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Evaluate efficacy of some eco-friendly chemical compounds against cucurbit fly *Dacus ciliatus* (Loew) (Tephritidae: Diptera) under laboratory conditions

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Abstract
The cucurbit fly, *Dacus ciliatus*, is a damaging pest of Cucurbitaceae crops, offers substantial problems to agricultural output worldwide. Despite its economic impact, limited research has been conducted on this species, particularly in Egypt. In this study, both Boric acid, Borax and Zinc sulphate plus sugar cane solution (10% conc.) as food attractant have been studied as an environmentally acceptable and secure insecticide for the purpose of controlling *D. ciliatus* (the newly emerged adult flies). The mortality percentages were observed after 24 hours, 48 hours, 3, 4, 5, 6 and 7 days of application. The results showed effective mortality percentage reached 97% after 7 days and 100% after 4 days at concentration 0.5,1 and 2%, respectively of boric acid. Whereas borax recorded mortality percentage reached 50% and 76.6% after 7 days and 100% after 4 days (at conc. 0.5, 1% and 2% respectively), while zinc sulfate recorded mortality percentage 53% and 80% after 7 days (at conc. 2g and 3g respectively) and reached 100% after 5 days (at conc. 4g). The current investigation demonstrates the existence of a direct correlation between death rate and treatment concentration and feeding period of application. According to these data, it is suggested to employ boric acid, zinc sulfate followed by borax in control of cucurbit fly *D. ciliatus* as eco- friendly chemical compounds.

Keywords: Cucurbit fly, *Dacus ciliatus*, Boric acid, Borax, Zinc sulphate, save pesticide, environment friendly

Introduction

Dacus ciliatus Loew (Diptera: Tephritidae), commonly known as cucurbit fly. It's an oligophagous pest that harms crops in both temperate and tropical areas., particularly targeting plants of the Cucurbitaceae family (Khater 2020; Nair *et al*. 2021) [15, 17]. It has several common names, Lesser pumpkin fly, Ethiopian fruit fly, cucurbit fly, *Dacus ciliatus* (Weems 2004) [26]. It was initially recorded as major pest on Cucurbitaceae since 1947 in Ombo, Upper Egypt by (Azab and Kira 1954) [4]. *Dacus ciliatus* is a dangerous pest of cucurbits, including melon, zucchini, and cucumbers. (Alagarmalai *et al.*, 2009) [2].

The female fly of this specie typically oviposits inside young fruits; the larvae develop within the fleshy tissues of fruits. Infestations have been recorded on several fruit crops, including marrow, gourds, squash, cucumber and cantaloupe (Fetoh 2006) [12].

The economic impact arises due to the requirement for expensive insecticides to manage and control the spread of this invasive fruit fly (Khater 2020) [15] posing a serious threat to fruit output. A new generation of ecologically friendly fruit fly control methods is emerging as a result of the recent strong demand for healthful food and significant restrictions on the use of insecticides. (Navarro-Llopis *et al*., 2011) [18].

All boron-related compounds, including boric acid and its sodium salts, are naturally present in fruits, vegetables, water, and forage crops. It is a vital component for many creatures and a necessary nutrient for plants (U.S. EPA. 1993 a) [24]. Scientists agree that judicious application of boric acid offers a safer, more effective alternative to many pesticides while avoiding the indoor air issues sometimes associated with pesticide sprays, despite the fact that exposure to boric acid has been linked to detrimental health effects.

In agriculture, boric acid is used as a fungicide, insecticide and herbicide in food crops and orchards (U.S. EPA, 1993b) [25]. Borates have also been used as a nutritional supplement for crops that prefer boron, like cabbage and sugar beets. (Rio Tinto Borax. 1995) [19]. Boric acid is a suitable pesticide for bait products since it has low toxicity, limited insect resistance, and does not repel insects. (Woods. 1994) [27].

Due to its low toxicity, limited insect resistance, and lack of insect repellency, boric acid is an appropriate pesticide for bait items. (Abdel-Hafeez *et al.* 2020) [23]

Zinc, an essential micronutrient metal, Since the 1930s, zinc is frequently added to plant fertilizers and animal feeds as a nutritional supplement to promote healthy growth and maximize yield because it is widely acknowledged as an essential element in the growth processes of both plants and animals. (DeLange, *et al.* 2010 and Montalvo, *et al.* 2016) [8, 16].

Zinc sulfate (ZnSO4 7 H2O) is crystal transparent odorless material, water soluble. Zinc acts as a growth hormone and regulates protein synthesis. Researchers are more interested in the detrimental effects on herbivore growth, development, and survival of high-concentration ZnSO4 solutions used as pesticides sprayed on plant leaves. Given that zinc sulfate is widely used in agriculture (Al-Dhafar, *et al.* 2012 and Sawsan, *et al.* 2015) [3, 20]. Zinc sulfate is generally regarded as having little toxicity.

Boric acid, borax and zinc sulphate are proven effective, low-cost control for many insect pests. Current control methods of this pest mainly depend on chemical insecticide application, which are dangerous to humans, animals, fish, beneficial insects, causing water and air pollution.

Therefore, it was necessary to search for environmentally friendly compounds that can be used in controlling the cucurbit fly.

Materials and Methods

This study was conducted during October and November 2025, under laboratory conditions at the plant protection Research institute, Agriculture Research Center, Dokki, Giza, Egypt. The photoperiod was 12:12 (L:D) hours, the temperature was 25 ± 2°C, and the relative humidity (RH) was 60% ± 10%.

Insect Cultural

Colony of *D. ciliatus*, was initiated in the laboratory with numbers of pupae obtained from infested squash. Fruits which were collected from untreated farmers field (El-Santa district, Gharbia governorate, Egypt). The infested squash fruits were put in a plastic container with sterile sand in the bottom to pupate under laboratory conditions. The pupae were collected daily from the sand, and placed in transparent Plexiglas cages (25 × 25 × 25 cm) for adult emergence.The newly emerged flies were fed on artificial diet consists of Sugar and hydrolyzed yeast powder in a 3:1 ratio and water till maturation (2 weeks after emergence). Fresh squash fruits were also placed in the cages as an oviposition site for 48 hours. The infested fruits were put in cylindrical transparent (1.5 L) plastic containers provided with moist sterilized sand (heated at 72°C for 72 hours) for larvae development, if necessary, the sand was changed. Third-instar larvae that are fully grown emerge from the fruits and pupate in the sand, the sand was seived every 2 days and the pupae were collected then put in sterile plastic Petri dishes with a fine mesh screen and a diameter of 90 mm for use.

Experimental procedure

Boric acid (H_3B0_3) (FRAKEN INTERNATIONAL TRADING CO. LTD.) and Borax ((disodium tetraborate decahydrate, $Na_2\ B_4\ O_7\ 10\ H_2\ O$) were used as a solution in three different concentrations (0.5%, 1%, and 2%), mixed with sugar. Sugar was formulated as a solution in concentration (10 %), that was used to treat cucurbit fly (just emerged).

Zinc sulfate monohydrate Assay: 99% was obtained from Ausen chemical Group CO, LTD. Three different concentrations, 2,3,4, mg of zinc sulfate/L. distilled water and sugar cane solution 10% conc. were mixed.

These formulations applied to the newly emerged fly (piece of swab was immersed in each concentration). Ten adult flies were added to each Petri dish, and the insects were left to feed on the treated swap. To record the data, a label is affixed to every dish.

Each concentration was duplicated three times using ten flies each. Control (untreated) fly were fed swabs soaked in distilled water and a 10% sugar cane solution.

The mortality percentages of treated flies were recorded after 24, 48 hours,3 days,4 days,5 days, 6 days and 7 days. Of application, calculated and corrected according to Abbott's formula (Abbott, 1925) [1].

$$\text{Corrected mortality rate (\%)} = \left(\frac{A-B}{A}\right) \times 100$$

When A = Population in the control treatment.
B = Population in the treated plot

Data Statistical Analysis

The statistical significance of the data was determined using one-way analysis of variance (ANOVA) by software Costat system, Version 6.311 (Costat, 2006) [6]. Death percentages were examined using, Abbott's formula (Abbott, 1925) [1] and then using software LDP Line to calculated LC50 values by using probit- analysis method of Finney (1971).

Results and discussion

1. **Mortality percentage of newly emerged flies feed on (Boric Acid+10% sugar cane solution) at different concentrations**

The data are displayed in Table I, which reveals a direct proportionality between the death rate of cucurbit fly *D. ciliatus* and concentrations of boric acid mixed with 10% sugar cane solution during seven days of application. The percentage of deaths increased as the concentration of boric acid increased. 0.5% boric acid produced the lowest death rate for the 10% sugar solution regime, followed by 1% and 2.0%. with averages of 97% and 100% after seven days and 4 days respectively. Also, the death percentage increased as exposure period of application increased, where it recorded 0% and 17% after 24 hours, while 67% and 100% was observed after 4 days.

Table 1: Mortality percentage of the newly emerged adults of *Dacus ciliatus* fed on (boric acid+10% sugar solution) at different concentrations

Conc. / date	0.5g	1 g	2 g
After 24 hrs	0%	0%	17%
After 48 hrs	3%	20%	57%
After three days	27%	57%	70%
After four days	67%	100%	100%
After five days	93%	-	-
After fix days.	97%	-	-
After seven days	97%	-	-
S.D	4.214487	4.214487	3.848455
S.E	2.433235	2.433235	2.2219065

S.D = Standard Deviation
S.E =Standard Error

2. **Mortality percentage of newly emerged adult flies feed on (Borax+10% sugar cane solution) at different concentrations**

The data are displayed in Table 2, which reveals a clear proportionality between the death rate of cucurbit fly *D. ciliatus* and concentrations of borax mixed with 10% sugar cane solution during seven days of application. The death rate rose as the borax concentration increased. For a 10% sugar cane solution regime, 0.5% borax had the lowest fatality rate, followed by 1% and 2.0%. with averages of 34% and 100% after 4 days and 50% and 76.6% after 7 days. the death percentage increased as exposure period of application increased, where it recorded 4.1%, 13.3% and 20% after 24 hours while 43% and 100% was observed after 4 days, while mortality percentage reached 50% and 76.6% after 7 days.

Table 2: Mortality percentage of the newly emerged adults of *Dacus ciliatus* fed on (borax + 10% sugar cane solution) at different concentrations

Conc. / date	0.5g	1g	2g
After 24 hrs	4.10%	13.30%	20%
After 48 hrs	17%	20.8%	62.5%
After three days	42.50%	30%	93.4%
After four days	43.40%	34%	100%
After five days	50%	50%	-
After six days.	50%	56.6%	-
After seven days	50%	76.60%	-
S.D	1.2891489	2.211442	3.4498573
S.E	0.7442904	1.276777	1.991776

S.D = Standard Deviation
S.E =Standard Error

3. Mortality percentage of newly emerged adult flies feed on ($ZnSO_4$+10% sugar cane solution) at different concentrations

Table 3 show that as the $ZnSO_4$ concentration increased, death percentage of cucurbit fly *D. ciliatus* was increased. For 10% sugar cane solution regime 2% $ZnSO_4$ resulted in the least death rate, followed by 3%, and 4% with means of 27%, 60% and 100% after 5 days of feeding, 53% and 80% at conc. 2g and 3g respectively was observed after 7 days. the death percentage increased as exposure period of application increased, where it recorded 0%, 3% and 3.3% after 24 hours, while 53% and 80% was observed after 7 days of feeding.

Table 3: Mortality percentage of the newly emerged adults of *Dacus ciliatus* fed on (zinc sulfate+ 10% sugar cane solution) at different concentrations

Conc. / date	2g	3g	4g
After 24 hrs	0%	3%	3.3%
After 48 hrs	7%	6%	6.9%
After three days	7%	17%	23.3%
After four days	27%	41.5%	59.2%
After five days	27%	60%	100%
After six days.	43%	73%	-
After seven days	53%	80%	-
S. D	2.2747754	3.0480282	3.8359205
S. E	1.3133422	1.7597799	2.2146697

S.D = Standard Deviation
S.E =Standard Error

Table 4: Lethal concentrations (LC50 % & LC90 %) tests against *Dacus ciliatus* exposed to boric acid, borax and zinc sulphate.

Substance / Lethal conc.	Boric acid	Borax acid	Zinc sulfate
LC_{50} %	0.4189	0.2394	1.4421
LC_{90} %	2.1289	21.5781	13.6401

According to these results included in Table 4, Ingestion of the poisonous bait produced with boric acid and sugar cane solution conc. 10%, lethal concentration of the mixture LC_{50} % values was 0.4189, and LC_{90} % was given as the highest mortality rate 2.1289. on the other hand, LC_{50} % value for borax mixed with sugar solution 10% conc. was 0.2394 while LC_{90} % was 21.5781. Zinc sulfate recorded LC_{50} % was 1.442, while LC_{90} % was 13.6401.

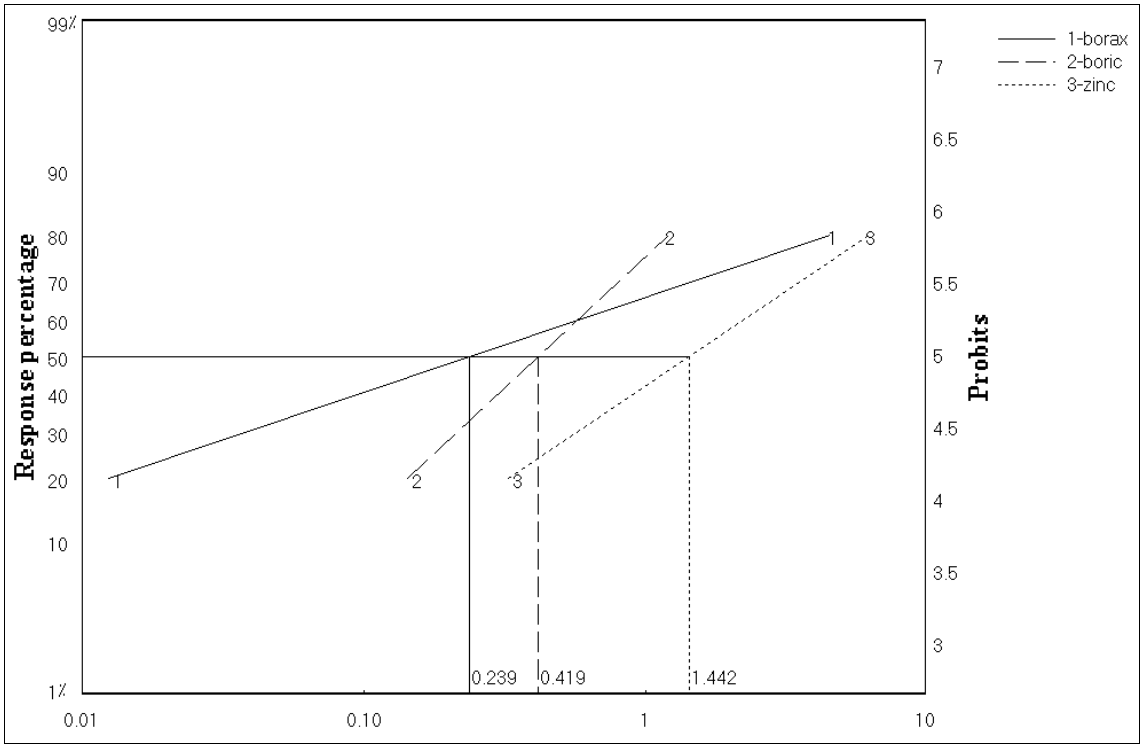

Fig 1: Toxicity line of boric acid, borax and zinc sulfate on cucurbit fly *Dacus ciliatus*

The present results are in agreement with those recorded by Daane *et al.* (2006) [7] mentioned that 0.5% boric acid resulted in a considerable reduction in Argentine ants, reduced mealybug density on vines, and less crop damage. Also, Hogsette *et al.* (2002) [13] Use boric acid at dose ranges of 3, 5, 7, 8, and 12% and 3, 5, 9, 17, and 33% as a toxicant against *Musca domestica* L. house flies. In two bioassays, the LC50s were 8.97 and 14.33%.

Enkerlin *et. al.* (1989) [11], assumed that After 22 hours, 90% of *Anastrepha ludens* (Loew) adults die after consuming the

toxic- bait, which is produced with boric acid and borax (3:1) + ICN hydrolyzed protein + water (5, 4, 91%).

Duyck *et al*. (2004) [10] reported that Borax considerably reduced the protein hydrolysates Nulure and Buminal's attractiveness to *B. cucurbitae*. Melon found the 5% Buminal solution more appealing after it was acidified from pH 6 to pH 3.

Chambers (1987) [5] mentioned that borate compounds can be employed as pesticides against fruit flies; they are also thought to be an effective alternative to malathion. Additionally, Naranjo *et al.*, (2013) indicated that toxic sugar and protein baits were created using boric acid at various doses ranging from 0.5 to 2%. Boric acid was chosen since it has previously been employed in experiments on harmful sugar baits and is both safe and environmentally beneficial.

Sohal & Labs (1979) [22] recoded that zinc sulfate is stored as an effort material in the fat bodies of adult houseflies, *Musca dosmestic*. Furthermore, Sell and Bodzinck (1971) [21] showed that 0.2% concentration of Zinc sulfate produced deterring feeding effects on *Heliothis virescens* freshly hatched larvae; additionally, Kavitha *et al*. (2012) [14] found that dietary zinc sulfate lowered protein levels in *Bombyx mori's* hemolymph and silk gland by 181% and 356%, respectively. Moreover, sulfate salts can kill insects because of their unique insecticidal properties. Al-Dhafar and Sharaby (2012) [3] discovered that in *Rhynchophorus ferrugineus*, a 0.566% ZnSO4 solution caused some peritrophic membranes to contract, some muscle layers to shed, and midgut epithelial cells and goblet cells in the distal region of the midgut to vacuolate and contract.

Conclusion

Finding from above study concluded that boric acid, followed closely by borax and zinc sulphate showed a great lethal effect against adult cucurbit fly *Dacuc ciliatus* in comparison with control under laboratory conditions. The results also showed that the effectiveness of these compounds depends on both concentration and feeding period. Further researches under field conditions is essential to confirm the laboratory finding so that it can be included in IPM programs for cucurbit fly.

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