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Effectiveness Buminal-Ammonia Mixtures on Attraction of the Mediterranean Fruit Fly, *Ceratitis capitata* with Particular Emphasis on their Hidrogenionic Potential (pH)

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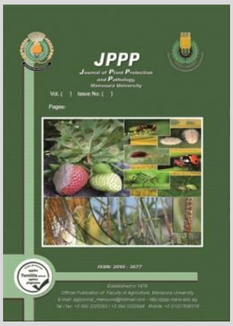

ABSTRACT

Food bait which is rich in nitrogen has an intensive impact on physiology and behavior of fruit flies. Addition of ammonia to food baits can improve their effectiveness and the pH-level of these baits plays an important role in attracting fruit flies, since the effectiveness of bait is diminished by decreasing the pH-level. Therefore, the current study examined the effectiveness of several mixtures of the protein-based bait, Buminal, and ammonia compounds (ammonium acetate, ammonium chloride, di-ammonium phosphate and phosphoric acid) in attracting the Mediterranean fruit fly, *Ceratitis capitata*. Traps provided with each of these different mixtures were hanged in two fruit orchards (Novel orang and Mandarin) and examined in three-day intervals for 12 day period. In each inspection time, fifty milliliters of each mixture in the field were taken to estimate the pH-level. Regardless, the concentration of ammonia compounds, addition of di-ammonium phosphate to Buminal attracted more fruit flies than other mixtures. Further, all the tested mixtures attracted more females than males in both orchards. Although, the highest captures of *C. capitata* were by mixture of Buminal 5%+di-ammonium phosphate 1%, it did not coincide with changing in pH levels of this mixture. Only, the changes in pH-level of Buminal 5%+di-ammonium phosphate 2% led to significant increase in the number of trapped flies. This study might suggest that increasing the pH-level of food lure above 7.6 might adversely decline the number of trapped flies. Buminal+di-ammonium phosphate mixture can be generalized in IPM programs for *C. capitata* in Egyptian fruit farms.

Keywords: IPM programs, protein-based baits, tephritids, traps

INTRODUCTION

The tephritid fruit fly, *Ceratitis capitata* (Wiedemann) is originated from Afrotropical parts but now it has been acclimatized to climatic of the Mediterranean basin (Franco *et al*., 2006). This insect is one of the harmful insects that infesting nuts, fruits and vegetables, with ability to attack over 400 species around the world (Liquido *et al*., 1991; White and Elson-Harris, 1992; Papadopoulos, 2014; Harbi, 2017). The host diversities in Egyptian farms and its continuous presence throughout the year is the most important reason for this insect to build up continuously its generations (Hashem *et al*., 2001; Ghanim and Moustafa, 2009; Ghanim, 2012; Moustafa *et al*., 2014; Ghanim, 2016 and 2017). Females of fruit flies lay eggs inside the fruits and their maggots devour into the fruit heart. Accordingly, the bacterial and fungal diseases could pass through the injury holes to make the secondary infestation. This infestation leads to fruit drop down and making it unsuitable for local and international markets (White and Elson-Harris, 1992; Borge and Basedow, 1997). Thus, this pest is a main reason to decrease both quality and quantity of fruits (Hassanein *et al*., 1995).

Tephritid fruit flies use chemical attractants in form of nutrients (Joachim-Bravo *et al*., 2001) or sex stimuli (Bayoumy *et al*., 2020). Nitrogen rich food sources have a vigorous impact on the behavior and physiology of fruit flies (Kaspi *et al*., 2000; Yuval *et al*., 2007; Hemeida *et al*., 2017; El-Metwally, 2018). Therefore, protein-based bait affects behaviorally and its efficiency depends on the fact that immature females require a meal rich in protein to be sexual mature and to develop the eggs in their ovarioles as well (Epsky *et al*., 2014 and Pinero *et al*., 2015).

Protein bait uses are more preferred because of less pesticide usage, harmful to natural enemies, and risk of spray drift, making it more suitable for using in Integrated Pest Management (IPM) programs. Further, traps are one principle of eight principles in IPM projects for monitoring of insect populations (Barzman *et al*., 2015). Therefore, optimizing the effectiveness of trap attractants to maximize pest detection is an important strategy in tephritid flies control projects (Lance, 2014). According to several authors (Abd El-Kareim *et al*., 2008; Moustafa and Ghanim, 2008; Ghanim *et al*., 2014; Bayoumy and El-Metwally, 2017), ammonia is linked to protein-rich foods which has long been recognized as food attracts. Yee and Landolt (2004) mentioned that, as the concentration of ammonia in lures increased, a significant increase in their attraction can be obtained as well. Similarity, Hemeida *et al*. (2017) and El-Metwally (2018) found that addition of ammonia can be highly improved protein-based baits.

The pH-level of the baits consider an important element to attract fruit flies, since their effectiveness in female attraction is declined as the pH-level diminished (Heath *et al*., 1994; Rousse *et al*., 2005; El-Gendy, 2012 and 2013; Paiva and Parra, 2013; Hemeida *et al*., 2017; and El-Metwally, 2018). The females of fruit fly are more attracted to baits with increasing their level of pH than males and determination of pH-level in the preferred bait formulations can be used to identify a new attractant (Hemeida *et al*., 2017; El-Metwally, 2018).

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Therefore, this study aims to examine the efficiency of different mixtures of Buminal-ammonia food lures on attraction of *C. capitata* with particular emphasis on determining the threshold of pH-level in lures that optimizing the trap captures.

MATERIALS AND METHODS

Compounds and mixtures

The commercial product of Buminal (hydrolyzed protein 39.78%) was brought from NABA GmbH company, Germany, and four compounds of ammonia: ammonium acetate (Am.Ac), ammonium Chloride (Am.Cl), di-ammonium phosphate (DAP) and Phosphoric Acid (PH.A) were brought from El-Gomhoria for Drugs and Chemicals Company. Buminal is used at one concentration of 5.0 % (vol/vol). Mixtures were prepared by adding each compound of ammonia to Buminal with three concentrations of 1.0, 2.0 and 3.0% used. Am.AC, Am.Cl and DAP were used in form of solid state; so, they were added as wt/vol, while PH.A was used in form of liquid state (wt/vol). Control treatment only consisted from Buminal 5.0% without addition of ammonia.

Field trials

Field trials were carried out in two citrus orchards: navel orange, *Citrus sinensis* L. and mandarin, *Citrus reticulata* Blanco. Both are belonging to Mansoura University farm, Egypt. The used fields were about 3.24 hectares (= eight feddans) for each orchard species. Trials were conducted during the periods from 11th of November 2019 till 25th of November 2019 in navel orange orchard and from 26th November till 10th of December 2019 in mandarin orchard.

The prepared mixtures from Buminal and ammonia compounds were installed in the Nadel traps modified by Hanafy *et al.* (2001). Each bait (treatment) was 250 milliliters and provided in the trap. Each treatment replicated four times. Traps were distributed in each fruit orchard species in a completely randomized design. In a shady place, traps were fixed in the trees at 1.5–2.0 meters above the ground. To eliminate the interference between treatments, the distance was about 40 m between every two traps. Traps examined three days in intervals for 12 days period. The total number of flies (females + males) captured were referred as number of flies/trap/day (FTDs). In each inspection time, the captured flies were removed from traps without refresh of bait mixture solution. Rotation of trap was taken place every examination time to eliminate the bias of flies to the preferred conditions (i.e. light, wind, and sun).

pH- level examination

To estimate pH-levels in the protein-based baits, fifty milliliters of each solution were taken in the field and transferred to laboratory for measuring the pH-level. In each orchard species, solutions were taken from each bait mixture at the time of trap hanging and after 3, 6, 9 and 12 days. The pH-level of these solutions were measured by Jenway 3510 pH meter.

Statistical analysis

One-way ANOVA was used to test whether the data of the experiment was significant or not. In case of significant, means were separated using least significant difference (LSD) at probability level of 0.05. The Person Product Moment correlation and regression analyses were also done. All analyses were conducted using CoHort Software (2004) and SigmaPlot software 12.

RESULTS AND DISCUSSION

Results

Data represented in Table (1) show the biggest number of females and males of *C. capitata* captured after three days (total FTD= 55.75 and 26.25) when pH-levels were 7.55 (Buminal 5%+DAP 1%) and 7.77 (Buminal 5%+DAP 3%) in navel orange. After six days, the biggest number of adults tapped (FTD= 71.25 and 59.75) was coincided with pH of 7.14 and 7.70 (Buminal 5%+DAP 1% and Buminal 5%+ Am.Ac 1%), respectively. After nine days, the biggest number of adults trapped (FTD= 54.5 and 49.25) was coincided with pH of 6.81 and 7.64 (Buminal 5%+ Am.Cl 2% and Buminal 5%+DAP 3%), respectively. While, the biggest number of *C. capitata* trapped after 12 days (FTD= 60.50) was recorded at pH-levels of 7.72 (Buminal 5% + DAP2%), 7.53 (Buminal 5% + DAP1%) and 7.64 (Buminal 5% + DAP3%). In contrary, the low treatments in capturing *C. capitata* adults were those of Buminal 5% + PH.A 2% and Buminal 5% + PH.A 1% when pH-levels ranged between 2.79 and 3.34.

Table 1. Mean number of *Ceratitis capitata* catches (females, males) in traps baited with different mixtures of Buminal-ammonia in navel orange and its relationship with pH-level at different inspection times.

Treatments	pH at zero time	FTD after three days			pH after three days	FTD after six days			pH after six days	FTD after nine days			pH after nine days	FTD after 12 days			pH after 12 days
		♀	♂	♀+♂		♀	♂	♀+♂		♀	♂	♀+♂		♀	♂	♀+♂	
Control (Buminal 5%)	5.30	1.75 ± 0.85	0.0 ± 0.0	1.75 ± 0.85	6.10	14.25 ± 1.49	0.0 ± 0.0	14.25 ± 1.49	6.4	25.25 ± 2.32	0.0 ± 0.0	25.25 ± 2.32	7.28	41.75 ±2.68	2.25 ± 0.85	44.00 ±3.02	7.46
Buminal 5%+DAP 1%	7.55	51.25± 3.44	4.5 ± 0.64	55.75 ± 4.09	7.14	65.00 ± 4.51	6.25 ± 1.31	71.25 ± 5.02	7.67	35.25 ± 2.43	2.25 ± 0.63	37.50 ±1.93	7.53	49.50± 1.65	3.75 ± 0.75	53.25 ±2.13	7.61
Buminal 5%+DAP 2%	7.12	5.5± 2.36	0.25 ± 0.25	5.75 ± 2.59	7.46	48.25 ± 5.11	6.00 ± 1.47	54.25 ± 6.11	7.68	40.75 ± 1.49	3.50 ± 0.95	44.25 ±1.54	7.72	54.25 ±2.28	6.25 ±0.94	60.50 ±1.89	7.81
Buminal 5%+DAP 3%	7.77	24.5 ± 11.21	1.75 ± 1.03	26.25 ± 10.27	7.34	43.00 ± 2.48	4.50 ± 0.86	47.5 ± 3.06	7.62	46.75 ± 2.13	2.50 ± 0.64	49.25 ±1.65	7.64	42.50 ±2.10	2.50 ±1.04	45.00 ±2.54	7.79
Buminal 5%+ Am.Ac 1%	7.33	11.25 ± 0.75	0.5 ± 0.28	11.75 ± 0.75	7.70	57.25 ± 4.64	2.50 ± 1.04	59.75 ± 4.92	7.26	25.25 ± 4.87	0.50 ± 0.28	25.75 ±4.64	7.15	17.75 ±1.93	1.00 ± 0.41	18.75 ±1.97	6.99
Buminal 5%+ Am.Ac 2%	7.20	12.5 ± 1.04	0.0 ± 0.0	12.50 ± 1.04	6.67	29.75 ± 1.79	0.25 ± 0.25	30.00 ± 1.58	7.25	1.75 ± 0.75	1.00 ± 0.41	2.75 ±0.75	7.18	2.75 ±0.85	0.25 ±0.25	3.00 ±0.71	7.06
Buminal 5%+ Am.Ac 3%	7.17	12.5 ± 1.32	0.25 ± 0.25	12.75 ± 1.37	6.77	14.25 ± 2.01	1.75 ± 1.75	16.00 ± 1.91	6.16	1.75 ± 0.75	0.50 ± 0.28	2.25 ±0.62	7.05	1.75 ±0.47	0.50 ±0.28	2.25 ±0.25	7.20
Buminal 5%+ Am.Cl 1%	7.17	11.75 ± 1.75	0.25 ± 0.25	12.00 ± 1.82	6.82	22.25 ± 0.85	1.00 ± 0.41	23.25 ± 0.85	6.32	14.5 ± 2.63	0.75 ± 0.47	15.25 3.03	6.91	15.5 ±5.23	0.50 ±0.28	16.00 ±5.41	6.39
Buminal 5%+ Am.Cl 2%	7.05	1.75 ± 0.47	0.0 ± 0.0	1.75 ± 047	6.53	13.50 ± 1.55	0.0 ± 0.0	13.5 ± 1.55	6.22	54.00 ± 2.48	0.50 ± 0.28	54.5 ±2.25	6.81	2.00 ±0.81	0.00 ±0.00	2.00 ±0.81	6.52
Buminal 5%+ Am.Cl 3%	6.86	13.5 ± 1.25	0.0 ± 0.0	13.50 ± 1.25	6.55	13.25 ± 1.84	1.00 ± 0.41	14.25 ± 1.65	7.02	3.25 ± 1.31	0.25 ± 0.25	3.50 ±1.55	6.10	4.50 ±1.32	0.25 ±0.25	4.75 ±1.37	6.54
Buminal 5%+ PH.A 1%	2.67	1.75 ± 0.47	0.0 ± 0.0	1.75 ± 0.47	3.04	1.75 ± 0.47	0.25 ± 0.25	2.00 ± 0.41	3.47	1.00 ± 0.41	0.00 ± 0.0	1.00 ±0.41	3.34	0.50 ±0.28	0.25 ±0.25	0.75 ±0.47	3.33
Buminal 5%+ PH.A 2%	1.96	2.0 ± 0.57	0.0 ± 0.0	2.00 ± 0.57	2.30	3.25 ± 0.47	1.00 ± 0.41	4.25 ± 4.25	2.84	2.00 ± 0.41	0.50 ± 0.28	2.50 ±0.64	2.79	0.25 ±0.25	0.00 ±0.00	0.25 ±0.25	2.72
Buminal 5%+ PH.A 3%	1.70	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	2.04	2.50 ± 0.64	0.0 ± 0.0	2.50 ± 0.64	2.56	1.00 ± 0.41	0.50 ± 0.28	1.50 ±0.50	2.46	0.75 ±0.75	0.25 ±0.25	1.00 ± 0.1	2.40
LSD at 5%	-----	9.81	1.05	9.35	----	7.57	2.08	8.36	-----	6.03	1.28	5.91	-----	5.87	1.55	6.22	-----

In mandarin orchards, the treatment of Buminal 5% + DAP 1% highly attracted *C. capitata* adults after three (FTD= 57.25) and six days (FTD= 73.50) since pH-levels were 7.75 and 7.16, respectively. After nine days, Buminal 5% + Am.Cl 2% attracted the biggest numbers of *C. capitata* since FTD was 55.75 adults and pH-level was 6.24. In respect to Buminal 5% + DAP 2%, it was the highest treatment in attracting *C. capitata* adults after 12 days (FTD= 61.50) with pH- level of 7.76. In mandarin orchards, Buminal 5% + PH.A 2% and Buminal 5% + PH.A 3% were the low treatments in capturing *C. capitata* adults; since pH-levels ranged between 2.75 and 2.48. As shown in Figure (1) and Tables (1 and 2), the highest treatments in attracting adults of *C. capitata* in navel orange and mandarin orchards were those of Buminal 5% + DAP 1% (pH-levels ranged between 7.14 and 7.16); since, the general mean of flies trapped (females + males) was 71.25 and 73.50, respectively. All the treatments checked attracted females more than males in both orchards (Tables 1 and 2) and (Figs. 1 and 2).

The relationship between number of attracted flies of *C. capitata* in traps baited with different Buminal-amonia compounds and their pH-levels of both navel orange and mandarin orchards at different inspection times is presented in Table (3). The Person Product Moment correlation values revealed that all protein-based baits exhibited non-significant values except the treatment of Buminal 5%+ di-ammonium phosphate (DAP) 2% which imply that as the pH-level of Buminal 5%+ (DAP) 2% increased, the number of trapped flies significantly increased.

The coefficient of determination that show the linear relationship between the number of adult catches expressed as FTDs and pH-values of different Buminal-Ammonia mixture at different inspection times in navel orange fruiting season at Mansoura district were weak (R^2 was 0.36 in both fruit orchards (Figs. 2 and 3).

Table 2. Mean number of *Ceratitis capitata* catches (females, males) in traps baited with different mixtures of Buminal-ammonia in mandarin and its relationship with pH-level at different inspection times.

Treatments	pH at zero time	FTD after three days			pH after three days	FTD after six days			pH after six days	FTD after nine days			pH after nine days	FTD after 12 days			pH after 12 days
		♀	♂	♂+♀		♀	♂	♂+♀		♀	♂	♂+♀		♀	♂	♂+♀	
Control (Buminal 5%)	5.35	2.5± 0.64	1.00 ±0.0	3.5± 0.64	6.13	15.25± 1.37	0.50± 0.28	15.75± 1.43	6.6	26.50± 2.5	0.00± 0.00	26.50± 2.5	7.27	41.75± 1.88	2.25± 0.85	44.00± 2.27	7.48
Buminal 5%+DAP 1%	7.75	53.0± 4.81	4.25± 0.47	57.25± 5.17	7.16	67.25± 4.33	6.25± 1.60	73.50± 4.87	7.68	36.50+ 3.09	2.25± 2.51	38.75± 2.56	7.55	50.75± 1.03	3.75± 0.75	54.50± 1.19	7.63
Buminal 5%+DAP 2%	7.15	6.0± 1.91	0.75± 0.25	6.75± 1.88	7.44	49.50± 4.91	7.00± 1.77	56.50± 6.08	7.67	41.00± 0.81	3.50± 3.83	44.50± 0.95	7.76	55.25 ±3.27	6.25± 0.94	61.50± 2.72	7.82
Buminal 5%+DAP 3%	7.79	26.25± 11.65	0.75± 0.25	29.00± 10.96	7.31	44.75± 2.56	5.00± 0.82	49.75± 3.14	7.65	47.75± 2.49	2.50± 2.58	50.25± 1.97	7.65	44.00± 2.12	2.50± 1.04	46.50± 2.50	7.80
Buminal 5%+ Am.Ac 1%	7.35	11.5± 0.28	0.75± 0.25	12.25± 0.25	7.74	58.00± 4.26	3.25± 0.85	61.25± 4.38	7.29	26.00± 4.88	0.50± 1.15	26.50± 4.66	7.17	19.5± 1.93	1.00± 0.41	20.50± 2.11	7.00
Buminal 5%+ Am.Ac 2%	7.24	13.5± 1.04	0.50± 0.28	14.00± 1.22	6.66	31.25± 1.65	1.00± 0.41	32.25± 1.65	7.26	2.25± 0.47	1.00± 1.63	3.25± 0.47	7.21	3.25± 0.62	0.25± 0.25	3.50± 0.50	7.09
Buminal 5%+ Am.Ac 3%	7.15	13.0± 1.08	0.75± 0.25	13.75± 1.18	6.78	15.50± 2.39	2.25± 0.47	17.75± 2.21	6.16	2.25± 0.63	0.50± 1.15	2.75± 0.75	7.09	2.25± 0.25	0.50± 0.28	2.75± 025	7.22
Buminal 5%+ Am.Cl 1%	7.16	12.0± 1.47	0.75± 0.25	12.75± 1.54	6.81	23.25± 0.75	1.50± 0.64	24.75± 1.11	6.35	15.00± 2.83	0.75± 1.91	15.75± 3.19	6.93	19.25± 3.01	0.50± 0.28	19.75± 0.25	6.42
Buminal 5%+ Am.Cl 2%	7.09	2.5± 0.28	0.50± 0.28	3.00± 0.41	6.55	14.50± 1.75	0.50± 0.28	15.00± 1.47	6.24	55.25± 2.72	0.50± 1.15	55.75± 2.78	6.82	3.00± 0.41	0.00± 0.00	3.00± 0.41	6.55
Buminal 5%+ Am.Cl 3%	6.89	14.5± 1.32	0.50± 0.28	15.00± 1.29	6.57	14.50± 2.11	1.25± 0.48	15.75± 1.65	7.05	3.75± 1.43	0.25± 1.00	4.00± 1.68	6.14	5.25± 1.31	0.25± 0.25	5.50± 1.32	6.57
Buminal 5%+ PH.A 1%	2.68	2.5± 0.28	0.50± 0.28	3.00± 0.41	3.06	2.50± 0.28	0.75± 0.48	3.25± 0.25	3.45	1.50± 0.28	0.00± 0.00	1.50± 0.28	3.36	1.50± 0.64	0.25± 0.25	1.75± 0.75	3.34
Buminal 5%+ PH.A 2%	1.99	2.5± 0.28	0.50± 0.28	3.00± 0.41	2.34	3.75± 0.47	1.50± 0.28	5.25± 0.47	2.86	2.50± 0.50	0.50± 1.15	3.00± 0.71	2.75	1.50± 0.64	0.00± 0.00	1.50± 0.64	2.73
Buminal 5%+ PH.A 3%	1.73	1.25± 0.25	0.50± 0.28	1.75± 0.25	2.07	3.00± 0.57	0.50± 0.28	3.50± 0.64	2.58	1.50± 0.64	0.50± 1.15	2.00± 0.71	2.48	1.25± 0.75	0.25± 0.25	1.50± 0.95	2.41
LSD at 5%	-----	10.33	0.98	9.98	----	7.38	2.34	8.18	-----	6.42	1.28	6.24	-----	4.78	1.55	4.94	-----

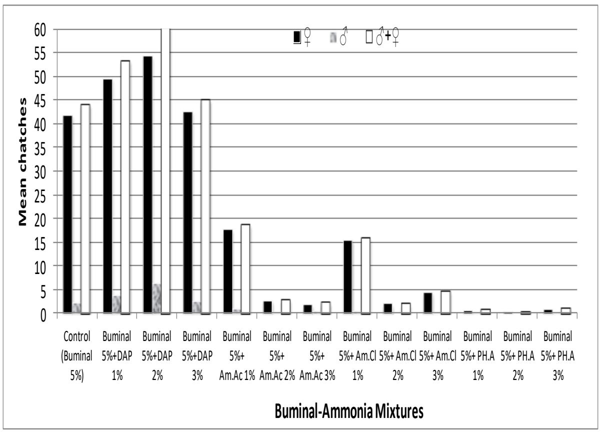

Fig. 1. Mean catches of *Ceratitis capitata* adults (females + males) in traps baited with various mixtures of Buminal-ammonia for a period of 12 days in navel orange at Mansoura district, Egypt.

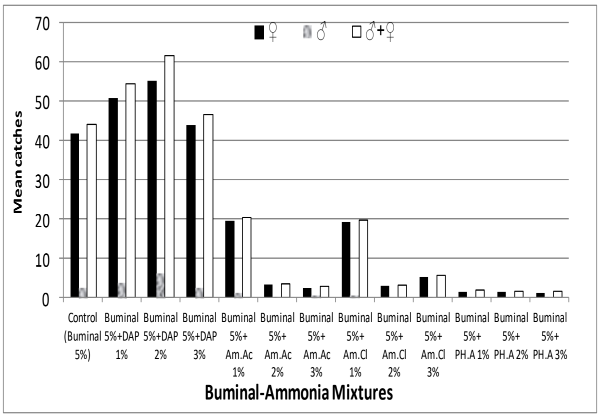

Fig. 2. Mean catches of *Ceratitis capitata* adults (females + males) in traps baited with various mixtures of Buminal-ammonia for a period of 12 days in mandarin at Mansoura district, Egypt.

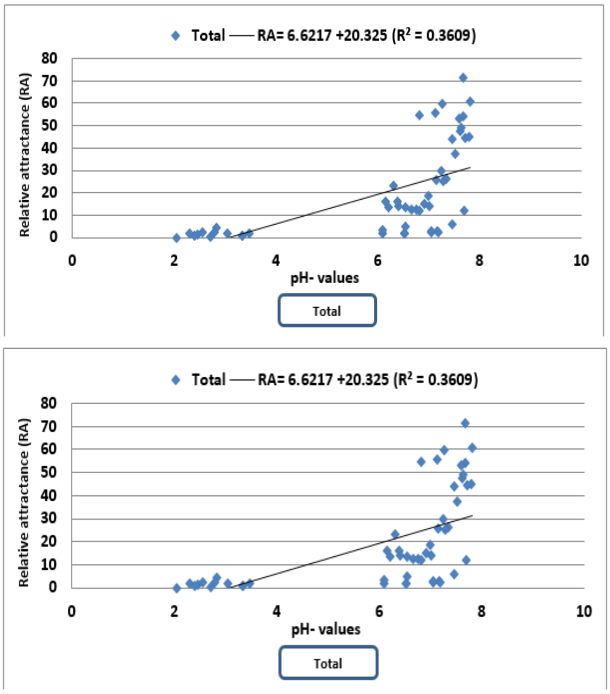

Fig. 3. The linear relationship between the number of adult catches expressed as FTDs and pH-values of different Buminal- Ammonia treatments at different inspection times in navel orange fruiting season at Mansoura district.

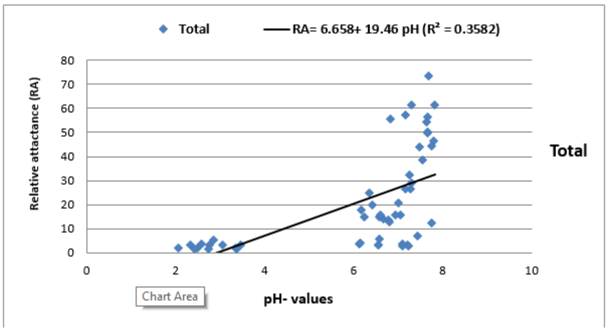

Fig. 4. The linear relationship between the number of adult catches expressed as FTDs and pH-values of different Buminal- Ammonia treatments at different inspection times in mandarin fruiting season at Mansoura district.

Table 3. The correlation coefficient values (r) and their probability levels (P) between numbers of attracted *Ceratitis capitata* flies in traps baited with different Buminal-amonia mixtures and their pH-levels at different times of inspection in two fruit orchards.

Buminal-ammonia mixtures	Correlation coefficient			
	Navel orange		Mandarin	
	r	*p*	*r*	*p*
Control (Buminal 5%)	0.937	ns	0.908	ns
Buminal 5%+DAP 1%	0.176	ns	0.18	ns
Buminal 5%+DAP 2%	0.95	*	0.91	*
Buminal 5%+DAP 3%	0.85	ns	0.871	ns
Buminal 5%+ Am.Ac 1%	-0.23	ns	-0.24	ns
Buminal 5%+ Am.Ac 2%	0.21	ns	0.15	ns
Buminal 5%+ Am.Ac 3%	-0.92	ns	-0.93	ns
Buminal 5%+ Am.Cl 1%	-0.75	ns	-0.87	ns
Buminal 5%+ Am.Cl 2%	0.65	ns	0.63	ns
Buminal 5%+ Am.Cl 3%	0.78	ns	0.63	ns
Buminal 5%+ PH.A 1%	-0.08	ns	-0.23	ns
Buminal 5%+ PH.A 2%	0.29	ns	0.32	ns
Buminal 5%+ PH.A 3%	0.64	ns	0.60	ns

Discussion

The current results revealed that mixing ammonium acetate, ammonium Chloride or di-ammonium phosphate with Buminal led to increase its pH-level which increase the ability of Buminal in attracting more *C. capitata* females and males. These results agree with those of El-Metwally (2018) and Ghanim (2018 and 2019); who found that addition of each of ammonium carbonate, ammonium acetate and di-ammonium phosphate to GF-120 (the insecticidal protein-based bait) raise its pH-level which translated in more attraction to *C. capitata* and *Bactrocera* zonata (Saunders). In this study, addition of di-ammonium phosphate to Buminal protein baits potentially increased the bait's efficiency in attracting *C. capitata*. In addition, this study showed that mixture of Buminal 5%+1% di-ammonium phosphate, since its pH-level ranged between 6.14 and 7.63 attracted more *C. capitata* flies than other mixtures in both orchards. These results are inconsistent with those of Pinero *et al.* (2015) who found that mixing ammonium acetate with protein baits significantly increased the attraction of bait for *C. capitata*. In other reports, Pelz *et al.* (2005) and Pelz-Stelinski *et al.* (2006) found that fruit flies spent more time around the mixed GF-120 bait by ammonium acetate. Similarity, the current findings are inconsistent with those of El-Metwally (2018) and Ghanim (2018 and 2019) who reported that mixing GF-120 bait with ammonium acetate elevated the ability of traps to capture more *C. capitata* and *B. zonata* flies. However, our results consistent with those of Hemeida *et al.* (2017) who mentioned that di-ammonium phosphate was more benefit than ammonium acetate in optimizing Buminal, Agrinal and Amadene baits in attracting adults of *B. zonata*. The differences between the current and previous results may be due to the different host plants, climatic conditions, and/or the concentration of the tested compounds. The ability of Buminal to attract *C. capitata* depends basically on its concentrations and pH-levels that derived from other compounds. Similarity, El-Gendy (2012), El-Metwally (2018) and Ghanim (2018 and 2019) reported that baits enhanced their ability in attracting *C. capitata* and *B. zonata* by adding ammonium compounds which resulted in heighten their pH-level. Ghanim (2018) found that GF-120 baits that manipulated by ammonium compounds influenced more by pH-level than concentrations. In addition, adding borax makes the solution of food attractants and ammonia compounds more alkaline with increasing the released ammonia from the solution, resulting in increasing the effectiveness of complex in attracting *C. capitata* and *B. zonata* flies (El-Gendy, 2013; Raga and Vieira, 2015). Further, Mazor *et al.* (1987), Epsky *et al.* (1993) and Heath *et al.* (1994) found that increasing the pH of the liquid baits, Buminal, Naziman and Nulure elevated their effectiveness in attracting *C. capitata* and *Anastrepha suspensa* (Loew).

The current study concluded that *C. capitata* preferred baits which had pH-levels ranged between 5.5 and 8.5 and the highest attractive treatments were occurred between 7.14 and 7.6 pH. However, increasing the pH-level of food lure above 7.6 might adversely decline the number of trapped flies. This could be due to higher release of ammonium at higher level of pH of protein bait. These results are partially in the same trend of Paiva and Parra (2013), El-Metwally (2018) and Ghanim (2018); they found the biggest captures of *C. capitata* and *B. zonata* appeared with baits adjusted to a pH ranged between 7.00 to 8.5. Although, the highest captures of *C. capitata* were by mixture of Buminal 5% + di-ammonium phosphate 1%, correlation analysis revealed that there was non-significant correlation between captures and pH levels of this mixture at different times of inspections. In contrast, as the pH level of Buminal 5% + di-ammonium phosphate 2%, the number of trapped flies significantly increased. El-Metwally (2018) and Ghanim (2018) found that when pH-levels in baits were below 5.5 or above 8.5, few numbers of *C. capitata* flies trapped. Our study revealed that increasing the pH level above 7.6 might adversely decline the number of trapped flies. This could be explained why the mixture of Buminal 5% + di-ammonium phosphate 1% attracted more numbers of flies than mixture of Buminal 5% + di-ammonium phosphate 1%, however the correlation with increasing pH levels lost in the former mixture compared to the latter one in which the pH level did not exceed 7.64. These results could be supported by IAEA (2003) who found that few numbers of fruit flies are attracted to the bait mixture when its pH became more acidic.

In this study females of *C. capitata* responded more to the increase in pH and concentrations of bait mixtures than males. Similar findings were obtained by El-Metwally (2018) and Ghanim (2018), for GF-120 bait mixtures. In addition, Buminal bait that mixed by ammonia compounds attracted females more than males of *C. capitata*. These results are consistent with those obtained by Yee (2007), Hemeida *et al.* (2017), El-Metwally (2018) and Ghanim (2018); they found that females of *Rhagoletis pomonella* (Walsh), *B. zonata* and *C. capitata* were more responded protein-based baits more than males. Also, Epsky *et al.* (1993), Heath *et al.* (1994), Abd El-Kareim *et al*. (2008), Moustafa and Ghanim (2008), El-Metwally (2012), El-Gendy (2012 and 2013) and Ghanim *et al*. (2014) reported the same finding.

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فاعلية مخاليط البومينال-الامونيا علي جذب ذبابة فاكهة البحر الأبيض المتوسط مع التأكيد علي مستوي الحموضة pH

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مصادر الغذاء الغنية بالنيتروجين يكون لها تأثير عالي علي فسيولوجي وسلوك ذباب الفاكهة، حيث أن الطعوم المبنية علي البروتين يمكن أن تتحسن عن طريق إضافة الأمونيا، وأن مستوي الحموضة pH لهذه الطعوم يلعب دور جوهري في جذب ذباب الفاكهة، حيث أن فاعلية هذه الطعوم تقل بانخفاض مستوي ال pH. ولهذا فإن الدراسة الحالية فحصت فاعلية عديد من المخاليط لكل من الطعم الغذائي المكون من مخلوط من البومينال ومركبات الأمونيا (أمونيا اسيتات، وامونيوم كلوريد، أمونيوم فوسفات و حمض الفوسفوريك) في جذب ذبابة فاكهة البحر الأبيض المتوسط. المصائد زودت بكل من هذه المخاليط علي حده، ثم تم تعليقها في مزرعتين للفاكهة (مزرعة برتقال ابو سره ومزرعة يوسيفي) وتم فحص هذه المصائد كل 3 أيام لمدة 12 يوم، حيث كان يتم أخذ 50 مل لتر من كل مخلوط في الحقل عند كل فحص ونقلها إلي المعمل من أجل تقدير مستوي ال pH. بصرف النظر عن تركيز مركبات الامونيا المستخدمة، فإن إضافة مركب الداي امونيوم فوسفات لمركب البومينال جذب أعداد كبيرة من ذباب الفاكهة بالمقارنة بمركبات الأمونيا الأخري، علاوة علي ذلك فإن كل المخاليط المستخدمة جذبت عدد أكبر من إناث ذبابة الفاكهة بالمقارنة بالذكور في كلا المزرعتين. بالرغم من أكبر عدد من ذباب الفاكهة تم اصطياده بواسطة المخلوط المكون من البيومينال 5% + داي أمونيوم فوسفات 1% إلا أن هذه اصطيادات المصيدة لم تكن ترتبط بشكل معنوي بتغير مستوي ال pH في هذا المخلوط، في حين أن التغيرات في مستوي ال pH للمخلوط البيومينال 5% + داي امونيوم فوسفات 2% أدت إلي زيادة معنوية في عدد الذباب المصطاد. هذه الدراسة ربما تقترح أن زيادة ال pH فوق مستوي الـ 7.6 ربما يخفض بصورة عكسية عدد الذباب الممسوك بالمصيدة، وعليه فإن المخلوط المتكون من البيومينال +داي أمونيوم فوسفات من الممكن تعميمه في برامج المكافحة المتكاملة لذبابة فاكهة البحر الابيض المتوسط في مزارع الفاكهة المصرية.