of the most common predator species in vegetables, ornamental plants and weeds. The fact that this species is widespread and in high numbers may be related to the high prey sequence in different cultivated plants, its ability to spend the winter as an adult, even its ability to reproduce in mild winters and the absence of reproductive diapause (Riudavets, 1995). Other species of the family Cocinellidae, except for the species belonging to genus *Scymnus*, were captured in low numbers at all trap heights. Hossain et al. (2020) revealed that the chilli thrips (Thysanoptera: Thripidae) were more frequently caught in blue traps placed at ground level, while species of Cocinellidae were primarily attracted to yellow sticky traps.

Average Number of Predatory Insects in Traps

While trap height and plant phenology were found to be important factors in catching insects, the interaction between trap height × plant phenology was not significant (Table 2). *Aeolothrips collaris* individuals were caught in traps when the plants were at vegetative stage during the early development period of the plants (Table 3). Although the low-level population density of *A. collaris* was slightly higher than the others at 60 cm height, numerical differences were not found to be significant among the trap heights ($P>0.05$). There was no significant effect of trap heights on the capture of *A. collaris* population, which was mostly detected with the acaries and thrips in the cotton fields.

Table 2. Results of two-way variance analysis (Anova-Univariate)

Year	Variation of sources	Degree of freedom	F	P
		Aeolothrips collaris		
2010	Trap height	3	4.622	0.004
	Plant phenology	2	52.232	0.0001
	Trap height × plant phenology	6	1.052	0.396
	Error	108		
		Deraeocoris pallens		
	Trap height	3	22.860	0.0001
	Plant phenology	2	44.380	0.0001
	Trap height × plant phenology	6	13.800	0.0001
	Error	108		
		Orius niger		
	Trap height	3	1.079	0.361
	Plant phenology	2	118.515	0.0001
	Trap height × plant phenology	6	1.079	0.380
	Error	108		
2011		*Orius niger*		
	Trap height	3	1.381	0.254
	Plant phenology	2	7.963	0.006
	Trap height × plant phenology	6	0.643	0.589
	Error	84		

Deraeocoris pallens was caught more at 60 cm trap height in 2010 when the plant phenology was at vegetative and boll forming stages ($F_{3.56}$=4.219, P=0.010 and $F_{3.56}$=22.751, P<0.0001 respectively; Table 3). *Deraeocoris pallens* was recorded in very few numbers on all traps in 2011.

Mean numbers of *O. niger* was significantly higher on traps with height of 60 cm at the vegetative and boll forming stages in 2010 ($F_{3.56}$=4.893, P=0.0015; $F_{3.56}$=3.879, P=0.04, respectively; Table 3). Fewer *Orius* individuals were caught in the traps when the plant height was above 100 cm i.e. boll maturation stage, and the differences in mean numbers between heights were insignificant (P>0.05). In 2011, when the plant phenology was at vegetative, mean numbers of *O. niger* were similar at 60, 80 and 100 cm heights, but significant compared to 120 cm height ($F_{3.56}$=2.715, P=0.047; Table 3). Although *Orius*'s mean numbers at 60 and 80 cm trap heights were slightly higher than numbers found in other trap heights, the differences were not significant (P>0.05) at the fruiting stage of plants.

When all plant phenology are considered together, the total average numbers of predatory insects are shown in Table 4. There was no significant difference among the trap heights in 2010 (P>0.05) for mean numbers of *A. collaris*. A significant number of *D. pallens* was caught at a trap height of 60 cm in 2010 ($F_{3.56}$=11.065, P<0.0001). In 2010, the number of *O. niger* was similar in traps with 60 and 80 cm heights, but a significant, compared to 120 cm trap height ($F_{3.56}$=4.323, P=0.037). In 2011, mean numbers *O. niger* were similar in all traps (P>0.05).

Table 3. Mean numbers of insects caught on yellow stick traps with various heights placed at different phenological stage of plants during 2010-2011

Yıl	Plant phenology (cm)	Trap Height (cm)	Average number of insects (number/trap) at different trap heights*		
			Aeolothrips collaris	*Dereaocoris pallens*	*Orius niger*
2010	Vegetative stage	60	1.2±0.21a**	0.6±0.83a	3.2±0.09a
		80	1.1±.0.13a	0.11±0.07b	2.9±0.15ab
		100	1.3±0.28a	0±0b	2.6±0.18b
		120	0.8±0.19a	0±0b	2.5±0.15b
	Boll forming	60	-***	2.7±0.25a	2.7±0.20a
		80	-	1.1±0.38b	2.4±0.32ab
		100	-	0.3±0.15c	2.0±0.26ab
		120	-	0.1±0.11c	1.7±0.21b
	Boll maturation	60	-	-	1.2±0.21a
		80	-	-	1.5±0.21a
		100	-	-	1.4±0.25a
		120	-	-	1.0±0.21a
2011	Vegetative stage	60	-	-	2.9±0.18a
		80	-	-	2.5±0.29a
		100	-	-	2.4±0.27a
		120	-	-	1.3±0.23b
	Boll forming	60	-	-	2,26±0.14a
		80	-	-	2.24±0.14a
		100	-	-	1,96±0.16a
		120	-	-	1.98±0.22a

(*) Means (± SEM) with the same letter in the columns are not significant at the P< 0.05 significance level according to the Tukey test.
(**) Logarithmic transformations [Ln (x+1))] were applied to data.
(***) Insects were not evaluated because they were collected in very low numbers caught in all traps at boll forming or maturatin stage of cotton in 2011.

Table 4. Total mean numbers of predatory insects caught on yellow stick traps with various heights, during 2010-2011

		Average number of insects (number/trap) at different trap heights*			
		Trap height			
Year	Predatory insect	60	80	100	120
2010	*Aeolothrips collaris*	0.4±0.12a	0.3±0.09a	0.4±0.14a	0.2±0.21a
	Deraeocoris pallens	1.1±0.23a	0.4±0.15b	0.2±0.05bc	0.1±0.01c
	Orius niger	2.4±0.17a	2.3±0.17a	2.0±0.15ab	1.8±0.50b
2011	*Orius niger*	2.5±0.13a	2.23±0.18a	2.15±0.15a	2.28±0.13a

(*) Means (± SEM) with the same letter in the rows are not significant at the P< 0.05 significance level according to the Tukey test.

In this study, predatory insects occurred mainly during the boll forming and boll maturation periods of the plants (July-August period). During periods when *D. pallens* and *O. niger* individuals were caught in relatively high numbers on the traps, dense populations of the cotton aphids and flower thrips were recorded on the plants (Atakan and Canhilal, 2004). *Aeolothrips collaris* individuals appeared earlier in association with red spider mites (vegetative developmental period). When the three predatory insect species are evaluated together; In general, high numbers of predatory insects were caught on traps placed at 60 and 80 cm heights. The trap heights of 60 and 80 cm represent the middle zone of the plants; thus, it could be said that common predators are mostly found in the middle part of the plants. In other words, when the plant heights increase, i.e. above 80 cm height, the number of the predatory insects caught at the traps decreases, and the differences among the mean numbers were insignificant (Table 3). Their occurrence at lower trap heights (60 and 80 cm) may be associated with higher humidity and lower temperature in the middle sections of the plants. Furthermore, another reason may be due to protection from their natural enemies such as larger hemipteran generalist predatory insects, *Nabis*, *Piocoris*, and *Geocoris* which can prey on *Orius* species i.e. intraguild predation (Rosenheim, 2005). In addition, the vertical distribution of predators at different trap heights may be related to their preys. In the previous study, with the plant samplings, *D. pallens* and *O. niger* were found mostly in the middle parts of the plants. In that study, it was interpreted that the higher prevalence of *D. palles* in the lower parts of the plant may be related to the settlement of their prey cotton aphid in this region (Atakan, 2000). Although *Orius* numbers caught were slightly higher in 60 and 80 cm trap heights in 2011, there was no significant difference with other trap heights (100 and 120 cm) (Table 4). The fact that similar numbers of *Orius* individuals were caught at all trap heights in the 2011 trial may be related to the high abundance of flower thrips, their specific prey throughout the cotton season (Riudavets, 1995; Atakan and Bayram, 2011), compared to the previous year.

Conclusion

Finally, based on these results, traps placed at 60 or 80 cm during period of June-August may be used to predict more accurately population densities of predatory insects. In other words, fewer predators were caught when the trap height was higher than the plant heights.

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