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Using Boric Acid as a Safety Insecticide for Controlling Peach Fruit Fly, *Bactrocera zonata*, Saunders (Diptera: Tephritidae)

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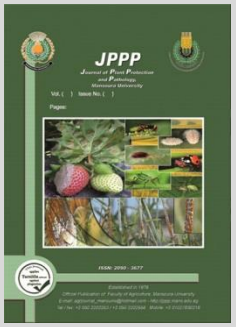

ABSTRACT

The peach fruit fly, *Bactrocera zonata* Saunders (Diptera: Tephritidae) is a very deleterious insect pest for fruits of many horticultural hosts. Boric acid had tested as a safe and friendly-environmental insecticide against the pest as baits for adults. Five formulations of baits (water, sugar solution at 5 and 10 % as well as Buminal solutions at 2.5 and 5 %) were applied at 4 concentrations of boric acid (0.5, 1, 1.5 and 2 %)for the newly emerged, 24 hrs old starved flies and 48 hrs old starved flies. The mortality percentages were recorded after 24 hrs and 48 hrs of application. The mortality percentages significantly ranged between 30- 90.67 for the newly emerged flies after 24 hrs and 34.67- 100 after 48 hrs. Also, the ranges of mortality for 24 hrs starved flies significantly were 42.33- 88.67 % after 24 hrs and 55- 100 % after 48 hrs, whereas that recorded for 48 starved flies significantly were 70.33- 93.67 % after 24 hrs and insignificantly 96- 100 % after 48 hrs. Also, results revealed that the mortality percentages increased with the increase of boric acid concentrations, exposure period of application and starvation duration. According to these results, it is recommended to use boric acid in control of peach fruit fly as effective partial bait or mass trapping techniques that ensure no direct contact with the plants.

Keywords: Peach fruit fly *Bactrocera zonata* Saunders (Diptera: Tephritidae), control, Boric acid, save pesticide, environment friendly.

INTRODUCTION

For its high production per unit area, and high income, fruits represent a very important constituent of the world agricultural production (Ravichandra, 2014). Fruit flies consider as dangerous pests to horticultural crops all over the world, because of high ability to adapt with various environments, high polyphagia and rapid reproduction (Liquido *et al*. 1991; White and Elson-Harris,1992; Barnes, 2004 and Sarwar, 2015) representing a real threat for fruit production. Recently, high demand for healthy food and a great restrictions on usage of insecticides, also, a new generation of fruit fly control techniques which are friendly to the environment are arising (Navarro-Llopis *et al*., 2011). Boric acid and its chemical relatives are widely found in different water sources (rivers, streams, oceans, groundwater), and also in the soil (U.S. Dept.1992a and U.S. EPA. 1993a) as well as in many human foods (people consume between 10 and 25 milligrams of boron in their food daily (U.S. Dept.1992a) and also represent as essential plant nutrients (Quarles, 2001). Boric acid applied in many medical and agricultural fields since it is harmless to birds, aquatic organisms, beneficial insects (honey bees and biological control agents) and mammals when used in low doses, (EFSA, 2004). Boron compounds often recommended as least-toxic pesticides for killing many harmful creatures (insects, mites, algae, fungi), (U.S. EPA, 1993a). These compounds are applied for some harmful insects such as ants, cockroaches and mosquitos (Cochran, 1995). About 189 registered products as pesticides (containing boric acid or any of its sodium salts as an active ingredient) in the U.S in 1948 (Wood, 1994). Advantages of boric acid over pesticides include that boric acid is a low-toxic for mammals, non-volatile mineral with insecticidal, fungicidal, and herbicidal properties. The boron compounds are naturally occurring, composed of complex molecules that are stable and do not break down, these compounds rapidly transform to borates, the naturally occurring form of boron without further degradation, less toxic to human, few insects have developed resistance to them also do not repel insects comparing to highly volatile, synthetic chemical pesticides (Quarles 1992, U.S. Dept., 1992b, Wood, 1994, Quarles, 2001). Negative effects on insects including: acting as a stomach poison (Cochran, 1995), used as a food attractant bait formulation (attractive Toxic Sugar Baits –ATSBs- contains boric acid as a toxic active ingredient) against mosquitoes (Müller & Schlein, 2008, Xue *et al*. 2011, 2013; Qualls *et al*., 2012 and Naranjo *et al*., 2013). Also, Xue and Barnard, 2003; Müller *et al*., 2010; Beier *et al*., 2012 used boric acid compounds against mosquitoes. When boric compounds used in the form of dry powder and ingested, it causes death due to starvation and dehydration few days later, (U.S. EPA, 1993c). Boric acid compounds absorb via wax layer of the insects outer surface, causing them to dry out and die (Quarles, 1992). Also, abrades the exoskeletons (Wood, 1994). For plants, small amounts of boron are needed. It is "one of the more essential minor elements for plant growth

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(U.S. EPA, 1993a). But, high concentrations are toxic, since it desiccates the plant, and interrupt photosynthesis (U.S. EPA, 1993c). So, it is used as herbicides (U.S. EPA, 1993a, U.S. EPA, 1993c). Symptoms of boron phytotoxicity include leaf burn, dead areas inside fruits, dead areas of bark, and dieback of stems (Nable *et al*., 1997). Also, boron stops fungi from producing spores, thus, they used for a long time, alone or as compounds for vermin control (Xue and Barnard, 2003). For mammals boron have harmful effects on animals (EFSA, 2004). Daily large chronic doses on dogs and rats shrink testicles, and affect reproduction causing toxicity to the testes as well histopathological changes and even sterility (Quarles, 1992).

The present study aims to evaluate the effect of boric acid as a safety insecticide for controlling peach fruit fly, *B. zonata*.

MATERIALS AND METHODS

Flies used

Adults of the peach fruit fly, *Bactrocera zonata* used for these experiments were obtained from the laboratory strain continuously reared in Horticultural Insects Research Department, Plant Protection Research Institute using the larval artificial diet (sugar 8.45 %, dried sterile yeast 8.45 %, wheat bran 33 %, sodium benzoate 0.3 %, citric acid 0.3 % and water 50 %). Adult flies fed on water and sugar + hydrolyzed protein (4:1). Sand is used as a pupation substrate (Afia, 2007).

Experimental procedure

Boric acid was used as baits in three formulations (mixed with water, sugar and Buminal). Sugar was formulated as a solution in two concentrations (5 and 10 %), whereas, Buminal (a source of protein) was formulated as a solution in two concentrations (2.5 and 5 %). Each formulation composed of 4 concentrations of Boric acid (0.5, 1, 1.5 and 2 %), these formulations applied to the newly emerged as well as starved flies for 24 and 48 hours after emergence (as solution in piece of sponge which put upon the cup tip top). Transparent plastic cups of 1000 mL of each were used as cages with a piece of fiber net fixed to the lid for feeding and aeration. Each treatment had 5 replicates. The insects were placed as adult flies 100 flies per cage. A label is fixed to each cup to record the data. The death flies was recorded after 24 and 48 hrs of application.

Statistical analysis: One-way ANOVA test was used for statistical analysis of data (IBM SPSS statistics, version 23).

RESULTS AND DISCUSSION

Results

A- The newly emerged flies

1- After 24 hours of application

Results in Table (1), showed that the gradual increase in boric acid concentrations for all treatments, the gradual increase in mortality percentages. Mortality percentages were directly proportional to the used concentrations of boric acid for the five tested baits (water, sugar or protein solutions). The differences in % mortality for the tested treatments were statistically significant. In case of water formulation, boric acid at 0.5 % showed the least % mortality of 37.33 that increased to 65 % at 1 % conc., followed by 1.5 and 2 % conc. Which recorded the highest mortality percentages (90 and 90.67, respectively). But, in case of 5 % sugar solution boric acid at 0.5 %, resulted also the least mortality percentage that gradually increased with the increase of boric acid concentrations (1, 1.5 and 2.0 %) to record mortality percentages of 36.33, 57.67, 64.67 and 71.67 %, respectively. The same trend was observed in case of 10 % sugar solution showing % mortalities of 30, 51, 57.33 and 76 at 0.5, 1, 1.5 and 2 % boric acid concentrations, respectively. With respect to baits of protein hydrolysate (Buminal at both 2.5 and 5 %), mortality percentages of *B. zonata* were nearly the same as that recorded with sugar solutions. For 2.5 % buminal, the mortality percentages were 30, 51, 57.33 and 76 at 0.5, 1, 1.5 and 2 % boric acid, respectively. Whereas, the respective mortalities for 5 % Buminal bait were 42.67, 51, 62.33 and 75.67 %. Generally, the newly emerged flies fed for 24 hours on different boric acid concentrations with several baits showed significantly and differently mortality percentages. The lowest mortalities was observed with the lowest concentrations and *vice versa*. Results revealed also that there were no correlation between death percentage and feeding formulation media. But, boric acid with water at 1.5 and 2 % recorded the highest mortalities.

Table 1. Mortality percentages of the newly emerged *Bactrocera zonata* after 24 and 48 hr fed on different baits of boric acid at different concentrations

Baits	% mortality ± SD at			
	0.5	1	1.5	2
	After 24 hr			
Water	37.33 ± 1.45 f	65 ± 2.89 c	90 ± 0.577 a	90.67 ±0 .667 a
5 % sugar	36.33 ± 1.45 f	57.67 ± 1.45 d	64.67 ± 0.88 c	71.67 ± 0.88 b
10 % sugar	30 ± 0.58 g	33 ± 1.52 g	52.33 ± 1.45 e	74.67 ± 0.88 b
2.5 % Buminal	30 ± 0.58 g	51 ± 0.58 e	57.33 ± 1.45 d	76 ± 0.58 b
5 % Buminal	42.67 ± 1.45 f	51 ± 0.58 e	62.33 ± 0.88 c	75.67 ± 0.88 b
	After 48 hr			
Water	75 ± 5 c	100 ± 0.0 a	100 ± 0.0 a	100 ± 0.0 a
5 % sugar	52.33 ± 1.4 d	74.0 ± 1.0 c	98.33 ± 1.67 a	100 ± 0.0 a
10 % sugar	34.67 ± 0.33 f	39.33 ± 1.45 f	72.33 ± 1.45 c	100 ± 0.0 a
2.5 % Buminal	55 ± 0.0 d	82.33 ± 1.45 b	100 ± 0.0 a	98.67 ± 1.3 a
5 % Buminal	56.37 ± 2.9 d	59.26 ± 2.9 d	67.67± 1.45 c	84.0 ± 1.0 b

2- After 48 hours of application

As shown in Table (1), the mortality percentages of the peach fruit flies significantly increased with the increase of feeding time on baits of boric acids showing directly proportional to concentrations of boric acid in the five feeding formulations (water, sugar or protein

solutions). Boric acid mixed with water recorded the highest mortality percentages at the tested concentrations (0.5, 1. 1.5 and 2 % o boric acid) of 75, 100, 100 and 100, respectively. For 5 % sugar solution, a gradual decrement in % mortality was observed (52.33, 74, 98.33 and 100 at boric acid concentrations of 0.5, 1, 1.5 and 2 %, respectively). Also, the same was occurred with 10 % sugar solution to record 34.67, 39.33, 72.33 and 100 % mortality at 0.5, 1, 1.5 and 2 % concentrations of boric acid, respectively. With regard to Buminal baits, at 2.5 % Buminal the mortality percentages were 55, 82.33, 100 and 98.67 % for 0.5, 1, 1.5 and 2 % boric acid, respectively. But, in case of 5 % Buminal bait the respective mortality percentages were the lowest of 56.37, 59.26, 67.67 and 84 %.

B - Flies of 24 hr old

1- After 24 hr of application

Results obtained in Table (2), indicated that the mortality percentages of 24-day-flies significantly differed with the tested treatments (baits) and increased with the increase of concentrations of boric acid. The highest concentration of boric acid (2 %) insignificantly recorded the highest mortalities for baits of sugar (5 and 10 %) and Buminal (2.5 and 5 %) which significantly varied with the same concentration water and the other concentrations of the used baits. The highest mortalities ranged between 84.67 – 88.67 %. On the other hand, the insignificantly lowest mortalities of 42.33, 44.33, 45.33 and 47.33 % were observed with the lowest concentration of boric acid (5 %) of 5 and 10 % sugar as well as 2.5 and 5 % Buminal baits, respectively.

2- After 48 hr of application

Data in Table (2), revealed that mortality percentages of the peach fruit fly adults for all used concentrations of each treatment significantly increased with the increase of exposure time. Flies exposed, for 48 hr, to all used baits recorded high mortality percentages that ranged between 72.0- 100, 73.33- 100, 55.0- 91.33, 81.67- 90.0 and 78.0- 100 for baits of water, 5 % sugar, 10 % sugar, 2.5 % Buminal and 5 % Buminal, respectively. The mortality percentages of the used baits increased with the increase of concentrations.

Table 2. Mortality percentages of 24 hr old flies of *Bactrocera zonata* after 24 and 48 hr fed on different baits of boric acid at different concentrations

Baits	% mortality ± SD at			
	0.5	1	1.5	2
	After 24 hr			
Water	63.33 ± 0.88 d	65.33± 1.45 d	65.67 ± 1.45 d	70.33 ± 1.45 c
5 % sugar	42.33 ± 1.45 g	64.67 ± 1.2 d	75.67 ± 2.02 c	88.67 ± 0.88 a
10 % sugar	44.33 ± 1.45 g	59.67 ± 0.88 e	80.67 ± 0.67 b	84.67 ± 1.45 a
2.5 % Buminal	45.33 ± 1.45 g	61.67 ± 2.02 e	70.67 ± 2.02 c	86.67 ± 1.33 a
5 % Buminal	47.33 ± 1.45 g	52.33 ± 1.45 f	65.0 ± 1.73 d	87.67± 1.76 a
	After 48 hr			
Water	72.0 ± 0.58 d	88 ± 1.16 b	88.67 ± 0.88 b	100 ± 0.0 a
5 % sugar	73.33 ± 0.88 d	83.33 ± 1.33 c	100 ± 0.0 a	100 ± 0.0 a
10 % sugar	55.0 ± 1.16 e	89.67 ± 0.88 b	91.0 ± 0.58 b	91.33 ± 2.6 b
2.5 % Buminal	81.67 ± 2.03 c	82.0 ± 1.73 c	84.0 ± 0.58 c	90.0 ± 1.16 b
5 % Buminal	78.0 ± 2.08 c	86.0 ± 2.30 b	92.0 ± 1.73 b	100 ± 0.0 a

C **- Flies of 48 hr old**

1- After 24 hr of application

Results in Table (3), cleared that gradual increase in mortality percentages of *B. zonata* adults of 48 hr old with the increase of boric acid concentration after 24 hr of application. The statistical analysis if variance proved that the differences between the tested baits were significant. For the tested concentrations of boric acid (0.5, 1, 1.5 and 2 %), the mortality percentages of water bait were 74, 75., 83.33 and 89.67, respectively. Whereas, that recorded with 5 % sugar bait were 71, 91, 91.33 and 93.33%, respectively. In case of 10 % sugar bait, the lowest mortality percentage of 70.67 was shown at 1 % boric acid, but the highest one (93.67 %) was observed at 2 % boric acid. With regard to Buminal baits (2.5 and 5 %), the mortality percentages slightly increased with the increase of boric acid concentrations (0.5, 1, 1.5 and 2 %) to record 71.67, 72.67, 79.33 and 92.67 % (for the first bait) and 70.33, 70.67, 75 and 90.67 % (for the second one), respectively.

Table 3. Mortality percentages of 48 hr old flies of *Bactrocera zonata* after 24 and 48 hr fed on different baits of boric acid at different concentrations

Baits	% mortality ± SD at			
	0.5	1	1.5	2
	After 24 hr			
Water	74.0 ± 0.58 c	75.33 ± 0.88 c	83.33 ± 1.20 b	89.67 ± 1.20 a
5 % sugar	71.0 ± 0.58 c	91.0 ± 0.58 a	91.33 ± 0.67 a	93.33 ± 0.68 a
10 % sugar	73.0 ± 1.16 c	70.67 ± 1.2 c	92.33± 0.68 a	93.67 ± 0.33 a
2.5 % Buminal	71.67 ± 0.88 c	72.67 ± 0.33 c	79.33 ± 0.88 b	92.67 ± 0.88 a
5 % Buminal	70.33 ± 0.88 c	70.67 ± 0.33 c	75.0 ± 0.57 c	90.67 ± 0.87 a
	After 48 hr			
Water	100 ± 0.0	100 ± 0.0	96.0 ± 2.08	100 ± 0.0
5 % sugar	99.33 ± 0.67	100 ± 0.0	98.67 ± 0.88	100 ± 0.0
10 % sugar	97 ± 1.53	100 ± 0.0	97.67 ± 1.45	99 1.0
2.5% Buminal	100 ± 0.0	98.67 ± 1.33	97.67 ± 0.33	100 ± 0.0
5 % Buminal	100 ± 0.0	99.33 ± 0.66	98.67 ± 0.88	100 ± 0.0

2- After 48 hr of application

As shown in Table (3), the mortality percentages of the peach fruit fly adults of 48 hr old fed on several types of boric acids baits at different concentrations were slightly and insignificantly varied. The mortality percentages ranged between 96- 100, 98.67- 100, 97- 100, 97.67- 100 and 98.67- 100 for boric acid baits of water, 5 % sugar, 10 % sugar, 2.5 % Buminal and 5 % Buminal, respectively.

Discussion

This work come in agreement to some extent with works done previously by other researchers in used doses, techniques and the results in general. Xue and Barnard, 2003 studied boric acid solutions toxicity to adult *Mosquitoes (Diptera: Culicidae)* in the laboratory and found that, median lethal concentrations (LC_{50} in %) at 24-h and 48-h exposure , to sucrose (10%) water containing 1% boric acid (boric acid bait) resulted in 98% mortality in blood fed, gravid, and parous. Hogsette et.al. 2002 uses boric acid as a toxicant against house flies, Musca domestica L with dose ranges of 3, 5, 7, 8, and 12%, and 3, 5, 9, 17, and 33%., in two bioassays and got LC_{50}s were 8.97 and 14.33%. Also, Balme et.al. 2013 conducted bait-consumption assays with 0.5% and 1.5% boric acid in 0.5 M sugar solution fed to house fly, *Musca domestica* L. Hooper-Bui and Rust 2000 used 0.5% boric acid, 1×10^{-6}% fipronil, and 0.025% hydramethylnon against ants, provided 100% mortality of workers. Results got by Gore and Schal 2004 showed that aqueous solutions of 0.5–2% boric acid and any of several inexpensive sugars, including fructose, glucose, maltose, and sucrose as a phagostimulant, at molar concentrations of 0.05–1.0, can provide rapid and effective kill of German cockroaches, *Blattella germanica* (L.). Also Gore et.al. 2004 in another study, found that bait, consisting of 1 or 2% boric acid and 0.5 M sucrose, showed significant reductions in cockroach populations (Gore et.al. 2004).

Boric acid used in five formulations, water, 5 % , 10 % sugar solution, 2.5 % and 5 % protein solutions, applied to just emerged , 24 hrs. & 48 hrs. after emergence starved flies. gave reduction percentage ranging from of 30 % to 90.67 % after 24 hrs. of just emerged flies feeding and 34.67 % to 100 % after 48 hrs. for just emerged flies feeding, and 42.33 % to 88.67 % after 24 hrs. of just emerged flies feeding and 55 % to 100 % after 48 hrs. of just emerged flies feeding and for 48 hrs., after emergence starved flies got 70.33 % to 93.67 % after 24 hrs. and 97 % to 100 % after 48 hrs., of just emerged flies feeding.

CONCLUSION

There were a direct proportionality between concentration of boric acid and death percentage in all feeding formulations, i.e. there is a gradual increase in death percentage as boric acid concentration increased, i.e. death percentage is directly proportional to concentration of boric acid in the five feeding formulations (water, sugar or protein solutions).

As starvation period prolonged, food consumption and consequently the amount of boric acid dissolved in the food formulation increased this resulted in increasing death percentage

There are differences in reduction percentages among different formulations with the same boric acid concentration but there without a distinct correlation between them.

It is strongly recommended to use boric acid in control of medfly in the mass trapping technique or any effective technique ensure no direct contact between the host plant and the boric acid formulations.

REFERENCES

Afia, Y.E., 2007. Comparative studies on the biology and ecology of the two fruit flies in Egypt Bactrocera zonata (Saunders) and Ceratitis capitata (Wiedemann). Ph.D. Thesis, Fac. Agric., Cairo Univ., 301pp

Balme, G. R.; Denning, S. S. and Watson, D. W. 2013.Boric Acid Aversion in Adult House Flies, *Musca domestica L.* J. of Agricultural and Urban Entomology, 29(1):85-92

Barnes, B., 2004. Proceedings of the 6th International Symposium on Fruit Flies of Economic Importance. Ultra Litho (Pty), Johannesburg, 510 pp.

Beier, J.C.; Müller, G.C.; Gu, W.D.; Arheart, K.L. and Schlein, Y., 2012. Attractive toxic sugar bait (ATSB) methods decimate populations of *Anopheles* malaria vectors in arid environments regardless of the local availability of favoured sugar-source blossoms. Malaria J., 11: 31.

Cochran, D.G., 1995. Toxic effects of boric acid on the German cockroach. Experientia, 51: 561-563.

EFSA, 2004. Opinion of the scientific panel on dietetic products, nutrition and allergies on a request from the commission related to the tolerable upper intake level of boron (sodium borate and boric acid) (Request N_ EFSAQ- 2003-018). European Food Safety Authority Journal, 80: 1-22.

Gore, J. C. ; Zurek, L. ; Santangelo, R. G. ; Stringham, S. M. ; Watson, D. W. and Schal, C. 2004.Water Solutions of Boric Acid and Sugar for Management of German Cockroach Populations in Livestock Production Systems J. of Economic Entomology, 97(2):715-720.

Gore, J. C. and Schal C. 2004. Laboratory Evaluation of Boric Acid-Sugar Solutions as Baits for Management of German Cockroach Infestations. J. of Economic Entomology, 97(2):581-587

Hogsette, J.A.; Carlson, D.A. and Nejame, A.S., 2002.Development of Granular Boric Acid Sugar Baits for House Flies (Diptera: Muscidae). J. of Economic Entomology, 95(5):1110-1112

Hooper-Bui, L.M. and Rust M. K. 2000. Oral Toxicity of Abamectin, Boric Acid, Fipronil, and Hydramethylnon to Laboratory Colonies of Argentine Ants (Hymenoptera: Formicidae) J. of Economic Entomology, 93(3):858-864

Liquido N.J.; Shinoba, L.A. and Cunningham, R.T., 1991. Host plants of the Mediterranean fruit fly (Diptera: Tephritidae): an annotated world review. Misc. Publ. Entomol. Soc. Am., 77: 1–52.

Müller, G.C. and Schlein, Y., 2008. Efficacy of toxic sugar baits against adult cistern-dwelling *Anopheles claviger*. Trans. R. Soc. Trop. Med. Hyg., 102: 480–484.

Müller, G.C.; Beier, J.C.; Traore, S.F.; Toure, M.B.; Traore, M.M.; Bah, S.; Doumbia, S. and Schlein, Y., 2010. Successful field trial of attractive toxic sugar bait (ATSB) plant-spraying methods against malaria vectors in the *Anopheles gambiae* complex in Mali, West Africa. Malaria J., 9: 210.

Nable, R.O.; Bañuelos, G.S. and Paull, J.G., 1997. Boron toxicity. Plant and Soil, 198: 181-198.

Naranjo, D.P.; Qualls, W.A.; Müller, G.C.; Samson, D.M.; Roque , D.; Alimi, T.; Arheart, K.L.; Beier, J.C. and Xue, R.D., 2013. Evaluation of boric acid sugar baits against *Aedes albopictus* (Diptera: Culicidae) in tropical environments. Parasitol. Res., 112: 1583–1587.

Navarro-Llopis, V.; Vacas, S.; Sanchis, J.; Primo, J. and Alfaro, C., 2011. Chemosterilant bait stations coupled with sterile insect technique: an integrated strategy to control the Mediterranean fruit fly (Diptera: Tephritidae). J. Econ. Entomol., 104: 1647–1655.

Qualls, W.A.; Xue, R.D.; Revay, E.E.; Allan, S.A. and Müller, G.C., 2012. Implications for operational control of adult mosquito production in Cisterns and Wells in St. Augustine, FL using attractive sugar baits. Acta Trop., 124: 158–161.

Quarles, W., 1992. Borates Provide 2-Least-Toxic Wood Protection. The IPM Practioner. Bio-Integral Research Center, Berkeley,CA, 14(10): 1-11.

Quarles, W., 2001. Boric Acid, Borates and Household Pests. The IPM Practioner. Bio-Integral Research Center, Berkeley, CA, 23(3): 1-12.

Ravichandra, N.G., 2014. Horticulture and its role in the national economies. In: R, C. (Ed.), Horticultural Nematology. Springer, New Delhi, pp. 1–3.

Sarwar, M., 2015. Quarantine treatments for mortality of eggs and larvae of fruit flies (Diptera: Tephritidae) invading fresh horticulture perishable produces. Int. J. Anim. Biol., 1, 196–201.

U.S. Dept., 1992a. Health and Human Services. Public Health Service. Agency for Toxic Substances and Disease Registry. Toxicological profile for boron. TP-91/05. pp., 54-55.

U.S. Dept., 1992b. Health and Human Services. Public Health Service. Agency for Toxic Substances and Disease Registry. Toxicological profile for boron. TP-91/05. p. 53.

U.S. EPA, 1993a. Office of Prevention, Pesticides and Toxic Substances. R.E.D. Facts: Boric acid.

U.S. EPA, 1993c. Office of Prevention, Pesticides and Toxic Substances. Reregistration eligibility decision (RED): Boric acid and its sodium salts. www.pesticide.gov/pesticides, 22: pp. 5-17.

White, I.M. and Elson-Harris M.M., 1992. Fruit Flies of Economic Significance: Their Identification and Bionomics. CAB International, London, UK, pp. 601.

Woods, W.G., 1994. An introduction to boron: History, sources, uses, and chemistry. Environ. Health Persp., 102: 5-11.

Xue, R.D. and Barnard, D.R., 2003. Boric acid kills adult mosquitoes (Diptera: Culicidae). J. Econ. Entomol., 96: 1559–1562.

Xue, R.D.; Müller, G.C.; Kline, D.L. and Barnard, D.R., 2011. Effect of application rate and persistence of boric acid sugar baits applied to plants for control of *Aedes albopictus*. J. American Mosquito Control Assoc., 27: 56–60.

Xue, R.D.; Müller, G.C.; Qualls, W.A.; Smith, M.L.; Scott, J.M.; Lear, J. and Cope, S.E., 2013. Attractive target sugar baits: Field evaluation and potential for use in mosquito control, Wing Beats 24: 13–18.

إستخدام حمض البوريك كمبيد آمن لمكافحة ذبابة ثمار الخوخ *Bactrocera zonata* (Saunders)

طارق عبد العاطى عبد الحفيظ ، سهام محمد المهدى و يسرى اسماعيل عافية

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تعتبرذبابة ثمار الخوخ ، Bactrocera zonata Saunders (Diptera: Tephritidae من احطر الافات الحشرية على المحاصيل البستانية .و قد تم اختبار حمض البوريك كمبيد حشري آمن وصديق للبيئة تم استخدامه لفترات طويلة ضد العديد من الكائنات الضارة مثل النمل و الصراصير و الناموس. تم تجربة حمض البوريك ضد ذبابة ثمار الخوخ كطعم للحشرات الكاملة فى خمس تركيبات من الطعوم (الماء ، محلول السكر عند 5 و 10٪ بالإضافة إلى المحاليل البروتينية عند 2.5 و 5٪) عند 4 تركيزات من حمض البوريك (0.5 ، 1 ، 1.5 و 2٪) للذباب بمجرد خروج الحشرة الكاملة ،او بعد 24 ساعة او 48 ساعة بعد خروج الحشرة الكاملة بدون اى تغذية و سجلت نسب الموت بعد 24 ساعة و 48 ساعة من التغذية بالطعوم . تراوحت نسب الابادة بشكل ملحوظ بين 30-90.67 للذباب الذي خرج حديثًا بعد 24 ساعة و 34.67- 100 بعد 48 ساعة من التغذية بالطعوم المستخدمة. أيضا ، كانت معدلات الابادة للذباب الجائع 42.33- 88.67٪ بعد 24 ساعة و 55- 100٪ بعد 48 ساعة ، في حين أن الذباب الجائع لمدة 48 ساعة سجل 70.33-93.67٪ بعد 24 ساعة و 96- 100 ٪ بعد 48 ساعة. كما أظهرت النتائج زيادة نسب الابادة مع زيادة تركيزات حمض البوريك وفترة التعرض للتطبيق ومدة المجاعة. وفقًا لهذه النتائج ، يوصى باستخدام حمض البوريك للتحكم في ذبابة ثمار الخوخ كطعم فعال أو تقنيات استخدام المصائد المكثفة تضمن عدم الاتصال المباشر بالنباتات