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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Investigation the effectiveness of attractants for genders of *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) on citrus varieties

Turunçgil çeşitleri üzerinde *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) cinsiyetleri için cezbedicilerin etkinliğinin araştırılması

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ABSTRACT

The study was conducted in 2016-2017 to investigate the effectiveness of attractants for genders of *C. capitata* (Wiedemann) (Diptera: Tephritidae) on citrus varieties in Hatay province of Türkiye. In both years, the SEDQ type traps with various attractants were used. After two years of the study, effectiveness of the attractants for genders of *C. capitata* varied in each of the variety and the sampling year. In 2016, a total of 3.006 *C. capitata* adults (2.644♀, 362♂) were caught by attractant traps at the 'w-murcott' mandarin orchard located at Narpak farms in Reyhanlı district. The highest mean of male of *C. capitata* was caught by the combination of ammonium acetate + trimethylamine + putrescine attractant traps, while the highest mean of female and male + female of *C. capitata* were caught by the ammonium acetate attractant traps. In 2017, a total of 2.338 *C. capitata* adults (1.375♀, 963♂) were caught by attractant traps at the 'satsuma' mandarin orchard located at Bahçe70 in Dörtyol district. The highest mean of male, female and male + female of *C. capitata* were caught by the ammonium acetate attractant traps. In both years, the mean of females was significantly higher than the mean of males. In addition, the percent of females was significantly higher than the percent of males.

ÖZET

Bu çalışma 2016-2017 yıllarında Hatay ilindeki narenciye çeşitlerinde cezbedicilerin *C. capitata*'nın cinsiyetleri üzerindeki etkinliğini araştırmak amacıyla yürütülmüştür. Her iki yılda da çeşitli cezbedicilere sahip SEDQ tipi tuzaklar kullanılmıştır. İki yıllık çalışmanın ardından, cezbedicilerin *C. capitata*'nın cinsiyetleri üzerindeki etkinliği çeşitlere ve örnekleme yıllarına göre farklılık göstermiştir. 2016 yılında Reyhanlı ilçesindeki Narpak çiftliklerinde bulunan 'w-murcott' mandalina bahçesinde toplam 3.006 adet (2.644 ♀, 362 ♂) *C. capitata* ergini cezbedici tuzaklar tarafından yakalanmıştır. *C. capitata'*nın en yüksek erkek ortalaması amonyum asetat + trimetilamin + putresin içeren cezbedici tuzakları kombinasyonunda yakalanırken, *C. capitata'*nın en yüksek dişi ve erkek + dişi ortalaması amonyum asetat içeren cezbedici tuzakları tarafından yakalanmıştır. 2017 yılında Dörtyol ilçesi Bahçe70'de bulunan 'satsuma' mandalina bahçesinde toplam 2.338 adet (1.375♀, 963♂) *C. capitata* ergini cezbedici tuzaklar tarafından yakalanmıştır. *C. capitata*'nın en yüksek erkek, dişi ve erkek+dişi ortalamaları amonyum asetat içeren cezbedici tuzaklar tarafından yakalanmıştır. Her iki yılda da dişilerin ortalaması erkeklerin ortalamasından önemli derecede yüksek bulunmuştur. Ayrıca dişilerin yüzdesinin erkeklerin yüzdesinden önemli ölçüde daha yüksek olduğu görülmüştür.

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INTRODUCTION

Citrus (Sapindales: Rutaceae) is one of the most significant fruit crops widely grown in tropical and subtropical regions of the world (Ollitrault et al., 2020; FAO, 2020). Citrus is grown in Türkiye where it comprises approximately 607,195 da of growing area and a total produce of 1,819,000 tons of yield annually, and Hatay province's share is 179,948 da and 716,732 tons (Anonymous, 2021). The Mediterranean fruit fly (medfly), *Ceratitis capitata* (Diptera: Tephritidae) is one of the most important pests for citrus fruits (Liquido et al., 1990; White & Elson-Harris, 1992; Gilbert & Bingham, 1999; Thomas et al., 2010; Akyol, 2014; Demirel & Akyol, 2017; Gürbüz, 2018; Yiğit, 2019). The Medfly is a polyphagous species attacking over 350 different host plants (Liquido et al., 1990; Akyol, 2014; Çalıklı, 2015; Kılıç, 2015; Demirel, 2023b). The control program of medfly is based on applications of organophosphate insecticides that are mainly used foliage baiting and cover spraying methods (Roessler & Chen, 1994; Vargas et al., 2001; Urbaneja et al., 2009). However, the intensity of insecticide use for medfly has resulted in the development of resistant populations, harmful effects on human health, beneficial insects and non-target organisms in the environment (Hoelmer & Dahlsten, 1993; Marty et al., 1994; Bachrouch, 2003; Urbaneja et al., 2004). One of the effective control methods as alternative to chemical control is traps containing baits with female and male lures (Papadopoulos et al., 2001; Heath et al., 2004). In addition, the traps baited with trimedlure and attractants are important tools for detection, monitoring and controlling of *C. capitata* on different host plants (Epsky et al., 1999; IAEA, 2003; Navarro-Lopis et al., 2008; Boulahia-Kheder & Jerraya, 2010; Boulahia-Kheder et al., 2011; Shelly et al., 2014; Akyol, 2014; Demirel, 2016; Demirel & Akyol, 2017; Gürbüz, 2018; Yiğit, 2019; Demirel, 2023a). The traps baited with protein-based baits and lures are also used for the capture of male and female of *C. capitata* (Heath et al., 1997; Gazit et al., 1998; IAEA, 2003; Navarro-Llopis et al., 2008; Shelly et al., 2014; Demirel, 2023a). Many commercial formulations of ammonia have been produced for use as lures in fruit fly traps including ammonium acetate (BioLure), ammonium bicarbonate (AgriSense Lure) and ammonium carbonate (ISCA technologies) (Shelly et al., 2014). In addition, several studies have been conducted to evaluate various attractants; a single of ammonium carbonate for females (Reynolds & Prokopy, 1997; Demirel, 2023a), combinations of ammonium acetate + putrescine (Heath et al., 1995); ammonium acetate + trimethylamine + putrescine (Heath et al. 1997; Katsoyannos et al., 1999; Epsky et al., 1999; Miranda et al., 2001; Alemany et al., 2004; Demirel, 2023a) and ammonium acetate + trimethylamine + cadaverine (Navarro-Llopis et al., 2008; Demirel, 2023a) were used for *C. capitata*. Moreover, the food-based baits of diammonium phosphate caught significant number of *C. capitata* (Boulahia-Kheder et al., 2012; Çalıklı, 2015) and the high number of nontarget insects (Boulahia Kheder & Jerraya, 2010; Çalıklı, 2015). The objective of the current study was to investigate the effectiveness of attractants for genders of *C. capitata* (Wiedemann) (Diptera: Tephritidae) on citrus varieties in Hatay province of Türkiye.

MATERIALS and METHODS

The studies were conducted in 2016-2017 to investigate the effectiveness of attractants for genders of *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) on citrus varieties in Hatay province of Türkiye. A single and the combinations of two and three attractants, ammonium acetate (AA), ammonium carbonate (AC), ammonium bicarbonate (AB), trimethylamine (TMA), diaminoalkane (cadaverine) (C) and 1,4-diaminobutane (putrescine) (P) were used as synthetic food-based lures with SEDQ type traps (Table 1). An attractant or mixed attractants impregnated into paper handkerchiefs were used. Each of the paper handkerchief package (10x7.5 cm) had a 3-mm diameter hole and contained 25 g attractant or mix of attractants, 2 ml of 10% propylene glycol to decrease water evaporation and 2 ml of 2% dichlorvos. In the first year, the study was conducted as randomized complete block design with 5 treatments and 10 replications at w-murcott mandarin orchard located at Narpak farms in Reyhanlı, Hatay. In the second year, the study was conducted as randomized complete block design with 5

treatments and 5 replications at satsuma mandarin orchard located at Bahçe70 in Dörtyol, Hatay. The traps were placed at 1.5-2m high on southeastern side of the w-murcott trees (1 trap per three trees) on 29 June 2016. The traps were placed at 1.5-2m high on southeastern side of the satsuma mandarin trees (1 trap per three trees) on 4 August 2017. Traps were removed from w-murcott trees on 10 November 2016 and from satsuma mandarin trees 16 November 2017. Traps brought to the laboratory and captured female and male of *C. capitata* were counted. All data were analyzed by analysis of variance (ANOVA) with the SAS software and means were separated by the Least Significant Difference (LSD) Multiple Comparison Tests ($P < 0.05$) (SAS Institute Inc. 1998).

Table 1. Traps baited with different attractants used at 'w-murcott' and 'satsuma' mandarin orchards in Reyhanlı and Dörtyol districts of Hatay province in 2016-2017

Çizelge 1. 2016-2017 yıllarında Hatay ili Reyhanlı ve Dörtyol ilçelerindeki 'w-murcott' ve 'satsuma' mandalina bahçelerinde tuzaklarda kullanılan cezbedici maddeler

Treatments (Lures)[a]	**2016**	**2017**
	Lures (gr)/trap[z]	**Lures (gr)/trap[z]**
Ammonium acetate	0.42	7.5
Ammonium carbonate	0.42	7.5
Ammonium bicarbonate	----	7.5
Ammonium acetate+Ammonium carbonate	0.42+0.42	----
Ammonium acetate +Trimethylamine+Putrescine	0.42+0.13+0.01	7.5+3.16+0.05
Ammonium acetate+Trimethylamine+Cadaverine	0.42+0.13+0.01	7.5+3.16+0.05

[a]Lures abbreviations: Ammonium acetate (AA), Ammonium carbonate (AC), Ammonium bicarbonate (AB), Ammonium acetate+Ammonium carbonate (AA+AC), Ammonium acetate + Trimethylamine + Putrescine (AA+TMA+P), Ammonium acetate+ Trimethylamine +Cadaverine (AA+TMA+C).

[z]Putrescine and Cadaverine used as (mg) and rest of the treatments (lures) used as (gr).

RESULTS and DISCUSSIONS

Effectiveness of the attractants for genders of *C. capitata* varied in each of the variety and the sampling year. In the first year, the highest mean of males of *C. capitata* was caught by the combination of ammonium acetate + trimethylamine + putrescine attractant traps ($F=1.78$, $P= 0.0860$), while the highest mean of female and male + female of *C. capitata* were caught by the ammonium acetate attractant traps ($F=0.71$, $P= 0.77412$; $F=0.55$, $P= 0.835$) and yet there were no significant differences among treatments (Table 2).

Table 2. Capture of the genders of *C. capitata* traps baited with attractants at w-murcott mandarin orchard in 2016

Çizelge 2. 2016 yılında w-murcott mandalina bahçesinde cezbedici tuzaklar tarafından yakalanan C. capitata'nın cinsiyetlere göre ortalamaları

Treatments (attractants)	**Means of catches insects per ten traps[z]**		
	***C. capitata* (♂)**	***C. capitata* (♀)**	***C. capitata* (♂,♀)**
Ammonium acetate	7.40a	74.80a	82.20a
Ammonium carbonate	6.20a	61.10a	67.30a
Ammonium acetate+Ammonium carbonate	6.20a	39.10a	45.30a
Ammonium acetate +Trimethylamine+Putrescine	11.90a	47.50a	59.40a
Ammonium acetate+Trimethylamine+Cadaverine	4.50 a	41.90a	46.40a

[z]Numbers within a column not followed by the same letter are significantly different ($P<0.05$) by LSD.

In the first year, a total of 3,006 *C. capitata* adults (2,644♀, 362♂) were caught by attractant traps at the 'w-murcott' mandarin orchard located at Narpak farms in Reyhanlı district (Figure 1). The mean of the females was significantly

higher than the mean of the males (F: 14.79; P: 0.0001). In addition, the percent of females (87.95) was significantly higher than the percent of males (12.04).

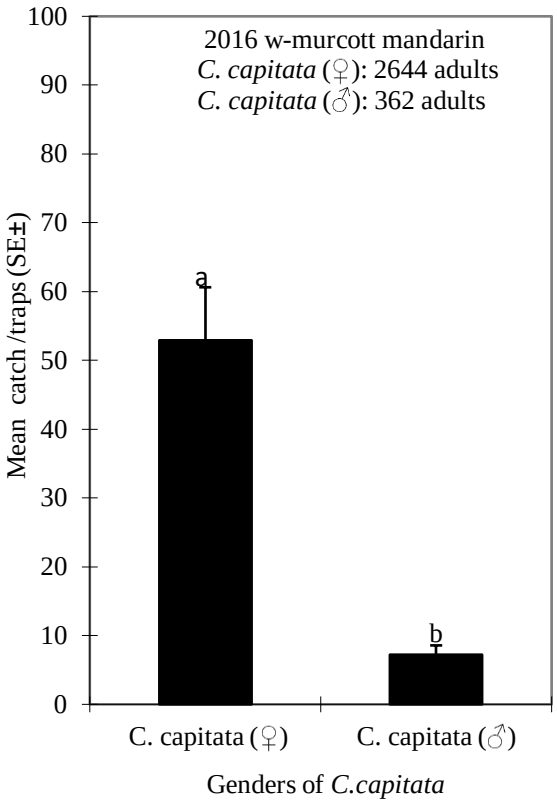

Figure 1. Figure 1. Mean (±SE) catches of medfly adults with traps baited with attractants (29 June-10 November, 2016) at w-murcott mandarin orchard. Different letters above bars indicate significant differences according to Least Significant Difference (LSD) (P < 0.05)

Şekil 1. W-murcott mandalina bahçesinde (29 Haziran-10 Kasım 2016) tarihleri arasında cezbedici içeren tuzaklar tarafından yakalanan Ceratitis capitata ortalamaları (±SE). LSD (P < 0,05) göre çubukların üzerindeki farklı harfler önemli farklılıkları gösterir

In the second year, the highest mean of male, female and male + female of *C. capitata* were caught by the ammonium acetate attractant traps (Table 3). The mean of the males was significantly higher for traps baited with ammonium acetate than those of baited with other attractants (F=7.63, P= 0.0003). The mean of the females was significantly higher for traps baited with ammonium acetate than those baited with ammonium carbonate, ammonium bicarbonate and ammonium acetate + trimethylamine + putrescine (F: 2.70, P: 0.0432). The mean of male + female of *C. capitata* was significantly higher for traps baited with ammonium acetate than traps baited with ammonium carbonate, ammonium bicarbonate, ammonium acetate + trimethylamine + putrescine and ammonium acetate + trimethylamine + cadaverine (F: 12.38, P: 0.0001).

Table 3. Capture of the genders of *Ceratitis capitata* traps baited with attractants at satsuma mandarin orchard in 2017

Çizelge 3. 2017 yılında satsuma mandalin bahçesinde cezbedici maddelerle yemlenen tuzakların Ceratitis capitata cinsiyetlerini yakalama ortalamaları

Treatments (attractants)	**Means of catches insects per five traps[z]**		
	***C. capitata* (♂)**	***C. capitata* (♀)**	***C. capitata* (♂,♀)**
Ammonium acetate	170.80a	123.40a	294.00a
Ammonium carbonate	1.80b	15.80b	17.60c
Ammonium bicarbonate	2.20b	28.60b	30.80c
Ammonium acetate +Trimethylamine+Putrescine	4.80b	36.80b	41.60bc
Ammonium acetate+Trimethylamine+Cadaverine	13.00b	70.60ab	83.60b

[z] Numbers within a column not followed by the same letter are significantly different (*P*<0.05) by LSD.

In the second year, a total of 2.338 *C. capitata* adults (1.375♀, 963♂) were caught by the attractant traps at the 'satsuma' mandarin orchard located at Bahçe 70 in Dörtyol district (Figure 2). The mean of females was significantly higher than mean of males (F: 3.28; P: 0.0024). In addition, the percent of females (58.81) was significantly higher than the percent of males (41.18).

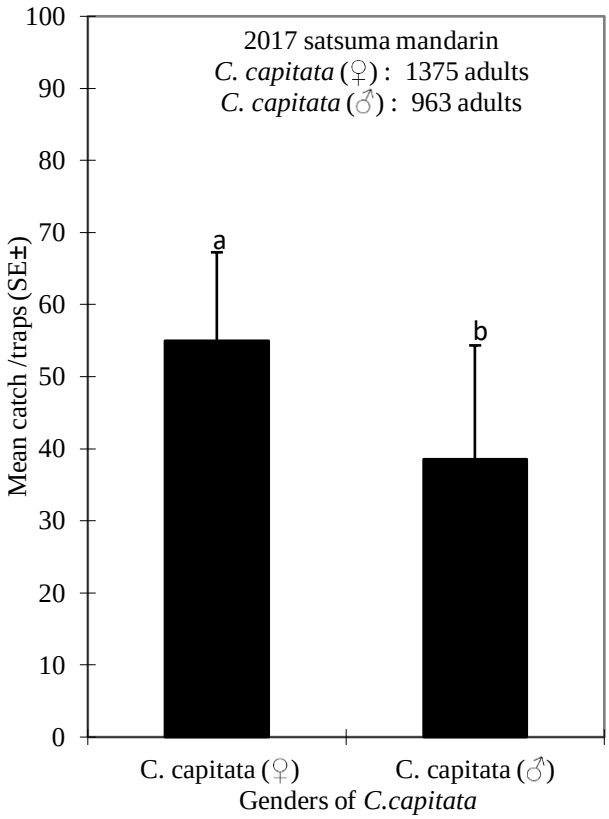

Figure 2. Mean (±SE) catches of medfly adults with traps baited with attractants (4 August-16 November, 2017) at satsuma mandarin orchard. Different letters above bars indicate significant differences according to Least Significant Difference (LSD) (P < 0.05)

Şekil 2. Satsuma mandalina bahçesinde (4 Ağustos-16 Kasım 2017) tarihleri arasında cezbedici içeren tuzaklar tarafından yakalanan Ceratitis capitata ortalamaları (±SE). LSD (P < 0,05) göre çubukların üzerindeki farklı harfler önemli farklılıkları gösterir

The trimedlure, ceralure, protein-based baits and lures are important components to detect, monitor and control of *C. capitata* on various fruits (Beroza et al., 1961; Cunningham, 1989; Heath et al., 1995; Heath et al., 1997; Gilbert & Bingham, 1999; IAEA, 2003; Navarro-Llopis et al., 2008; Shelly et al., 2014; Demirel & Akyol, 2017; Kılıç & Demirel, 2018; Demirel et al., 2018; Demirel, 2019ab; Sayım, 2019; Demirel, 2023a). The trimedlure and ceralure are widely used as synthetic attractant for males of *C. capitata* (Beroza et al., 1961; Leonhardt et al., 1987; Jang et al., 2003; IAEA, 2003; Akyol, 2014; Kılıç, 2015; Demirel & Akyol, 2017; Gürbüz, 2018; Kılıç & Demirel, 2018; Demirel, 2023a). Traps baited with protein-based baits and lures are also used for capture of males and females of *C. capitata* (Heath et al., 1997; IAEA, 2003; Navarro-Llopis et al., 2008; Shelly et al., 2014; Demirel et al., 2018; Acar, 2019; Demirel, 2019ab; Sayım, 2019; Yiğit, 2019; Çay, 2021; Acımış Sarıgül, 2022; Demirel, 2023a). In addition, the food-based lures capture both females and males (Epsky et al., 1999; IAEA, 2003; Shelly et al., 2014; Demirel et al., 2018; Acar, 2019; Demirel, 2019ab; Sayım, 2019; Yiğit, 2019; Çay, 2021; Acımış Sarıgül, 2022; Demirel, 2023a), whereas food-based baits have been reported to cause the high capture of nontarget insects (Katsoyannos et al., 1999; Boulahia Kheder & Jerraya, 2010; Boulahia-Kheder et al., 2012; Çalıklı, 2015; Demirel, 2019ab).

The formulations of ammonia have been produced for use as lures in fruit fly traps, including ammonium acetate, ammonium bicarbonate and ammonium carbonate (Shelly et al., 2014; Demirel, 2019ab; Demirel, 2023a). In addition, ammonium acetate, putrescine (Heath et al., 1995; Demirel et al., 2018; Demirel, 2019a), ammonium acetate, putrescine, trimethylamine (Heath et al., 1997; Demirel et al., 2018; Demirel, 2019a; Demirel, 2023a), ammonium acetate, trimethylamine, cadaverine (Navarro-Llopis et al., 2008; Demirel et al., 2018; Demirel, 2019a; Demirel, 2023a), ammonium acetate, n-methyl pyrrolidine (Navarro-Llopis et al., 2008) and ammonium acetate, trimethylamine (Navarro-Llopis et al., 2008; Demirel et al., 2018; Demirel, 2019ab) were used for luring *C. capitata*. Moreover, ammonium carbonate has long been known to attract females of *C. capitata* (Gothilf & Levin, 1989; Reynolds & Prokopy, 1997; Demirel et al., 2018; Demirel, 2019ab; Demirel, 2023a). Furthermore, an effective female-targeted trapping system baited with ammonium acetate, putrescine and trimethylamine was developed (Heath et al., 1997; Katsoyannos et al., 1999; Demirel et al., 2018; Demirel, 2019a; Demirel, 2023a). Several studies have confirmed the high selectiveness and effectiveness of the combinations of several synthetic food attractants based on ammonium acetate, putrescine and trimethylamine for *C. capitata* females capture (Heath et al., 1997; Epsky et al., 1999; Miranda et al., 2001; Alemany et al., 2004; Demirel et al., 2018; Demirel, 2019a; Demirel, 2023a). Demirel (2019b) reported that the trapping the genders of *C. capitata* on pomegranate fruits with various attractants varied in each of the sampling years. In the first year, a total of 2,789 *C. capitata* adults (1619♀, 1170♂) were caught by attractant traps at the 'Katırbaşı' pomegranate orchard. The highest mean of male, female and male + female of *C. capitata* were caught by the combination of ammonium acetate + ammonium carbonate attractant traps. In the second year, a total of 7,787 *C. capitata* adults (5271♀, 2516♂) were caught by attractant traps at the 'Hicaz' pomegranate orchard. The highest mean of male *C. capitata* was caught by the combination of ammonium acetate + ammonium bicarbonate attractant traps. Demirel et al. (2018) reported that effectiveness of various attractants to medfly on pomegranate fruits in Hatay province. The effectiveness of various attractants to *C. capitata* on pomegranate fruits varied in each of the sampling years and variety of pomegranate. In 2015, a total of 6,444 medfly adults were caught by attractant traps at the 'Hicaz' pomegranate and the highest mean of catches were caught by the combination of ammonium acetate + ammonium bicarbonate attractant traps. In 2016, a total of 5,482 medfly adults were caught by attractant traps at the 'Katırbaşı' pomegranate and the highest mean of catches were caught by the combination of ammonium acetate + trimethylamine + diaminoalkane (cadaverine) attractant traps. Demirel (2023b) reported that the study was conducted in 2016-2018 to determine comparison of food-based synthetic attractants for capture of *C. capitata* on persimmon fruits in Dörtyol and Antakya district of Hatay province. As a result of two years of investigations, efficacy of various attractants varied in each of the sampling years. In 2016, the highest mean of *C. capitata* were observed by the combination of ammonium acetate

+ ammonium carbonate attractant traps. In 2018, the highest mean of C*. capitata* were observed by a single of ammonium carbonate and ammonium bicarbonate attractant traps.

In conclusion, after two-year of the study, the effectiveness of attractants for genders of *C. capitata* varied in each of the variety and sampling year. In 2016, the highest mean of the males of *C. capitata* was caught by the combination of ammonium acetate + trimethylamine + putrescine attractant traps. In 2017, the highest mean of male, female and male + female of *C. capitata* were caught by the ammonium acetate attractant traps. In both years, the mean of females was significantly higher than the mean of males. In addition, the percent of females was significantly higher than the percent of males.

STATEMENT OF CONFLICT OF INTEREST

The author(s) declare no conflict of interest for this study.

AUTHOR'S CONTRIBUTIONS

The contribution of the authors is equal.

STATEMENT OF ETHICS CONSENT

Ethical approval is not applicable, because this article does not contain any studies with human or animal subjects.

REFERENCES

Acar, M. (2019). Hatay ili turunçgil bahçelerinde Akdeniz meyve sineği, *C. capitata* (Wiedemann) (Diptera: Tephritidae)'nin cezbediciler ile kontrolü ve zarar oranının belirlenmesi. Yüksek Lisans Tezi, Hatay Mustafa Kemal Üniversitesi, Fen Bilimleri Enstitüsü, Bitki Koruma Anabilim Dalı, 50 s, Hatay.

Acımış Sarıgül, İ. (2022). Adana ilinde erkenci-geççi turunçgil çeşitlerinde Akdeniz meyve sineği, *C. capitata* (Wiedemann) (Diptera: Tephritidae)'nin kitlesel tuzaklama ile kontrolü ve zarar oranının belirlenmesi. Yüksek Lisans Tezi, Mustafa Kemal Üniversitesi, Fen Bilimleri Enstitüsü, Bitki Koruma Anabilim Dalı, 30 s, Hatay.

Akyol, E. (2014). Hatay ili mandalina bahçesinde kitlesel tuzaklama yöntemi ile Akdeniz meyve sineği, *C. capitata* (Wiedemann) (Diptera: Tephritidae)'nin kontrolü ve zarar oranının belirlenmesi. Yüksek Lisans Tezi, Mustafa Kemal Üniversitesi, Fen Bilimleri Enstitüsü, Bitki Koruma Anabilim Dalı, 51 s, Hatay.

Alemany, A., Alonso, D., & Miranda, M.A. (2004). Evaluation of improved Mediterranean fruit fly attractants and retention systems in the Balearic Islands (Spain). *In: Proceedings of the 6th International Symposium on Fruit Flies of Economic Importance,* Ed. by Barnes BN, Isteg Scientific Publications, Centurion, 355-359.

Anonymous (2021). *Turkish Statistical Institute.* https://biruni.tuik.gov.tr/bitkiselapp/bitkise_l.zul (Access date: 27.10.2023).

Bachrouch, O. (2003). Lutte biologique contre la mouche Méditerranéenne des fruits *C. capitata* Wiedmann (Diptera: Tephritidae) par le biais de bio-pesticides. Mémoire de Mastère, Institut National Agronomique de Tunisie, 110 p, Tunisia.

Beroza, M., Green, N., Gertler, S.I., Steiner, L.F., & Miyashita, D. (1961). Insect attractants, new attractants for the Mediterranean fruit fly. *Journal of Agricultural and Food Chemistry, 9,* 361-365. https://doi.org/10.1021/jf60117a007

Boulahia-Kheder, S., & Jerraya, A. (2010). Premiers résultats en Tunisie sur la capture de masse, moyen alternatif de lutte contre la mouche méditerranéenne des fruits *C. capitata* (Diptera, Tephritidae). *Annales de l"INRAT, 82,* 168-180.

Boulahia-Kheder, S., Loussaïef, F., Ben Hmidène, A., Trabelsi, I., Jrad, F., Akkari, Y., & Fezzani, M. (2012). Evaluation of two IPM programs based on mass-trapping against the Mediterranean fruit fly *C. capitata* on citrus orchards. *Tunisian Journal of Plant Protection,* 7, 53-66.

Boulahia-Kheder, S., Salleh, W., Awadi, N., Fezzani, M., & Jrad, F. (2011). Efficiency of different traps and lures used in mass-trapping of the Mediterranean fruit fly *C. capitata* Wied. (Diptera: Tephritidae). Integrated control in Citrus fruit crops. *IOBC/WPRS Bulletin, 62,* 215-219.

Çalıklı, Ş. (2015). Akdeniz meyve sineği, *C. capitata* (Wiedemann) (Diptera:Tephritidae)'nin mücadelesinde farklı cezbedicilerin kullanılması. Yüksek Lisans Tezi, Mustafa Kemal Üniversitesi, Fen Bilimleri Enstitüsü, Bitki Koruma Anabilim Dalı, 65 s, Hatay.

Çay, C.A. (2021). Hatay ili Samandağ ilçesindeki mandalin çeşitlerinde Akdeniz meyve sineği, *C. capitata* (Wiedemann) (Diptera: Tephritidae)'nin kitlesel tuzaklama ile kontrolü ve zarar oranının belirlenmesi. Yüksek Lisans Tezi, Mustafa Kemal Üniversitesi, Fen Bilimleri Enstitüsü, Bitki Koruma Anabilim Dalı, 56 s, Hatay.

Cunningham, R.T. (1989). Parapheromones. *In: World crop pests, vol. 3A. Fruit flies, their biology, natural enemies and control (A.S. Robinson and G. Hooper, Eds.),* Elsevier, Amsterdam, 221-230.

Demirel, N. (2019a). Efficacy of various attractants to Mediterranean fruit fly, *C. capitata* (Wiedemann) (Diptera: Tephritidae) on persimmon fruits in Turkey. *Fresenius Environmental Bulletin, 28* (7), 5390-5397.

Demirel, N. (2019b). Trapping genders of *C. capitata* (Diptera: Tephritidae) and other Dipteran with various attractants on pomegranate fruits in Turkey. *Fresenius Environmental Bulletin, 28* (4), 2937-2941.

Demirel, N. (2023a). Comparison of food-based synthetic attractants for capture of *C. capitata* (Diptera: Tephritidae) on persimmon fruits. *International Journal of Life Sciences and Biotechnology, 6* (3), 302-310. https://doi.org/10.38001/ijlsb.1354718

Demirel, N. (2023b). Infestation rates of Mediterranean fruit fly [*C. capitata* (Wiedemann) (Diptera: Tephritidae)] on common guava (*Psidium guajava* L.) fruits. *Mustafa Kemal Üniversitesi Tarım Bilimleri Dergisi, 28* (3), 649-657. https://doi.org/10.37908/mkutbd.1326527

Demirel, N. (2016). Population density and damage ratios of Mediterranean fruit fly, *C. capitata* Wiedemann (Diptera Tephritidae) on pomegranate orchards in Turkey. *Entomology and Applied Science Letters, 3* (5), 1-7. www.easletters.com

Demirel, N., Yıldırım, A.E., & Kılıç, G. (2018). Effectiveness of various attractants for Mediterranean fruit fly, *C. capitata* (Wiedemann) (Diptera: Tephritidae) on pomegranate fruits in Turkey. *Fresenius Environmental Bulletin, 27* (5), 3191-3198.

Demirel, N., & Akyol, E. (2017). Evaluation of mass trapping for control of Mediterranean fruit fly, *C. capitata* (Wiedemann) (Diptera: Tephritidae) in Satsuma mandarin in Hatay province of Turkey. *International Journal of Environmental & Agriculture Research, 3* (12), 32-37. https://ijoear.com/

Epsky, N.D., Hendrichs, J., Katsoyannos, B.I., Vasquez, L.A., Ros, J.P., Zumreoglu, A., Pereira, R., Bakri, A., Seewooruthun, S.I., & Heath, R.R. (1999). Field evaluation of female targeted trapping systems for *C. capitata* (Diptera: Tephritidae) in seven countries. *Journal of Economic Entomology, 92* (1), 156–164. https://doi.org/10.1093/jee/92.1.156

FAO (2020). *FAOSTAT online database.* Available at link. https://www.fao.org/faostat

Gazit, Y., Rössler, Y., Epsky, N.D., & Heath, R.R. (1998). Trapping females of the Mediterranean fruit fly (Diptera: Tephritidae) in Israel: comparison of lures and trap type. *Journal of Economic Entomology, 91* (6), 1355-1359. https://doi.org/10.1093/jee/91.6.1355

Gilbert, J., & Bingham, R.R. (1999). Insect Trapping Guide. California Department of Food and Agriculture, MF 1-9.

Gothilf, S., & Levin, G. (1989). Attraction of the Mediterranean fruit fly to ammonium and protein bait. *In: Fruit flies of economic importance (Cavalloro R., ed).* A.A. Balkema, Rotterdam, pp. 387-391.

Gürbüz, T. (2018). Antalya ili turunçgil bahçelerinde Akdeniz meyve sineği, *C. capitata* (Wiedemann) (Diptera: Tephritidae)'nin kitlesel tuzaklama ile kontrolü ve zarar oranının belirlenmesi. Yüksek Lisans Tezi, Mustafa Kemal Üniversitesi, Fen Bilimleri Enstitüsü, 77 s, Hatay.

Heath, R.R., Epsky, N.D., Dueben, B.D., Rizzo, J., & Jeronimo, F. (1997). Adding methyl-substituted ammonia derivatives to food-based synthetic attractants on capture of the Mediterranean and Mexican fruit flies (Diptera: Tephritidae). *Journal of Economic Entomology, 90,* 1584-1589. https://doi.org/10.1093/jee/90.6.1584

Heath, R.R., Epsky, N.D., Guzmán, A., Dueben, B.D., Manukian, A., & Meyer, W.L. (1995). Development of a dry plastic insect trap with food-based synthetic attractant for the Mediterranean fruit fly and Mexican fruit fly (Diptera: Tephritidae). *Journal of Economic Entomology, 88,* 1307-1315. https://doi.org/10.1093/jee/88.5.1307

Heath, R.R., Epsky, N.D., Midgarden, D., & Katsoyannos, B.I. (2004). Efficacy of 1,4-diamino-butane (Putrescine) in a food-based synthetic attractant for capture of Mediterranean and Mexican fruit flies (Diptera: Tephritidae). *Journal of Economic Entomology, 97,* 1126-1131. 10.1603/0022-0493(2004)097[1126:eodpia]2.0.co;2

Hoelmer, K.A., & Dahlsten, D.L. (1993). Effect of malathion bait spray on Aleyrodes spiraeoides (Homoptera: Aleyrodidae) and its parasitoids in northern California. *Environmental Entomology, 22,* 49-56. https://doi.org/10.1093/ee/22.1.49

IAEA (2003). Trapping guidelines for area-wide fruit fly programmes. Insect Pest Control Section, International Atomic Energy Agency, Vienna, Austria.

Jang, E.B., Holler, T., Cristofaro, M., Lux, S., Raw, A.S., Moses, A.L., & Carvalho, L.A. (2003). Improved attractants for Mediterranean fruit fly, *C. capitata* (Wiedemann): responses of sterile and wild flies to (-) enantiomer of ceralure B1. *Journal of Economic Entomology, 96,* 1719-1723. https://doi.org/10.1603/0022-0493-96.6.1719

Katsoyannos, B.I., Heat, R.R., Papadopoulus, N.T., Epsky, N.D., & Hendrichs, J. (1999). Field evaluation of Mediterranean fruit fly (Diptera: Tephritidae) female selective attractants for use in monitoring programs. *Journal of Economic Entomology, 92,* 583-589. https://doi.org/10.1093/jee/92.3.583

Kılıç, G. (2015). Hatay ili Trabzon hurması bahçelerinde Akdeniz meyve sineği, *C. capitata* (Wiedemann) (Diptera: Tephritidae)'nin popülasyon yoğunluğu ve zarar oranının belirlenmesi. Yüksek Lisans Tezi, Mustafa Kemal Üniversitesi, Fen Bilimleri Enstitüsü, Bitki Koruma Anabilim Dalı, 142 s, Hatay.

Kılıç, G., & Demirel, N. (2018). A population fluctuation and damage rates of *C. capitata* (Diptera: Tephritidae) on persimmon fruits in Turkey. *Fresenius Environmental Bulletin, 27* (7), 5072-5077.

Leonhardt, B.A., Cunningham, R.T., Rice, R.E., Harte, E.M., & Mcgovern, T.P. (1987). Performance of controlled-release formulations of trimedlure to attract the Mediterranean fruit fly, *C. capitata*. *Entomologia Experimentalis et Applicata, 44,* 45-51. https://doi.org/10.1111/j.1570-7458.1987.tb02238.x

Liquido, N.J., Shinoda, L.A., & Cunningham, R.T. (1990). Host plants of the Mediterranean fruit fly (Diptera, Tephritidae) an annotated world review. Miscellaneous Publications 77. Entomological Society of America, Lanham, MD. p.1863-1878. https://doi.org/10.1093/jee/83.5.1863

Marty, M.A., Dawson, S.V., Bradman, M.A., Harnly, M.E., & Dibartolomeis, M.J. (1994). Assessment of exposure to malathion and maloxon due to aerial application over urban areas of southern California. *Journal of Exposure Science & Environmental Epidemiology, 4,* 65-81. https://europepmc.org/article/med/7894269

Miranda, M.A., Alonso, R., & Alemany, A. (2001). Field evaluation of Medfly (Dipt., Tephritidae) female attractants in a Mediterranean agrosystem (Balearic Islands, Spain). *Journal of Applied Entomology, 125,* 333-339. https://doi.org/10.1046/j.1439-0418.2001.00548.x

Navarro, V., Alfaro, F., Dominguez, J., Sanchis, J., & Primo, J. (2008). Evaluation of traps and lures for mass trapping of Mediterranean fruit fly in citrus groves. *Journal of Economic Entomology, 101,* 126-131. https://doi.org/10.1093/jee/101.1.126

Ollitrault, P., Curk, F., & Kruege, R. (2020). Citrus taxonomy. *In: Talon, M., Caruso, M., Gmitter, F.G. (Eds.), The genus Citrus.* Woodhead Publishing, Duxford, UK, pp. 57-81.

Papadopulos, N.T., Katsoyannos, B.I., Kouloussis, N.A., Hendrichs, J., Carey, J.R., & Heath, R.R. (2001). Early detection and population monitoring of *C. capitata* (Diptera: Tephritidae) in a mixed-fruit orchard in Northern Greece. *Journal of Economic Entomology, 94,* 971-978. https://doi.org/10.1603/0022-0493-94.4.971

Reynolds, A.H., & Prokopy, R.J. (1997). Evaluation of odor lures for use with red sticky spheres to trap apple maggot (Diptera: Tephritidae). *Journal of Economic Entomology, 90,* 1655-1660. https://doi.org/10.1093/jee/90.6.1655

Roessler, Y., & Chen, C. (1994). The Mediterranean fruit fly, *C. capitata*, a major pest of citrus in Israel, its regulation and control. *Bulletin OEPP/EPPO Bulletin, 24,* 813-816. https://doi.org/10.1111/j.1365-2338.1994.tb01102.x

SAS Institute (1998). *User's guide, version 6.* SAS Institute, Cary, NC, USA.

Sayım, Z. (2019). Hatay ili Trabzon hurması bahçelerinde Akdeniz meyve sineği, *C. capitata* (Wiedemann) (Diptera: Tephritidae)'nin cezbediciler ile kontrolü ve zarar oranının belirlenmesi. Yüksek Lisans Tezi, Hatay Mustafa Kemal Üniversitesi, Fen Bilimleri Enstitüsü, Bitki Koruma Anabilim Dalı, 60 s, Hatay.

Shelly, T.E., Epsky, N., Jang, E.B., Reyes-Flores, J., & Vargas, R.I. (2014). Trapping and the Detection, Control, and Regulation of Tephritid Fruit Flies. Lures, Area-Wide Programs, and Trade Implications, 643 p.

Thomas, M.C., Heppner, J.B., Woodruff, R.E., Weems, H.V., Steck, G.J., & Fasulo, T.R. (2010). Mediterranean fruit fly, *C. capitata* (Wiedemann) (Diptera: Tephritidae). University of Florida, IFAS Extension. EENY-214. https://edis.ifas.ufl.edu/publication/IN371

Urbaneja, A., Chueca, P., Monton, H., Pascual-Ruiz, S., Dembilio, O., Vanaclocha, P., Abad-Moyano, R., Pina, T., & Castanera, P. (2009). Chemical alternatives to malathion for controlling *C. capitata* (Diptera: Tephritidae), and their side effects on natural enemies in Spanish citrus orchards. *Journal of Economic Entomology, 102,* 144-151. https://doi.org/10.1603/029.102.0121

Urbaneja, A., Dembilio, O., Tortosa, D., Vinuela, E., & Castanera, P. (2004). Efectos secundarios de tratamientos cebo usados para el control de *C. capitata*, sobre fauna útil. *Phytoma España, 160,* 28-40. https://redivia.gva.es/handle/20.500.11939/4067?locale-attribute=es

Vargas, R.I., Peck, S.L., McQuate, G.T., Jackson, C.G., Stark, J.D., & Armstrong, J.W. (2001). Potential for areawide integrated management of Mediterranean fruit fly (Diptera: Tephritidae) with a braconid parasitoid and a novel bait spray. *Journal of Economic Entomology, 94,* 817-825. https://doi.org/10.1603/0022-0493-94.4.817

White, I.M., & Elson-Harris, M. (1992). *Fruit flies of economic importance: their identification and bionomics.* CAB International, Wallingford, U.K. 601 pp.

Yiğit, S. (2019). Erkenci mandarin çeşitlerinde Akdeniz meyve sineği, *C. capitata* (Wiedemann) (Diptera: Tephritidae)'nin kitlesel tuzaklama ile kontrolü ve zarar oranının belirlenmesi. Yüksek Lisans Tezi, Mustafa Kemal Üniversitesi, Fen Bilimleri Enstitüsü, Bitki Koruma Anabilim Dalı, 50 s, Hatay.