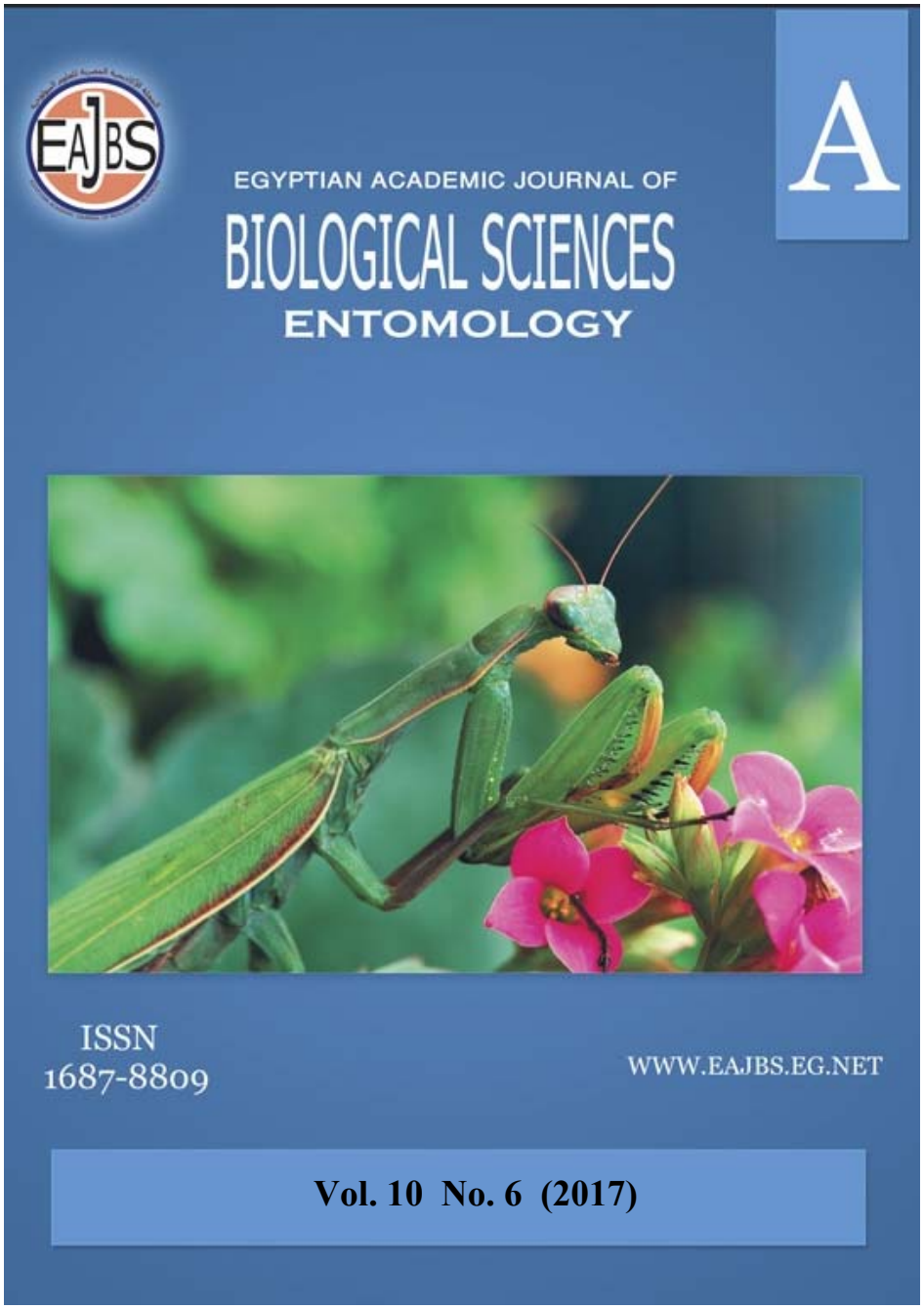


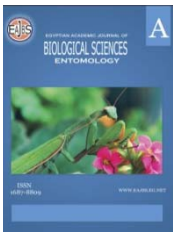
Egyptian Academic Journal of Biological Sciences is the official English language journal of the Egyptian Society for Biological Sciences, Department of Entomology, Faculty of Sciences Ain Shams University.
Entomology Journal publishes original research papers and reviews from any entomological discipline or from directly allied fields in ecology, behavioral biology, physiology, biochemistry, development, genetics, systematics, morphology, evolution, control of insects, arachnids, and general entomology.
www.eajbs.eg.net

Citation: *Egypt. Acad. J. Biolog. Sci. (A. Entomology) Vol. 10(6)pp: 153- 166(2017)*

Egypt. Acad. J. Biolog. Sci., 10(6): 153–166 (2017)

Egyptian Academic Journal of Biological Sciences
A. Entomology

ISSN 1687- 8809
www.eajbs.eg.net



Enhancement of Some Protein-Based Baits for Attracting *Bactrocera zonata* (Diptera: Tephritidae) by Adding Ammonium Compounds

Ibtesam A. Hemeida[1], Nabil M. Ghanim[2], Ahmed M. Z. Mosallam[2], Hamdy A. El-Shabrawy[1], And Basma M. Metwaa[2]

[1] *Department of Economic Entomology and Pesticides, Fac. of Agric., Cairo Univ., Giza, Egypt.*

[2] *Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza, Egypt*

Hbs2009@hotmail.com

ARTICLE INFO

Article History
Received: 8/9/2017
Accepted: 9/10/2017

Keywords:
Bactrocera zonata
Buminal
Agrinal
Amadene
Ammonium acetate
Ammonium phosphate
Mcphail traps

ABSTRACT

The peach fruit fly, *Bactrocera zonata* (Saunders) became a serious pest in Egypt; however, it attacking a wide range of fruit species. The purpose of this study was to enhance of Buminal, Agrinal and Amadene (commercially available protein-based baits in Egypt) in attracting *B. zonata* by using ammonium acetate and di-ammonium phosphate under the field conditions of a mango orchard. McPhail traps were used containing mixtures of protein-bait and ammonium compound (with ratios of 1:1, 2:1 and 1:2, respectively) in comparison with either protein-bait or ammonium compound alone. The obtained results showed that the attracted *B. zonata* flies to the mixtures between Buminal and ammonium acetate did not differ significantly with Buminal alone; while, all mixtures between the same bait and di-ammonium phosphate were significantly higher than Buminal alone. With respect to Agrinal, when it mixed with ammonium acetate (at a ratio of 1:1) or mixed with di-ammonium phosphate (at all ratios) attracted significantly higher numbers of *B. zonata* flies in comparison with Agrinal alone. Mixtures containing di-ammonium phosphate (at all ratios) or ammonium acetate (at a ratio of 1:1) mixed with Amadene exhibited significantly higher attractability for *B. zonata* flies in comparison with Amadene alone. On another hand, all of the tested treatments attracted more females than males. As a conclusion, each of Agrinal or Amadene can be enhanced by mixing any of them with di-ammonium phosphate or ammonium acetate at a ratio of 1:1 which resulting significantly higher attractability of *B. zonata* especially females; while, Buminal can be enhanced by mixing it with di-ammonium phosphate at the same ratio.

INTRODUCTION

Fruit flies (Diptera: Tephritidae) stand out as one of the most economically important groups of insect pests attacking fruits and vegetables grown in temperate, tropical, and subtropical areas of the world (White and Elson-Harris, 1992; Hashem *et al.*, 2001; Amro & Abdel-Galil, 2008 and Ghanim & Moustafa, 2009). Economically, these pests instigate quarantine restrictions on infested areas,

requiring that commercial fruits undergo protective and quarantine treatment prior to export (Vargas *et al.*, 2008). The peach fruit fly, *Bactrocera zonata* (Saunders) is native to tropical Asia, but it was spread to other regions of the world including the Middle East region (Agarwal *et al.*, 1999 and El-Minshawy *et al.*, 1999). *B. zonata* is a polyphagus insect which attack more than 50 species of fruit and vegetable crops as well as wild host plants. In Egypt, *B. zonata* became a serious pest; however, it attacks a wide range of fruits that differ in their ripening time stage all over the year (White and Elson-Harris, 1992).

Dietary sources of nitrogen have a strong influence on the physiology and behaviour of tephritid flies (Kaspi *et al.*, 2000 and Yuval *et al.*, 2007). This behaviorally-based tactic targets female fruit flies primarily based on the female's need for protein for adequate egg production (Epsky *et al.*, 2014 and Pinero *et al.*, 2015). Consequently, efforts to suppress pestiferous fruit fly populations around the world have relied heavily on the application of proteinaceous bait sprays mixed with toxicants (Vargas *et al.*, 2001; Moreno and Mangan, 2002 and Barry *et al.*, 2003).

To have effective suppression against fruit fly populations, protein-based bait formulations must induce good levels of attraction to the source, and stimulate flies to ingest a lethal dose of the toxicant upon contact (Mangan, 2009 and 2014). Ammonia-releasing substances play an important role in fruit fly attraction to food sources (Epsky and Heath, 1998 and Hull and Cribb, 2001). This information has led to the development of effective ammonia-containing lures. The level of attraction of fruit flies to ammonia-based compounds is known to be dose-dependent, and the range of unattractiveness is very narrow, while the range of rejection (repellence) is much wider (Bateman and Morton, 1981 and Mazor *et al.*, 2002). Application of 1% (wt:vol) ammonium acetate to protein baits elicited an adequate female response (Pinero *et al.*, 2015). This amount corresponds to the amount of ammonium acetate present in GF-120 and protein baits that is very effective against fruit flies (Moreno and Mangan, 2002; Mangan and Moreno, 2004; Vargas *et al.*, 2008 and Mangan, 2014). Overall, the effects of ammonium acetate added to protein baits were more important for females than males. This finding highlights the importance of adding this compound to commercial baits or local products to enhance their effectiveness for monitoring and suppression the populations of fruit flies (Pinero *et al.*, 2015).

So, the purpose of this study is to enhance attractability of Buminal, Agrinal and Amadene (commercially available protein-based baits in Egypt) for *B. zonata* by using ammonium acetate and di-ammonium phosphate which are of effective attractants for both females and males of *B. zonata* (Hanafy *et al.*, 2001; Amin, 2003; Saafan, 2005 and Abd El-Kareim *et al.*, 2008) under the field conditions of a mango orchard.

MATERIALS AND METHODS

Baits used:

1) Ammonium acetate: at 3% (w/v) (AA).
2) Di-ammonium phosphate: at 3% (w/v) (DAP).
3) Buminal: at 5% (v/v) (Bu).
4) Agrinal: at 5% (v/v) (Ag).
5) Amadene: at 5% (v/v) (Am).
6) AA + Bu with a ratio of 1:1 (AA.1:Bu.1).
7) AA + Bu with a ratio of 2:1 (AA.2:Bu.1).
8) AA + Bu with a ratio of 1:2 (AA.1:Bu.2).

9) DAP + Bu with a ratio of 1:1 (DAP.1:Bu.1).
10) DAP + Bu with a ratio of 2:1 (DAP.2:Bu.1).
11) DAP + Bu with a ratio of 1:2 (DAP.1:Bu.2).
12) AA + Ag with a ratio of 1:1 (AA.1:Ag.1).
13) AA + Ag with a ratio of 2:1 (AA.2:Ag.1).
14) AA + Ag with a ratio of 1:2 (AA.1:Ag.2).
15) DAP + Ag with a ratio of 1:1 (DAP.1:Ag.1).
16) DAP + Ag with a ratio of 2:1 (DAP.2:Ag.1).
17) DAP + Ag with a ratio of 1:2 (DAP.1:Ag.2).
18) AA + Am with a ratio of 1:1 (AA.1:Am.1).
19) AA + Am with a ratio of 2:1 (AA.2:Am.1).
20) AA + Am with a ratio of 1:2 (AA.1:Am.2).
21) DAP + Am with a ratio of 1:1 (DAP.1:Am.1).
22) DAP + Am with a ratio of 2:1 (DAP.2:Am.1).
23) DAP + Am with a ratio of 1:2 (DAP.1:Am.2).

Field experiment:

To evaluate the efficacy of ammonium acetate or di-ammonium phosphate for enhancing attractability of Buminal, Agrinal and Amadene for *B. zonata*, an experiment was conducted from the 22nd of August till the 19th of September 2017. An area of about 5.5 feddans cultivated with different varieties of mango trees of more than 20 years old were selected for the present study. This orchard located at the Agricultural Experiment Station of Cairo University at Giza district, Egypt. Glass McPhail traps (McPhail, 1939) were used in this experiment by putting about 200 ml of each bait in the trap. Each treatment was replicated three times. The traps were hung in a shady side of the trees at about two meters in height. Traps were distributed at about 20 meters apart between every two adjacent traps in a completely randomized design. Traps were inspected weekly twice (after 4 and 7 days). Captured females and males of *B. zonata* in each trap were counted. The weekly total numbers of flies were recorded as FTD (No. of Flies/Trap/Day). The solutions were renewed every week and the experiment was repeated four times during four successive weeks.

Statistical analysis:

Data were analyzed using analysis of variance (ANOVA) followed by Least Significant Difference (LSD). Probability of 0.05 or less was considered significant. All statistical analysis was done with CoHort Software (2004).

RESULTS

1. Enhancement of Buminal:

1.1. By using ammonium acetate:

Data presented in Table (1) show that Buminal alone is significantly differed with the other mixtures during the first week; while, during the second one, both mixtures of AA.2+Bu.1 and AA.1+Bu.2 were significantly high attractive to *B. zonata*. During the third and fourth weeks, the numbers of captured *B. zonata* flies by AA.1+Bu.1 and AA.2+Bu.1 were significantly higher than that of Buminal alone.

Figure (1) showed that the grand mean of attracted *B. zonata* flies was significantly higher in case of ammonium acetate alone, but the other tested treatments insignificantly differed. The mixture of AA.1+Bu.1 increased the attractiveness to *B. zonata* by 1.7 times of Buminal alone.

Table (1). FTD values of *B. zonata* adults to Buminal either alone or added with ammonium acetate at different ratios in mango orchard at Giza governorate, Egypt.

Treatment	1st week			2nd week			3rd week			4th week		
	♀	♂	Total	♀	♂	Total	♀	♂	Total	♀	♂	Total
AA	5.29 A	1.00 A	6.29 A	11.43 A	2.00 A	13.43 A	6.14 A	2.86 A	9.00 AB	13.14 A	2.14 A	15.29 A
Bu	2.71 BC	0.29 B	3.00 B	3.14 D	0.52 C	3.67 C	2.71 B	1.29 B	4.00 C	2.29 D	0.57 B	2.86 D
AA.1+Bu.1	3.38 B	0.48 B	3.86 B	3.67 CD	1.24 B	4.90 BC	6.38 A	3.52 A	9.90 A	3.38 C	1.14 B	4.52 BC
AA.2+Bu.1	2.48 C	0.33 B	2.81 B	5.62 B	0.62 BC	6.24 B	6.76 A	1.33 B	8.10 B	4.48 B	0.95 B	5.43 B
AA.1+Bu.2	2.48 C	0.57 AB	3.05 B	4.33 C	1.05 BC	5.38 B	2.05 B	0.90 B	2.95 C	2.62 CD	1.14 B	3.76 CD

Notice: In each column, means have the same letter did not significantly differ at probability of 5%.

On another hand, all tested treatments attracted females more than males (Fig., 1). The highest mean number of females per a male was recorded with AA.2+Bu.1 (5.99 females); while, the lowest was recorded with AA.1+Bu.1 (2.63 females).

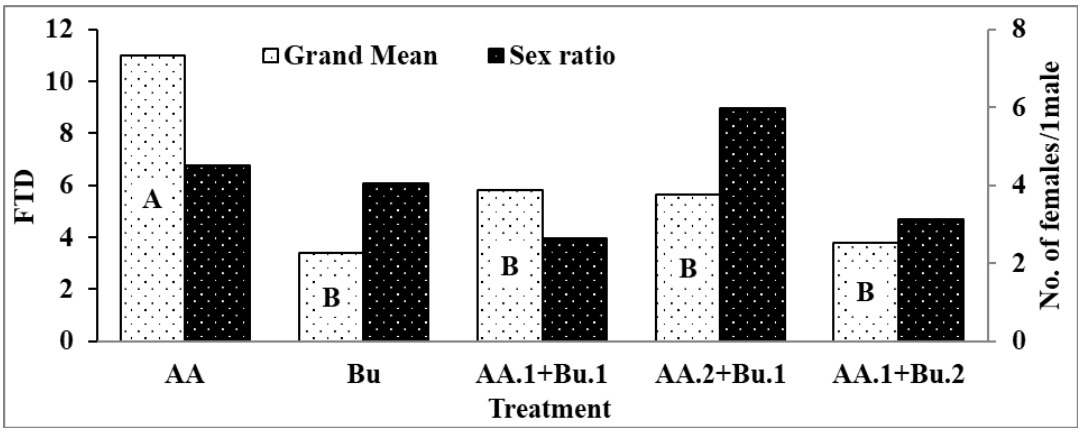


Fig. (1). Daily mean of sex ratio (famles/1 male) and daily grand mean of attracted *B. zonata* adults to Buminal either alone or added with ammonium acetate at different ratios all over the four weeks in mango orchard at Giza governorate, Egypt.

1.2. By using di-ammonium phosphate:

As shown in Table (2), according to the total captured flies Buminal alone was significantly the lowest attractable for *B. zonata* adults comparedto the other tested treatments all over the four weeks. On contrary, during the first and fourth weeks DAP.1+Bu.1 was significantly the highest in attracting *B. zonata* flies; while, DAP.2+Bu.1 was the highest during the second week with significantly differences with the other tested treatments. DAP alone significantly surpassed the other treatments during the 3rd week.

Table (2). FTD values of *B. zonata* adults to Buminal either alone or with added di-ammonium phosphte at different ratios in mango orchard at Giza governorate, Egypt.

Treatment	1st week			2nd week			3rd week			4th week		
	♀	♂	Total	♀	♂	Total	♀	♂	Total	♀	♂	Total
DAP	6.71 C	0.71 B	7.43 C	5.71 D	1.57 A	7.29 D	9.57 A	3.00 A	12.57 A	8.57 A	1.43 A	10.00 A
Bu	2.71 E	0.29 C	3.00 E	3.14 E	0.52 C	3.67 E	2.71 D	1.29 CD	4.00 D	2.29 D	0.57 B	2.86 C
DAP.1+Bu.1	12.29 A	0.86 AB	13.14 A	12.86 B	1.14 B	14.00 B	6.86 B	1.57 BC	8.43 C	8.57 A	1.57 A	10.14 A
DAP.2+Bu.1	11.29 B	1.05 A	12.33 B	13.57 A	1.05 B	14.62 A	9.86 A	1.05 D	10.90 B	5.57 C	0.86 B	6.43 B
DAP.1+Bu.2	4.71 D	0.95 AB	5.67 D	8.14 C	0.48 C	8.62 C	5.86 C	1.86 B	7.71 C	7.71 B	1.71 A	9.43 A

The grand mean of attracted *B. zonata* flies was significantly lower in Buminal alone which significantly between the rests of the tested treatments (Fig., 2). Also, it can be noticed that adding di-ammonium phosphate to Buminal with a ratio of 1:1 increased Buminal's attractability 3.4 times.

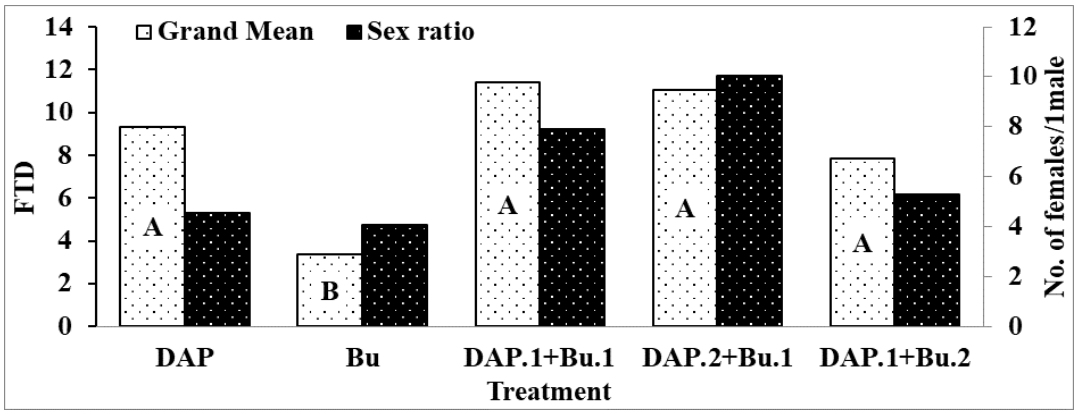


Fig. (2). Daily mean of sex ratio (famles/1 male) and daily grand mean of attracted *B. zonata* adults to Buminal either alone or with added di-ammonium phosphate at different ratios all over the four weeks in mango orchard at Giza governorate, Egypt.

With respect to sex ratio (Fig., 2), the highest number of females per one male was recorded at DAP.2+Bu.1 (10.05 females); while, the lowest value was recorded with Buminal alone (4.06 females).

2. Enhancement of Agrinal:

2.1. By using ammonium acetate:

Both of Agrinal alone and AA.1+Ag.2 exhibited the lowest attractabillity of *B. zonata* during the second, third and fourth weeks showing insignificantly differences between them; while, during the first week AA.1+Ag.2 only was significantly the lowest (Table, 3). AA.1+Ag.1 had a relatively moderate rank during the four weeks of the study.

Table (3). Mean number of daily attracted *B. zonata* adults to Agrinal either alone or with added ammonium acetate at different ratios in mango orchard at Giza governorate, Egypt.

Treatment	1st week			2nd week			3rd week			4th week		
	♀	♂	Total	♀	♂	Total	♀	♂	Total	♀	♂	Total
AA	5.29 A	1.00 A	6.29 A	11.43 A	2.00 A	13.43 A	6.14 A	2.86 A	9.00 A	13.14 A	2.14 B	15.29 A
Ag	2.62 B	0.38 BC	3.00 B	1.48 C	0.29 B	1.76 C	2.48 BC	0.95 B	3.43 B	1.76 D	0.38 C	2.14 D
AA.1+Ag.1	2.81 B	0.67 ABC	3.48 B	3.52 B	1.95 A	5.48 B	3.38 B	1.14 B	4.52 B	10.38 B	1.71 B	12.10 B
AA.2+Ag.1	3.52 B	0.71 AB	4.24 B	1.81 C	0.38 B	2.19 C	2.95 BC	1.38 B	4.33 B	3.81 C	3.10 A	6.90 C
AA.1+Ag.2	0.71 C	0.19 C	0.90 C	2.00 C	0.43 B	2.43 C	2.29 C	1.10 B	3.38 B	1.14 D	0.71 C	1.86 D

During the four weeks of investigation, AA significantly recorded the highest values of attracted adults of *B. zonata*. Unfortunately, adding Ammonium Acetate to Agrinal did not enhance attractability for *B. zonata* adults.

As shown in Fig. (3), ammonium acetate alone was the best attractant all over the four weeks. AA.1+Ag.1 ranked the second one followed by AA.2+Ag.1. While, both of Agrinal alone and AA.1+Ag.2 were insignificantly the lowest attractable treatments for *B. zonata* flies. Also, data in Fig. (3) show that AA.1+Ag.1 increased the attractiveness of *B. zonata* by 2.5 times of Agrinal alone.

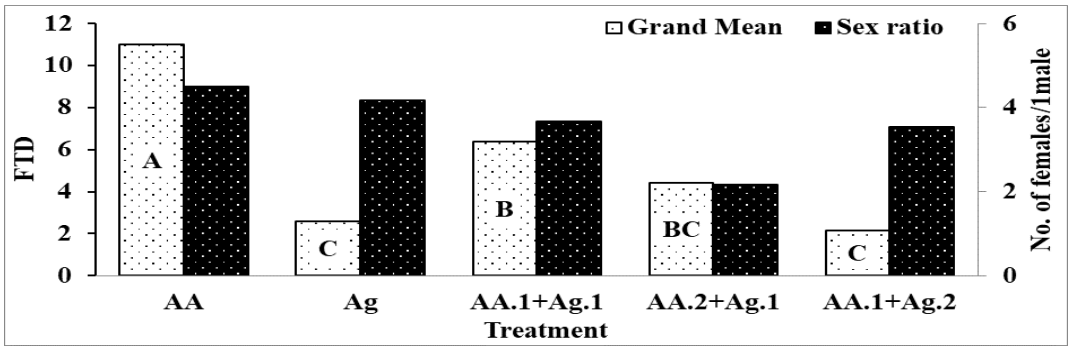


Fig. (3). Daily mean of sex ratio (famles/1 male) and daily grand mean of attracted *B. zonata* adults to Agrinal either alone or with added ammonium acetate at different ratios all over the four weeks in mango orchard at Giza governorate, Egypt.

The highest number of females per one male was obtained with ammonium acetate alone (4.50 females) followed by Agrinal alone (4.17 females). While, the lowest number of females per one male (2.17 females) was obtained with AA.2+Ag.1 treatment (Fig., 3).

2.2. By using di-ammonium phosphate:

Agrinal alone was significantly the lowest attractive to *B. zonata* flies in comparison with the other tested treatments all over the four weeks. On contrary, the mixture of DAP.1+Ag.1 was significantly the highest treatment in attracting *B. zonata* flies during the first week. But, DAP.2+Ag.1 significantly recorded the highest value of FTD of *B. zonata* during the second, third and fourth weeks (Table, 4).

Table (4). FTD values of *B. zonata* adults to Agrinal either alone or with added di-ammonium phosphate at different ratios in mango orchard at Giza governorate, Egypt.

Treatment	1st week			2nd week			3rd week			4th week		
	♀	♂	Total	♀	♂	Total	♀	♂	Total	♀	♂	Total
DAP	6.71 C	0.71 AB	7.43 C	5.71 B	1.57 A	7.29 B	9.57 C	3.00 AB	12.57 C	8.57 B	1.43 B	10.00 B
Ag	2.62 E	0.38 B	3.00 D	1.48 D	0.29 C	1.76 D	2.48 D	0.95 D	3.43 E	1.76 E	0.38 C	2.14 D
DAP.1+Ag.1	19.00 A	0.95 A	19.95 A	12.29 A	1.29 AB	13.57 A	9.00 C	1.71 C	10.71 D	5.57 D	1.29 B	6.86 C
DAP.2+Ag.1	5.90 D	0.52 AB	6.43 C	12.33 A	1.90 A	14.24 A	13.76 A	2.90 B	16.67 A	11.05 A	2.19 A	13.24 A
DAP.1+Ag.2	12.14 B	0.86 AB	13.00 B	3.90 C	0.81 BC	4.71 C	11.19 B	3.62 A	14.81 B	7.33 C	1.76 AB	9.10 B

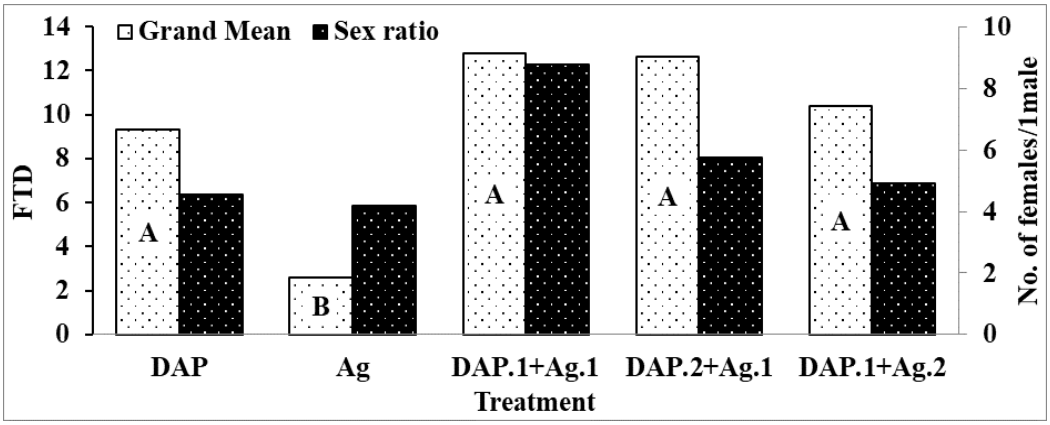


Fig. (4). Daily mean of sex ratio (famles/1 male) and daily grand mean of attracted *B. zonata* adults to Agrinal either alone or with added di-ammonium phosphate at different ratios all over the four weeks in mango orchard at Giza governorate, Egypt.

In general, Agrinal alone was the lowest treatment for attracting *B. zonata* flies which significantly differed with the other tested treatments (Fig., 4). All of the rest treatments significantly super passed Agrinal alone, but they were insignificantly differed. The mixture of DAP.1+Ag.1 increased the attractability of Agrinal to *B. zonata* by 4.9 times. The highest number of females per one male was obtained with DAP.1+Ag.1 (8.75 females); while, the lowest was obtained with Agrinal alone (4.17 females) (Fig., 4).

3. Enhancement of Amadene:

3.1. By using ammonium acetate:

Data presented in Table (5) show that Amadene alone exhibited the lowest mean numbers of attracted *B. zonata* flies represented as FTD values during the four weeks, which insignificantly varied with the mixture of AA.1+Am.2 during the second and fourth weeks. The mixture of AA.1+Am.1 was significantly more attractive to *B. zonata* than that of attracted by Amadene alone during the four weeks of investigation.

Table (5). FTD values of *B. zonata* adults to Amadene either alone or with added ammonium acetate at different ratios in mango orchard at Giza governorate, Egypt.

Treatment	1st week			2nd week			3rd week			4th week		
	♀	♂	Total	♀	♂	Total	♀	♂	Total	♀	♂	Total
AA	5.29 D	1.00 AB	6.29 D	11.43 A	2.00 A	13.43 A	6.14 C	2.86 A	9.00 C	13.14 A	2.14 A	15.29 A
Am	5.00 D	1.14 A	6.14 D	2.86 C	1.00 BC	3.86 C	2.14 E	0.57 C	2.71 E	2.43 D	0.95 B	3.38 D
AA.1+Am.1	11.86 B	0.48 B	12.33 B	6.86 B	1.62 AB	8.48 B	13.57 A	1.57 B	15.14 A	10.29 B	2.29 A	12.57 B
AA.2+Am.1	7.24 C	0.81 AB	8.05 C	6.67 B	0.57 C	7.24 B	9.24 B	2.52 A	11.76 B	5.24 C	1.24 B	6.48 C
AA.1+Am.2	13.43 A	0.76 AB	14.19 A	3.43 C	0.43 C	3.86 C	4.57 D	1.00 BC	5.57 D	3.14 D	1.14 B	4.29 D

Figure (5) show that the grand mean of attracted *B. zonata* flies was insignificantly higher with AA.1+Am.1 and ammonium acetate alone, but they significantly differed with Amadene alone, which was the lowest attractable for *B. zonata* flies. So, it can be noticed that adding ammonium acetate to Amadene with a ratio of 1:1 increased the efficiency of Amadene in attracting *B. zonata* flies by 3.0 times.

On the other hand, all of the tested treatment attracted females more than males (Fig., 5). The highest mean number of females per one male was recorded with AA.1+Am.2 (7.38 females); while, the lowest value was recorded with Amadene alone (3.40 females).

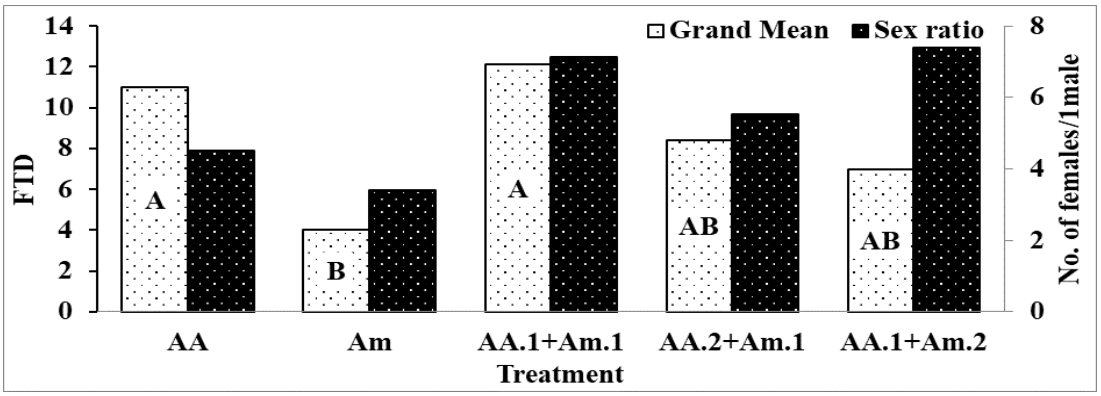


Fig. (5). Daily mean of sex ratio (famles/1 male) and daily grand mean of attracted *B. zonata* adults to Amadene either alone or with added ammonium acetate at different ratios all over the four weeks in mango orchard at Giza governorate, Egypt.

3.2. By using di-ammonium phosphate:

As shown in Table (6), Amadene alone was significantly the lowest attractive to *B. zonata* flies in comparison with the other tested treatments all over the four weeks. On contrary, during the first and second weeks DAP.2+Am.1 significantly recorded the highest mean numbers of attracted *B. zonata* flies, whereas the mixtures DAP.1+Am.2 and DAP.1+Am.1 were the most attractive during the third and fourth weeks for the first and second mixtures, respectively. The differences between them and the other tested treatments were significant.

Table (6). FTD values of *B. zonata* adults to Amadene either alone or with added di-ammonium phosphate at different ratios in mango orchard at Giza governorate, Egypt.

Treatment	1st week			2nd week			3rd week			4th week		
	♀	♂	Total	♀	♂	Total	♀	♂	Total	♀	♂	Total
DAP	6.71 D	0.71 B	7.43 D	5.71 D	1.57 BC	7.29 D	9.57 D	3.00 A	12.57 C	8.57 D	1.43 BC	10.00 D
Am	5.00 E	1.14 AB	6.14 D	2.86 E	1.00 C	3.86 E	2.14 E	0.57 C	2.71 D	2.43 E	0.95 C	3.38 E
DAP.1+Am.1	28.05 B	1.62 A	29.67 B	21.19 B	2.33 AB	23.52 B	17.76 B	2.48 AB	20.24 B	31.62 A	4.19 A	35.81 A
DAP.2+Am.1	37.38 A	1.10 AB	38.48 A	28.52 A	2.52 A	31.05 A	10.67 C	3.10 A	13.76 C	12.52 B	1.67 BC	14.19 B
DAP.1+Am.2	24.90 C	1.05 AB	25.95 C	17.48 C	1.19 C	18.67 C	22.19 A	1.90 B	24.10 A	10.05 C	1.81 B	11.86 C

The grand mean of attracted *B. zonata* flies was significantly lower with Amadene alone. The mixtures of DAP.1+Am.1, DAP.2+Am.1 and DAP.1+Am.2 were insignificantly the most attractable for *B. zonata* flies, where they significantly increased the attractability than that recorded with Amadene or Di-ammonium phosphate (Fig., 6). Also, it can be noticed from this figure that the mixture of DAP.1+Am.1 increased Amadene's attractiveness to *B. zonata* by 6.8 times.

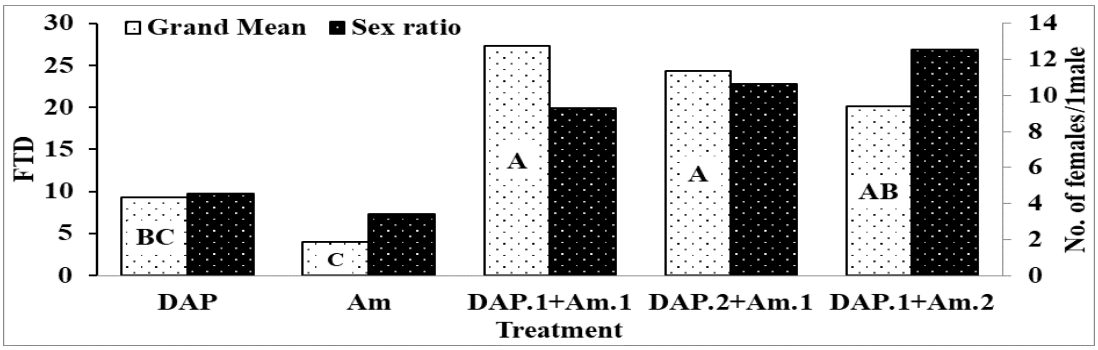


Fig. (6). Daily mean of sex ratio (famles/1 male) and daily grand mean of attracted *B. zonata* adults to Amadene either alone or with added di-ammonium phosphat at different ratios all over the four weeks in mango orchard at Giza governorate, Egypt.

With respect to sex ratio (Fig., 6), the highest mean number of females per one male was recorded with DAP.1+Am.2 (12.54 females); while, the lowest value was recorded with Amadene alone (3.40 females).

DISCUSSION

According to Kaspi *et al.* (2000) and Yuval *et al.* (2007), dietary sources of nitrogen have a strong influence on the physiology and behaviour of tephritid flies. Heath *et al.* (2004) and Leblanc *et al.* (2010) added that a variety of baits take advantage of the key role that ammonia plays in fruit fly attraction by including ammonia in their formulations. For example, ammonium acetate has been shown to be the most attractive component of Biolure for *C. capitata*. Also, Pinero *et al.* (2011) reported a significant effect of adding ammonium acetate to GF-120,

regardless of the amount added, for *Bactrocera cucurbitae* (Coquillet) and *Bactrocera dorsalis* (Hendel), and a significant positive relationship was obtained between relative amounts of ammonium acetate in the bait and the numbers of *C. capitata* females responding.

The present results showed that mixing di-ammonium phosphate (3% w/v) to the commercially protein-based baits of Buminal, Agrinal or Amadene (5% v/v) with a ratio of 1:1 significantly increased their attractability to *B. zonata* flies by ranges of 3.4 to 6.8 times. Also, adding ammonium acetate (3% w/v) to Agrinal or Amadene (5% v/v) with the same ratio significantly increased their attractability for *B. zonata* flies by 2.5 and 3.0 times, respectively. These results are in agreement with those obtained by Pinero *et al.* (2015) who documented a significant increment in response of females of *C. capitata* to some protein-baits tested when ammonium acetate was added to the bait. Bateman and Morton (1981) demonstrated that increases in ammonia produced as a consequence of bacterial degradation of protein were associated with increases in bait attractiveness to females of fruit flies. Also, Mazor (2009) documented low attractiveness of proteinaceous baits that were associated with low release rates of ammonia, whereas other sources of ammonia such as fertilizers (e.g., ammonium nitrate) and manure were found to release much higher rates of gaseous ammonia and this resulted in much higher attractiveness to female *C. capitata* under laboratory conditions.

With respect to the mixtures between Buminal and ammonium acetate, the present results indicated that there were no significant differences between them and Buminal alone. Also, Pinero *et al.* (2015) reported that the addition of ammonium carbonate to some protein-baits resulted no significant increase in bait attractiveness to females of *C. capitata*. Also, *Rhagoletis cerasi* L. did not significantly attract to ammonium carbonate (Katsoyannos *et al.*, 2000). Even within the same fly species, there was some variability regarding the attractiveness of ammonia-releasing substances. For example, whereas eastern populations of *Rhagoletis pomonella* (Walsh) showed a low response to ammonium carbonate (Reynolds and Prokopy, 1997 and Rull and Prokopy, 2000), western populations of the same species were found to have the same or a greater level of response to the same ammonium compound compared with fruit-based lures (Yee *et al.*, 2014). The variations between the present results and the others may be attributed to the variation of the tested ammonium compound and/or fruit fly species.

The present study conclusively documents that adding di-ammonium phosphate or ammonium acetate increased the numbers of attracted females in comparison with attracted males especially with Buminal and Amadene. These findings supported by Pinero *et al.* (2015); who mentioned that adding ammonium acetate to a variety of protein baits and materials, resulting in enhanced *C. capitata* response, especially for females. The same authors added that ammonium carbonate increased *C. capitata* female response to the commercial protein-bait of DacGel and showed no significant effects in the other tested commercial protein-baits including Buminal in Hawaii.

In conclusion, the commercial protein-based baits of Agrinal or Amadene can be enhanced by mixing any of them with di-ammonium phosphate or ammonium acetate at a ratio of 1:1; while, Buminal can be enhanced by mixing it with di-ammonium phosphate at the same ratio. These enhancements resulting higher significant attractability for *B. zonata* flies especially females.

REFERENCES

Abd El-Kareim, A.I, L.M. Shanab, M.E. El-Naggar and N.M. Ghanim, 2008. Response of peach fruit fly, *Bactrocera zonata* (Saunders) (Diptera: Tephritidae) to some ammonium compounds as olfactory stimulants. J. Agric. Sci., Mansoura Univ., 33(12): 8965-8973.

Agarwal, M.L., K. Pramod and P. Kumar, 1999. Effect of weather parameters on population dynamics of peach fruit fly, *Bactrocera zonata* (Saunders). Entomol., 24 (1): 81-84.

Amin, A.A., 2003. Studies on the peach fruit fly, *Bactrocera zonata* (Saund.) and its control in Fayoum governorate. M.Sc. Thesis, Fac. Agric., Fayoum University, 127pp.

Amro, M.A. and F.A. Abdel-Galil, 2008. Infestation predisposition and relative susceptibility of certain edible fruit crops to the native and invading fruit flies (Diptera: Tephritidae) in the New Valley oases, Egypt. Ass. Univ. Bull. Environ. Res., 11 (1): 89-97.

Barry, J.D., L.C.K. Tran and J.G. Morse, 2003. Mating propensities from different ratios of male and female Mediterranean fruit flies (Diptera: Tephritidae). Florida Entomologist, 86: 225–226.

Bateman, M.A. and T.C. Morton, 1981. The importance of ammonia in proteinaceous attractants for fruit-flies (Family, Tephritidae). Australian J. Agric. Res., 32: 883–903.

CoHort Software (2004). CoStat. www.cohort.com Montery, California, USA.

El-Minshawy, A.M., M.A. Al-Eryan and A.I. Awad, 1999. Biological and morphological studies on the guava fruit fly *Bactrocera zonata* (Saunders) (Diptera: Tephritidae) found recently in Egypt. 8th Nat. Conf. of Pest & Dis. of Veg. & Fruits in Ismailia, Egypt, pp 71-82.

Epsky, N.D. and R.R. Heath, 1998. Exploiting the interactions of chemical and visual cues in behavioral control measures for pest tephritid fruit flies. Fla. Entomol., 81: 273–282.

Epsky, N.D., P.E. Kendra and E.Q. Schnell, 2014. History and development of food-based attractants, pp. 75–118. In T. Shelly, N. Epsky, E.B. Jang, J. Reyes-Flores and R.I. Vargas (eds.), Trapping and the detection, control, and regulation of tephritid fruit flies: lures, area-wide programs, and trade implications. Springer, Netherlands.

Ghanim, N.M. and S.A. Moustafa, 2009. Flight activity of Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) in response to temperature and relative humidity at Dakahlia governorate. Bull. Ent. Soc. Egypt, 86: 209-221.

Hanafy, A.H., A.I. Awad and M. Abo-Sheasha, 2001. Field evaluation of different compounds for attracting adults of peach fruit fly *Bactrocera zonata* (Saunders) and Mediterranean fruit fly, *Ceratitis capitata* (Wied.) in guava orchards. J. Agric. Sci. Mansoura Univ., 26(7): 4537- 4546.

Hashem, A.G., S. M.A. Mohamed and M.F. El-Wakkad, 2001. Diversity and abundance of Mediterranean and peach fruit flies (Diptera: Tephritidae) in different horticultural orchards. Egyptian J. Appl. Sci., 16(2): 303-314.

Heath, R.R., N.D. Epsky, D. Midgarden and B.I. Katsoyannos, 2004. Efficacy of 1,4-Diaminobutane (putrescine) in a food-based synthetic attractant for capture of Mediterranean and Mexican fruit flies (Diptera: Tephritidae). J. Econ. Entomol., 97: 1126–1131.

Hull, C.D. and B.W. Cribb, 2001. Olfaction in the Queensland fruit fly, *Bactrocera tryoni*. I: Identification of olfactory receptor neuron types responding to environmental odors. J. Chem. Ecol., 27: 871–887.

Kaspi, R., P.W. Taylor and B. Yuval, 2000. Diet and size influence sexual advertisement and copulatory success of males in Mediterranean fruit fly leks. Ecological Entomology, 25: 279–284.

Katsoyannos, B.I., N.T. Papadopoulos and D. Stavridis, 2000. Evaluation of trap types and food attractants for *Rhagoletis cerasi* (Diptera: Tephritidae). J. Econ. Entomol., 93: 1005–1010.

Leblanc, L., R.I. Vargas and D. Rubinoff, 2010. Attraction of *Ceratitis capitata* (Diptera: Tephritidae) and endemic and introduced nontarget insects to Biolure bait and its individual components in Hawaii. Environ. Entomol., 39: 989–998.

Mangan, R.L., 2009. Effects of bait age and prior protein feeding on cumulative tie-dependent mortality of *Anastrepha ludens* (Diptera: Tephritidae) exposed to GF-120 spinosad baits. J. Econ. Entomol., 102: 1157–1163.

Mangan, R.L., 2014. History and development of food-based attractants, pp. 423–456. In T. Shelly, N. Epsky, E.B. Jang, J. Reyes-Flores and R.I. Vargas (eds.), Trapping and the detection, control, and regulation of tephritid fruit flies: Lures, Area-Wide Programs, and Trade Implications. Springer, Netherlands.

Mangan, R.L. and D.S. Moreno, 2004. Dilution and persistence of baits and safer pesticides for spray application, pp. 305–312. In B.N. Barnes (ed.) Proceedings of 6th International Symposium on Fruit Flies of Economic Importance, Stellenbosch, South Africa, 6–10 May 2002, Irene, South Africa, Isteg Scientific Publishers.

Mazor, M., 2009. Competitiveness of fertilizers with proteinaceous baits applied in Mediterranean fruit fly, *Ceratitis capitata* Wied. (Diptera: Tephritidae) control. Crop Prot., 28: 314–318.

Mazor, M., A. Peysakhis and G. Reuven, 2002. The rate of release of ammonia - the key component in the attraction of female Mediterranean fruit fly to food lures, pp. 323–329. In P. Witzgall, B. Mazomenos and M. Konstantopoulou (eds.), Use of Pheromones and Other Semiochemicals in Integrated Production. IOBCWPRS Bull., 25: 9.

McPhail, M. (1939). Protein lures for fruit flies. J. Econ. Entomol., 32: 758-761.

Moreno, D.S. and R.L. Mangan, 2002. Bait matrix for novel toxicants for use in control of fruit flies (Diptera: Tephritidae), pp. 333–362. In G. Hallman and C.P. Schwalbe (eds.), Invasive arthropods in agriculture. Science Publishers, Inc., Enfield, NH.

Pinero, J.C., R.F.L. Mau and R.I. Vargas, 2011. A comparative assessment of the response of three fruit fly species (Diptera: Tephritidae) to a spinosad-based bait: Effect of ammonium acetate, female age, and protein hunger. Bull. Ent. Res., 101: 373–381.

Pinero, J.C., S.K. Souder, T.R. Smith, A.J. Fox and R.I. Vargas, 2015. Ammonium acetate enhances the attractiveness of a variety of protein-based baits to female *Ceratitis capitata* (Diptera: Tephritidae). J. Econ. Entomol., 108(2): 694–700.

Reynolds, A.H. and R.J. Prokopy, 1997. Evaluation of odor lures for use with red sticky spheres to trap apple maggot (Diptera: Tephritidae). J. Econ. Entomol., 90: 1655–1660.

Rull, J. and R.J. Prokopy, 2000. Attraction of apple maggot flies, *Rhagoletis pomonella* (Diptera: Tephritidae) of different physiological states to odour-baited traps in the presence and absence of food. Bull. Ent. Res., 90: 77–88.

Saafan, M.H., 2005. Field evaluation of some attractants for attracting the adults of Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) and peach fruit fly, *Bactrocera zonata* (Saunders) in citrus orchards. Egyptian J. Agric. Res., 83 (3): 1141-1156.

Vargas, R.I., S.L. Peck, G.T. McQuate, C.G. Jackson, J.D. Stark and J.W. Armstrong, 2001. Potential for areawide integrated management of Mediterranean fruit fly (Diptera: Tephritidae) with a braconid parasitoid and a novel bait spray. J. Econ. Entomol., 94: 817–825.

Vargas, R.I., R.F.L. Mau, E.B. Jang, R.M. Faust and L. Wong, 2008. The Hawaii Fruit Fly Area-Wide Pest Management Program, pp. 300–325. In O. Koul, G.W. Cuperus and N.C. Elliott (eds.), Area-wide IPM: Theory to Implementation. CABI Books, London, United Kingdom.

White, I.M. and M. Elson-Harris, 1992. Fruit flies of economic significance: their identification and bionomics, p. 601. International Institute of Entomology, London, United Kingdom.

Yee, W.L., M.J. Nash, R.B. Goughnour, D.H. Cha, C.E. Linn and J.L. Feder, 2014. Ammonium carbonate is more attractive than apple and hawthorn fruit volatile lures to *Rhagoletis pomonella* (Diptera: Tephritidae) in Washington State. Environ. Entomol., 43: 957–968.

Yuval, B., M. Maor, K. Levy, R. Kaspi, P.W. Taylor and T.E. Shelly, 2007. Breakfast of champions or kiss of death? Survival and sexual performance of protein fed, sterile Mediterranean fruit flies. Florida Entomologist, 90: 115–122.

ARABIC SUMMARY

تحسين بعض الطعوم البروتينية لجذب ذبابة ثمار الخوخ بإضافة مركبات الأمونيوم

ابتسام عبد المنعم حميده[١]، نبيل محمد غانم[٢]، أحمد محمود زكي مسلم[٢]، حمدي عبد الصمد الشبراوي[١] وبسمة مطاوع مطاوع[٢]

١- قسم الحشرات الاقتصادية والمبيدات ، كلية الزراعة ، جامعة القاهرة ، جيزة ، مصر
٢- معهد بحوث وقاية النباتات ، مركز البحوث الزراعيه ، الدقى ، جيزة ، مصر

تعتبر ذبابة الخوخ *Bactrocera zonata* من الآفات الهامة في مصر، حيث أنها تهاجم عدد كبير من محاصيل الفاكهة، وبالتالي كان الهدف من هذه الدراسة هو تحسين قدرة جذب مركبات البومينال، الأجرينال والأمادين (طعوم بروتينية متاحة تجارياً في مصر) عن طريق خلطها مع مركب الأمونيوم أسيتات أو مركب الداي أمونيوم فوسفات، وذلك تحت الظروف الحقلية في يستان مانجو حيث تم استخدام مصايد ماكفيل المحتوية على خليط من الطعوم البروتينية و مركبات الأمونيوم (بنسب ١ : ١ ، ٢ : ١ و ١ : ٢ على الترتيب) ومقارنتها بالمصائد المحتوية على أي من الطعوم البروتينية أو مركبات الأمونيوم بمفردها. أظهرت النتائج عدم وجود فروق معنوية في عدد الحشرات المنجذبة عند استخدام خليط البومينال مع الأمونيوم أسيتات مقارنة باستخدام البومينال بمفرده، في حين أن خلط البومينال مع مركب الداي أمونيوم فوسفات بأي نسبة أدي الى زيادة معنوية في عدد الحشرات المنجذبة عنها في حالة استخدام مركب البومينال بمفرده. بالنسبة للأجرينال فإن خلطه بمركب الأمونيوم أسيتات (بنسبة ١ :١) أو مع مركب الداي أمونيوم فوسفات (بكل النسب) أدي لزيادة عدد الحشرات المنجذبة زيادة معنوية عن عدد الحشرات المنجذبة عند استخدام مركب الأجرينال بمفرده. عند خلط مركب الأمادين مع مركب الداي أمونيوم فوسفات (بكل النسب) أو مع الأمونيوم أسيتات (بنسبة ١:١) كان عدد الحشرات المنجذبة أكبر معنوياً من عدد الحشرات المنجذبة عند استخدام الأمادين بمفرده. ومن ناحية أخرى فإن كل المعاملات المستخدمة أدت لجذب عدد أناث أكبر من عدد الذكور. عامة يمكن القول أنه يمكن تحسين قدرة كلاً من الأجرينال أو الأمادين على جذب الحشرات عن طريق خلطها مع مركب الداي أمونيوم فوسفات أو الأمونيوم أسيتات بنسبة ١:١ مما يؤدي لزيادة قدرة المواد على جذب ذبابة الخوخ "خاصة الإناث" زيادة معنوية، في حين أنه يمكن تحسين قدرة البومينال على جذب الحشرات عن طريق خلطه مع الداي أمونيوم فوسفات بنفس النسبة.