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Comparative Efficiency of Phenol Compounds on Certain Biological Aspects of Two Species of Fruit Flies

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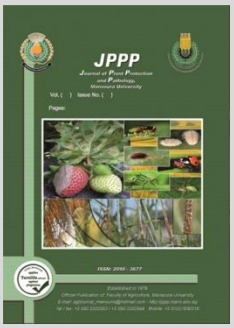

ABSTRACT

The present work was conducted to evaluate the comparative efficiency of certain phenol compounds (Salicylic acid, Benzoic acid, Acetylsalicylic acid and Sodium benzoate) on certain biological aspects of the Mediterranean fruit fly (MFF), *Ceratitis capitata* and the peach fruit fly (PFF) *Bactrocera zonata* under laboratory conditions. Salicylic acid and acetylsalicylic acid showed the same record on larval duration of MFF (10.5 days) and lowest record of % pupation of 70.5 and 75.8%, respectively. Also, control recorded the lowest pupal duration 8.1 days and highest average of fecundity (27.9 eggs/female), daily rate of oviposition (11.5 eggs/female/day), the total of deposited eggs of 1628.3, % hatchability 96.7% and longevity of males 27.5 days, whereas sodium benzoate showed the highest average of oviposition period (31.1 days) and high female longevity 35.7 days for MFF. Larval duration of PFF significantly showed the shortest period of 7.6 days and highest % pupation 100% with larval diet treated with sodium benzoate. Control showed the shortest pupal duration 7.8 days and highest average of fecundity (22.8 eggs/female), daily rate of oviposition (8.6 eggs/female/day), the total of deposited eggs of 1454.7, % hatchability of 92.3% and longevity of males (45.1 days). But, sodium benzoate showed the highest period of oviposition 38.8 days and females longevity 54.5 days.

Keyworeds: Mediterranean fruit fly, *Ceratitis capitata*, peach fruit fly, *Bactrocera zonata*

INTRODUCTION

Mediterranean fruit fly (MFF), *Ceratitis capitata* and the peach fruit fly (PFF) *Bactrocera zonata* is an important quarantine pest around the world. Both flies have sources of food all year round due to mixed orchards in the same area causing serious economic losses (White and Elson-Harris, 1992 and Saafan *et al*., 2005). The annual costs of damage they caused in the Near East are estimated to 320 million EUR (EPPO and CABI, 2005). Although the control measures are implemented in all parts of the world through male extermination and integrated pest management, they have minimal impact on the population. Hence, new strategies are needed to control these harmful pests. Phenolic compounds had toxic action on larval development of certain insects (Movva and Pathipati, 2017). Also, Verghese *et al*. (2012) stated that phenolics play a defensive role in preventing *Bactrocera dorsalis* herbivory in mango. Damodaram *et al*. (2015) indicated that salicylic acid was responsible for induced tolerance in mango fruits which reduces larval growth, subsequent adult emergence and egg laying of females of *B. dorsal*. Phenolic compounds stimulate plants to enhance anti-insect activity, antifungal and acaricidal activities (Bokshi *et al*., 2003; Shaat and Galal 2004 and Tak *et al*., 2006). Exogenous application of phenolic compounds may have a significant practical application in agriculture, horticulture (Senaratna *et al*., 2000).

The present work was conducted to test the comparative effect of certain phenol compounds on MFF and PFF larva development under laboratory conditions.

MATERIALS AND METHIODS

The Med-fruit fly, *C. capitata* and peach-fruit fly, *B. zonata* used for experiments was obtained from laboratory cultures at (25 ± 3ºC and 65 ± 5%R.H)., continuously reared in Horticulture Insect Research Department, Plant Protection Research Institute (PPRI), Agriculture Research Center (ARC) Awadallah and EL-Hakim (1987).

Four phenol compounds were used as treatments (Salicylic acid - Acetylsalicylic acid - Benzoic acid - Sodium benzoate) which added to artificial diets, at concentrations of 4 %, each treatment had three replications. About 3000 one-day old eggs (nearly 0.3 ml) were put on each replicate weighed 100 g of larval artificial diet for both species. Egg hatch (%) and mean larval duration were determined. Also, the pupation percentage, mean pupal weight (mg), pupal duration, % emergence and sex ratio as % of emerged male were recorded. Ten pairs of newly emerged adults of each species (10 males and 10 females) were selected from each treatment, replicated 3 times were transferred in small cages and fed on sugar solution (5%) and left for depositing eggs. The biological aspects of adults such as fecundity (mean no. of eggs/ female) and longevity of both males and females were estimated for both species. All the values were represented as mean ± SE (SD). Statistical analyses of the obtained

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results were conducted using SAS (2004) computer program. Statistical analyses included using ANOVA and regression models. Mean separation was conducted using LSD in the same program.

RESULTS AND DISCUSSION

Results

The Mediterranean fruit fly *C. capitata* (MFF)

The larval artificial diet treated with different phenol compounds for immature stages of *C. capitata* (Table, 1) high significantly recorded the shortest period of 10.1 days for control, whereas the longest period of 11.2 days was investigated with diet treated with benzoic acid. Artificial diet treated with salicylic acid recorded the lowest pupation (%) of 70.5%. Also, the pupal duration of MFF high significantly recorded the shortest period of 8.1 days for control but the longest period 11.8 days was shown with diet treated with benzoic acid. The other tested characteristics (weight of pupa, % emerged flies and sex ratio) insignificantly affected.

Table 1. Effect of different phenol compounds on immature stages of the Mediterranean fruit fly *C. capitata* (MFF) under laboratory conditions. (Means ± SD)

Different compounds	% hatching eggs	Larval duration (days)	Pupation (%)	Weight of pupa (mg)	Pupal duration (days)	% emerged flies	Sex ratio as % emerged male
Salicylic acid	29.3±1.2	10.5±0.1 C	70.5±3.4 B	0.0052±0.001	11.6±0.1 A	97±5.2	53.3±12.6
Acetylsalicylic acid	29±1	10.5±0.1 C	75.8±4 B	0.0077±0.002	10.7±0.3 B	94.2±5	50.1±6.4
Benzoic acid	25.3±4.2	11.2±0.1 A	90.7±12.4 A	0.0057±0.0004	11.8±0.1 A	100±0	51.8±8.8
Sodium benzoate	27.3±2.1	10.9±0.1 B	96.5±3.6 A	0.0089±0.002	9.4±0.2 C	100±0	52.1±7
Control	28±1	10.1±0.1 D	96.4±3.6 A	0.0076±0.001	8.1±0.2 D	98.9±2	50.2±6.3
F value	1.52 n.s.	58.86	10.62	3.17 n.s.	217.78	1.60 n.s.	0.08 n.s.
LSD at 0.05	-	0.1837	11.69	-	0.3370	-	-
Pr > F	0.2689	<.0001	0.0013	0.0630	<.0001	0.2487	0.9873

Means in the same row followed by the same letter are insignificantly differed (P > 0.05).

As shown in Table (2), the larval artificial diet of MFF treated with sodium benzoate high significantly showed the highest average of oviposition period (31.1 days). But, control high significantly showed the highest average of fecundity (27.9 eggs/female), daily rate of oviposition (11.5 eggs/female/day), the total of deposited eggs of 1628.3, % hatchability 96.7% and longevity of males 27.5 days. Whereas, sodium benzoate showed high significant affect on longevity of females 35.7 days. The post-oviposition period insignificantly affected.

Table 2. Effect of different phenol compounds on mature stages of the Mediterranean fruit fly *C. capitat*a (MFF) under laboratory conditions. (Means ± SD)

Different compounds	Pre-oviposition period (days)	Oviposition period (days)	Post-oviposition period (days)	Fecundity eggs /female	Daily rate of oviposition eggs/female/ day	Total of deposited eggs	% Hatchability	Longevity (days)	
								Male	Female
Salicylic acid	3	16±2.4 C	1.4±1.1	3.9±0.9 D	2.5±0.6 D	252±20 D	74.7±2.5 D	13±1.2 C	20.4±1.8 C
Acetylsalicylic acid	3	18.3±4 C	2.5±0.8	9.6±0.7 C	5.4±1 B	631.7±90.2 C	78.7±1.5 C	18.3±3 BC	23.6±4.8 BC
Benzoic acid	3	19.3±3.1 C	1±0.5	10.7±0.9 BC	5.6±0.4 B	719±103.9 C	82.7±2.1 B	23±3.9 AB	23.3±2.6 BC
Sodium benzoate	3	31.1±1.8 A	1.6±0.5	11.9±0.1 B	3.8±0.2 C	1076±69.9 B	83.7±2.5 B	19.9±1 B	35.7±1.8 A
Control	3	24.3±0.6 B	0.6±0.3	27.9±0.6 A	11.5±0.5 A	1628.3±30.5 A	96.7±2.1 A	27.5±5.3 A	27.9±0.6 B
F value	-	15.70	3.36 n.s.	500.89	104.34	160.75	43.61	7.93	14.74
LSD at 0.05	-	4.791	-	1.263	1.063	129.1	3.958	6.035	4.884
Pr > F	-	0.0003	0.0573	<.0001	<.0001	<.0001	<.0001	0.0038	0.0003

Means in the same row followed by the same letter are insignificantly differed (P > 0.05).

The peach fruit fly *B. zonata* (PFF)

Data shown in Table (3) reveal that the larval diet of PFF treated with sodium benzoate significantly recorded the lowest averages of larval duration (7.6 days) and highest % pupation (100%). But, the larval artificial diet treated with salicylic acid showed significant effect on pupal duration (10.9 days). The other tested biological aspects statistically showed insignificantly differences.

Table 3. Effect of different phenol compounds on immature stages of the peach fruit fly *B. zonata* (PFF) under laboratory conditions. (Means ± SD)

Different compounds	% hatching eggs	Larval duration (days)	Pupation (%)	Weight of pupa (mg)	Pupal duration (days)	% emerged flies	Sex ratio as % emerged male
Salicylic acid	27.7±2.5	8.6±0.6 B	79.9±7.1 B	0.0070±0.002	10.9±0.1 C	93.9±2.6	47.7±17.9
Acetylsalicylic acid	26.3±3.2	10.9±0.02 A	86.7±9.7 B	0.0062±0.002	11.7±9.7 A	95.2±0.002	51.3±0.1
Benzoic acid	29±1.7	11.3±0.2 A	80.6±4.3 B	0.0072±0.001	11.3±0.3 B	97.1±2.5	48.4±10.4
Sodium benzoate	27.7±2.3	7.6±0.1 C	100±0 A	0.0080±0.003	8.9±0.3 D	88±1.7	48.3±6.1
Control	29±1	8.3±0.1 B	88.6±3.7 B	0.0080±0.0001	7.8±0.1 E	98.7±2.3	51.7±13.1
F value	0.72 n.s.	94.20	5.59	0.62 n.s.	206.57	2.84 n.s.	0.07 n.s.
LSD at 0.05	-	0.5372	10.80	-	0.3703	-	-
Pr > F	0.5987	<.0001	0.0125	0.6610	<.0001	0.0823	0.9899

Means in the same row followed by the same letter are insignificantly differed (P > 0.05).

The biological aspects of mature stages of PFF significantly affected without the post-oviposition period Table (4). Sodium benzoate showed high significant effect on oviposition period (38.8 days) and longevity of females 54.5 days. Whereas, control significantly showed the highest average of fecundity (22.8 eggs/female), daily rate of oviposition (8.6 eggs/female/day), the total of deposited eggs of 1454.7, % hatchability of 92.3% and longevity of males of 45.1 days.

Table 4. Effect of different phenol compounds on mature stages of the peach fruit fly *B. zonata* (PFF) under laboratory conditions. (Means ± SD)

Different compounds	Pre-oviposition period (days)	Oviposition period (days)	Post-oviposition period (days)	Fecundity eggs /female	Daily rate of oviposition eggs/female/day	Total of deposited eggs	% Hatchability	Longevity (days)	
								Male	Female
Salicylic acid	15	30.5±1.1 B	0.5±0.1	9.4±0.3 B	3.1±0.2 B	855±11.3 BC	78.7±2.1 BC	35.7±2.1 B	46±1.1 BC
Acetylsalicylic acid	15	32.3±3.3 B	1.1±0.6	10.7±1.5 B	3.3±0.5 B	883.3±160.5 BC	75.7±2.1 C	40.7±2.2 AB	48.4±3.3 B
Benzoic acid	15	24.9±4.6 C	0.9±0.1	9.8±1.1 B	4.1±1.2 B	740.7±42 C	81.3±1.5 B	37.9±3.9 B	40.8±4.5 C
Sodium benzoate	15	38.8±2.1 A	0.7±0.5	11±0.7 B	2.9±0.3 B	983.7±69.9 B	77.3±4.2 BC	38.9±2.3 B	54.5±1.9 A
Control	15	26.7±2.4 BC	1.3±0.8	22.8±0.8 A	8.6±0.6 A	1454.7±40.5 A	92.3±3.2 A	45.1±3.4 A	43±2.9 BC
F value	-	10.29	1.28 n.s.	103.62	41.66	33.74	17.06	4.56	9.47
LSD at 0.05	-	5.329	-	1.747	1.162	150.4	5.059	5.213	5.434
Pr > F	-	0.0014	0.3412	<.0001	<.0001	<.0001	0.0002	0.0235	0.0020

Means in the same row followed by the same letter are insignificantly differed (P > 0.05).

Discussion

The Mediterranean fruit fly MFF, *Ceratitis capitata* (Wied.) and the peach fruit fly (PFF) *Bactrocera zonata* (Saunders) are considered serious pest species in Egypt due to the multiplicity of their hosts causing quantitative and qualitative losses to several crops. The resulting losses are about $100 million annually (FAO, 2001). The effect of phenol compounds on certain biological aspects of MFF and the peach-fruit fly larva development under laboratory conditions was studied. Previously, different studies concentrated on the effect of phenolic compounds and their derivatives on insects proved that these compounds play a vital role in control insects through several mechanisms including contact toxicity, suppression of oviposition, antifeedant, growth inhibitor and induce both direct and indirect defenses such as induced responses in plants. Benzoic acid showed the longest larval period of 11.2 days for MFF, But. Sodium benzoate showed the shortest period of 7.6 days for PFF. Movva and Pathipati (2017) stated that phenolic compounds such as sinapic acid, chlorogenic acid had toxic natures on larval development of *Spodoptera litura* F. and deterred oviposition when dietary exposure. Also, salicylic acid play an anti-nutritive compounds in plants (Van Poecke and Dicke, 2002; Peng *et al*., 2004 and Conrath *et al*., 2015). Results revealed acetylsalicylic acid was reduced the severity infestation of dry rot in field-grown tubers in some post-harvest wound-inoculated treatments Bokshi *et al*. (2003). Benzoic acid, sulfosalicylic acid and methyl salicylic acid were effective in inducing tolerance to heat, drought and chilling stress (Senaratna *et al*., 2003). Salicylic acid and acetylsalicylic acid showed the lowest % pupation of MFF (70.5 and 75.8%, respectively). Whereas, the same compounds showed 79.9 and 86.7% of pupation for PFF. Tak *et al*. (2006) tested benzoic acid against adults of *Tyrophagus putrescentiae* as acaricidal agents using direct contact toxicity bioassay, the LD_{50} values was 4.80 µg/cm^2. Application of methyl salicylate (1%) on cucumber and bean significantly reduced the percentage of damaged area caused by thrips feeding (Koschier *et al*., 2007). In case of MFF benzoic acid showed the lowest level of deposited eggs 740.7 egg. Also, methyl salicylate inhibited oviposition of *Mamestra brassicae* on cabbage (Ulland *et al*., 2008). Karatolos and Hatcher (2009) recorded increased *Myzus persicae* mortality by direct application of acetylsalicylic acid on sprouts of plants. Mobarak *et al*. (2017) indicated that LC_{50} of acetylsalicylic acid was 210.6 ppm after a week of treatment affecting *Eobania vermiculata*' mucus gland. De Carvalho *et al*. (2019) indicated that salicylic acid at 100 mg/L was responsible for approximately of larvae mortality 39% and 48% of *Aedes* aegypti and *Culex quinquefasciatus*, respectively. Fecundity of PFF recorded 9.4 eggs/female for females that emerged from diet treated with salicylic acid .In fields, methyl salicylate had a significantly greater effect on *Sitobion avenae* population suppression, partly by attracting *Metasyrphus corolla* (Wang *et al*., 2019). In case of MFF salicylic acid showed the shortest oviposition period 16 days, and shortest male and female longevity (13 and 20.4 days). Also, the same compound showed the lowest fecundity (3.9 eggs/female), daily rate of oviposition (2.5 eggs/female/day) and total of deposited eggs of 252 and % hatchability of 74.7%. Treated plants with *Pseudomonas putida* and salicylic acid showed, in the life table study, that pre-adult survival, longevity, reproductive period, and fecundity were lowest for *Brevicoryne brassicae* on cabbage (Khoshfarman-Borji *et al*., 2020).

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مقارنة كفاءة بعض مركبات الفينول على بعض الصفات البيولوجية لنوعين من ذباب الفاكهة

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تم إجراء هذا العمل لتقييم كفاءة بعض مركبات الفينول (حمض السالسيليك وحمض البنزويك وحمض أسيتيل السالسيليك وبنزوات الصوديوم) على بعض الجوانب البيولوجية لذبابة فاكهة البحر المتوسط وذبابة ثمار الخوخ تحت ظروف المختبر. أوضحت النتائج المتحصل عليها من البيئة الغذائية المعامله بحمض السالسيليك وحمض أسيتيل السالسيليك تساوى مدة الطور اليرقى عند 10.5 يوم لذبابة فاكهة البحر المتوسط وكانت النسبة مئوية من العذارى 70.5 و 75.8 % على التوالي. كما سجلت تجربة المقارنة أقل مدة لتطور العذارى 9.4 يوم وأعلى معدل للخصوبة (27.9 بيضة / أنثى) ومعدل وضع البيض اليومي (11.5 بيضة / أنثى / يوم) وإجمالي البيض الكلى 1628.3 بيضة ونسبة فقس 96.7٪ وأطول مدة عمر 27.5 يومًا للذكور ، في حين أظهرت بنزوات الصوديوم أعلى متوسط لفترة وضع البيض (31.1 يومًا) وأطول مدة عمر الإناث 35.7 يومًا بالنسبة لذبابة فاكهة البحر المتوسط. اما ذبابة ثمار الخوخ سجلت بدرجة معنوية أقصر مدة للطور اليرقى 7.6 يوم وأعلى نسبة مئوية من العذارى 100٪ التي تمت معالجة بيئتها الغذائية ببنزوات الصوديوم. في حين أظهرت تجربة المقارنة أقصر مدة لتطور العذارى 7.8 يوم وأعلى معدل للخصوبة (22.8 بيضة / أنثى) و معدل بيض يومي (8.6 بيضة / أنثى / يوم) و إجمالي البيض الكلى 1454.7 و نسبة فقس 92.3٪ وأطول مدة عمر للذكور 45.1 يوم .بينما أظهرت بنزوات الصوديوم أعلى فترة لوضع البيض 38.8 يوم وأطول مدة عمر الإناث 54.5 يوم.