Using Wood Vinegar as a Natural Pesticide for Reducing Greenhouse Gases to Mitigate Climatic Change Effect Compared with That of Indoxacarb Against the Peach Fruit Fly, *Bactrocera zonata*

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Abstract

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The current study aimed to evaluate the toxicity of wood vinegar, a natural pesticide made from rice husk, and indoxacarb against the peach fruit fly's third larval instars, one-day-old and seven-day-old pupae. The tested compounds showed toxicity against different developmental stages of the peach fruit fly. Adult flies that emerged from (i) pre-pupae in sand treated with sub-lethal concentrations (LC_{50}=0.36 ppm, 0.87 % ppm of indoxacarb, and wood vinegar, respectively), (ii) from treating 1-day-old pupae in sand with sub-lethal concentrations (LC_{50} 0.44 ppm, 0.98 % of indoxacarb and wood vinegar, respectively), and (iii) from 7-day-old pupae in sand treated with sub-lethal concentrations (LC_{50} 2.86 ppm, 1.25 % of indoxacarb and wood vinegar, respectively), were assessed by the comet test for detecting broken DNA strands in individual eukaryotic cells. Results obtained showed that insects treated with indoxacarb and wood vinegar had significantly increased tail length (TL), tail moment, DNA tail %, and over all DNA damage values expressed in the body cells, compared to the untreated control.

Keywords: *Bactrocera zonata*, comet assay, indoxacarb, wood vinegar, greenhouse gas, climate change

Introduction

Bactrocera zonata is a highly harmful and destructive tephritid species that poses a threat to Egypt's commercial fruit production (EPPO, 2002). Different application methods, including pesticides, such as pyrethroids and organophosphates, were used for the control of peach fruit fly. However, there are many problems associated with the use of chemical pesticides such as emergence of pest resistance, toxicity of chemical residues, and the inability of these chemical compounds to penetrate infested fruits and kill immature stages inside the fruit (El-Gendy, 2018). To avoid the negative effects of chemical pesticides, other environment friendly control measures were considered such as soil treatment for the elimination of pupae and pre-pupae of the peach fruit fly (El-Gendy & AbdAllah, 2019), and the use of natural products to replace chemical insecticide sprays (Kim *et al.,* 2008).

Real and persistent efforts must be made to reduce greenhouse gas emissions, which are the primary contributor to climate change, in order to combat its threats (Ali *et al.,* 2013). The agricultural industry is recognized to contribute to greenhouse gas emissions (Clay *et al.,* 2019). Due to growing agricultural production to meet rising demand for food, the agriculture sector's GHG emissions have drastically expanded over the past 50 years (Smith *et al.*, 2014). On the other hand, there are many attempts to take advantage of agricultural residues and raise its added value such as biochar by agricultural residues pyrolysis. Pyrolysis is one of the modern methods that has proven its efficiency in converting biomass into energy and various products such as biochar, wood vinegar, tar and syngas (Kan *et al*., 2016), that can significantly increase yield (Baimark & Niamsa, 2009). The most important advantages of the pyrolysis process for agricultural residues are its various products that lead to a reduction in GHGs emissions (Yorgun & Yildiz, 2015).

The byproduct of making charcoal is wood vinegar. It is a liquid produced in the Iwate kiln from the gas and combustion of fresh wood burning in an anaerobic environment. The resulting gas is cooled and condensed into liquid after combustion (Pangnakorn *et al.,* 2012). This product is approximately 80–90% water, and the remaining part is comprised of more than 200 diverse organic compounds, including acetic acids, phenolic acids, organic acids, alkanes and esters compounds, alcohol acids (including acetic acid and carboxylic acid), alcohols, methanol, formaldehyde, ethyl-valerate, phenols, aldehydes, ketones, furans, and pyran derivatives, nitrogen compounds, and tar compounds (Martin *et al.,* 2017). Plant height, leaf length, and bud/twig growth are all greatly increased by a dose of 3-5% wood vinegar (Nurhayati *et al.,* 2005). Wood vinegar is used in the field of plant protection to suppress microorganisms that cause bacterial and fungal illnesses in a variety of crops. It is also used for pest and termite control (Kim *et al.,* 2008).

Indoxacarb, an oxadiazine novel pesticide that blocks neuronal sodium channels of insect (Levi *et al.,* 2019) is approved for use as a pre-treatment for controlling fleas,

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ticks, beetles, and non-specific flies associated with livestock and pets (IRAC, 2018).

The single-cell gel electrophoresis (SCGE) assay, often known as the comet assay, is a genotoxicity test that may identify DNA damage (Afify & Negm, 2018). According to Ghazawy *et al.* (2021) and Mona *et al.* (2022), the comet test is an easy, precise, economical, and quick way to identify DNA strands damage in individual eukaryotic cells. It can also be used for a number of other purposes, such as genotoxicity studies, DNA repair, and bio-monitoring of the human population.

This work was carried out to estimate the toxic and genotoxic effects of wood vinegar as a new natural insecticide extracted from agricultural residues, and compared with indoxacarb, which is a safe product used to treat soil against immature stages of the peach fruit fly.

Materials and Methods

Insect rearing:

The third larval instar, 1-day-old pupae and 7-day-old pupae of *B. zonata* were procured from the Plant Protection Research Institute, Dokki, Giza, and were reared under controlled laboratory conditions at a temperature of 25°C and relative humidity of 60%. A synthetic diet made up of 500 ml of water, 3 g of sodium benzoate, 3 g of citric acid, 84.50 g of sugar, 84.50 g of brewer's yeast, and 330 g of wheat bran was used to rear the insect larvae. In a plastic container filled with the above described diet, insect eggs were spread on the diet's surface, placed in 20 × 10 × 8 cm plastic trays and firmly covered with muslin. To enable the larvae to pupate, the plastic trays were placed in plastic boxes with sand at the bottom. (Shehata *et al.,* 2006).

B. zonata adults were raised in a cage (100 × 30 × 30 cm). Adults were fed a 3:1 ratio of sucrose and a fortified protein hydrolysate. In addition, water in a tiny plastic bottle was supplied. A plastic fruit, with several tiny pores to hold eggs was added to the cage. To prevent eggs from dryness, 3 ml of water were added into the plastic fruit.

Pesticides used and evaluated treatments

The insecticides used in this study were (i) indoxacarb: (Flax extra 15% SC, Sumitomo®), and (ii) wood vinegar extracted from rice husk, obtained from the Central Laboratory for Agriculture Climate, Dokki,Giza.

In a sandy soil passed through a 1 mm sieve, two compounds were tested against certain immature stages of the *B. zonata* fruit fly. Each plastic cup contained 100 g of the sieved sandy soil. Each compound's concentration was diluted with tap water to a final volume of 15 milliliters before being added. 50 fully developed larvae (the third larval instar), one-day-old pupae, or seven-day-old pupae were placed in each cup containing the treated soil. The cups were then tightly closed with muslin fastened with rubber bands, and kept in the laboratory the adult stage emerged. For each investigated chemical, three and five concentrations of wood vinegar and indoxacarb, respectively, were evaluated in five replicates, compared with soil and water only as control. All individuals failed to emerge were considered dead.

Preparation of samples for the comet test

Five insects were chopped and placed in a 1 ml cold phosphate buffer solution (Ca^{+2} free) to obtain the entire body cells of *B. zonata* for each sample. Alkaline SCG (single cell gel) test was used to examine DNA damage. The alkaline (pH 13) version of the comet assay was utilized to calculate the genotoxic effects of indoxacarb and wood vinegar by measuring the degree of DNA damage in the entire body cells of *B. zonata*. Alkali-labile sites, cross-linking with a single cell, and DNA single-strand breaks (incomplete excision repair sites and frank strand breaks) were all investigated using the alkaline SCG test biochemical procedure.

Using the comet test technique

As described by Singh *et al.* (1988), 10 µl of cell suspension (the prepared sample) and 90 µl of 0.75% low melting point agarose were added to microscope slides that had previously been coated with 1.5% normal melting point agarose. The slides were then covered, and agarose solidification was accomplished by setting them on ice. The slides were then exposed to a lysis buffer (2.5 M NaCl, 100 mM EDTA, 10 mM Tris, 0.25 M NaOH, 1% Triton X-100, pH 10.0) for 24 hours at 4°C after the covers had been removed. After the lysis, the slides were placed in a horizontal gel electrophoresis tank, and the DNA was given 20 minutes to unwind in the electrophoresis buffer (300 mM NaOH and 1 mM EDTA, pH 8.0). Electrophoresis was carried out at 21V and 300 mA for 20 minutes at 4 °C. The slides were then neutralised with neutralisation buffer, fixed with methanol, and allowed to dry overnight at room temperature before being stained with ethidium bromide (2 g/ml in 0.4 M Tris-HCl, pH 7.4). Three replicates of each sample were tested.

Identifying DNA damage

Using an excitation filter of 524 nm and a barrier filter of 605 nm, an Axio fluorescence microscope (Carl Zeiss, Germany) was used to analyse the slides. An ethidium bromide stain of DNA was used with a fluorescence microscope and a ×40 objective to evaluate DNA damage (depending on the size of the cells being scored). Using a comet analysis system 4.0 created by Kinetic Imaging, Ltd (Liverpool, U.K.) connected to a CCD camera, the length of DNA migration was determined (tail length) (TL), as well as the percentage of migrated DNA (DNA tail %), and the product of both was dubbed as the tail moment (TM). Each sample contained 50 to 100 randomly chosen cells, with at least 25 cells on each slide and three slides per treatment.

Detection of polyphenolic compounds using HPLC

Agilent's 1260 series was used for HPLC analysis. An Eclipse C18 column (4.6 mm×250 mm i.d., 5 m) was used for the separation. Water (A) and 0.05% trifluoroacetic acid in acetonitrile (B) flowed through the mobile stage at a rate of 0.9 ml/min. The following instructions were being sequentially coded for the mobile stage in a linear gradient: 0 minutes (82% A), 0–5 minutes (80% A), 5-8 minutes (60% A), 8 minutes (12%), 12 minutes (15%), 15 minutes (16%), and 16 minutes (20%). At 280 nm, the multi-wavelength detector was observed. Each sample solution had a 5l insertion volume. The column was kept at a constant

temperature of 40°C. The standards used were gallic acid, chlorogenic acid, catechin, methyl gallate, caffeic acid, syringic acid, pyro-catechol, rutin, ellagic acid, coumaric acid, vanillin, ferulic acid, naringenin, taxifolin, cinnamic acid, and kaempferol

Statistical analysis

The mortality rates in the treatments were compared and corrected using Abbott's formula (Abbott, 1925). For studied toxicants, probit analysis was performed to determine LC_{90}, LC_{50}, and the slope of regression lines (Finney, 1971). The statistical analysis of the DNA damage measurements (DNA tail %, TL and TM), which were presented as mean standard error (P 0.05), was done using analysis of variance (ANOVA). Based on the evaluation of the effects of different treatments (indoxacarb and wood vinegar), different stages (pre-pupae, 1-day-old pupae, and 7-day-old pupae), and the third factor of sex (male and female) on DNA damage measurements (DNA tail%, TL, and TM) using SPSS software, a minimum of five distinct insects per replicate of the same sample (n = 3) were used (version 24; SPSS, Chicago, IL, USA).

Results

Toxicity of wood vinegar and indoxacarb against peach fruit fly, *B. zonata*

To study the toxicological effects of wood vinegar and indoxacarb on *B. zonata*, the experiment was carried out on the third larval instar, 1-day-old pupae, and 7-day-old pupae insect stages. Results obtained (Table 1) showed that the LC_{50} of indoxacarb on the third larval instar, 1-day – old-pupae, and 7-day - old - pupae of peach fruit fly were 0.04, 0.05 and 0.52 ppm, respectively. The slope values for indoxacarb were 0.84, 0.71 and 0.77 for the 3rd larval instar, 1-day old pupae and 7-day old pupae of *B. zonata,* respectively. The LC_{50} values for wood vinegar were 0.87, 0.98 and 1.25% for the three different tested insect stages, respectively (Table 1). The slope values for the toxicity lines of wood vinegar were 2.6, 2.51 and 1.9 for the 3rd larval instar, 1-day old pupae and 7-day old pupae of the peach fruit fly, respectively.

Single-cell gel electrophoresis (comet assay)

Figure 1 depicts the normal DNA damage sustained by *B. zonata* body cells after being exposed to the LC_{50} concentrations of indoxacarb and wood vinegar. Due to DNA strand breaks, DNA fragments travel from the nucleoid core toward the anode after electrophoresis, generating a comet-like morphology. The body cells in the control samples have spherical, undamaged DNA (Figure 1-A and 1-B). Indoxacarb and wood vinegar treatments caused a unique tail-like extension in the nuclei of the body cells of insects, indicating DNA damage and strand breaks in those cells (Figures 1-C, 1-D, 1-E, and 1-F). By using a comet test, the DNA damage in the body cells of the three different stages of *B. zonata* that had been exposed to the LC_{50} concentrations of indoxacarb and wood vinegar was quantitatively analysed and expressed as tail length (TL), DNA tail %, and tail moment (TM). DNA tail % refers to the percentage of DNA that is in the tail, and the tail moment (TM), which is the product of DNA tail% and tail length (TL), is thought to be the parameter with the greatest responsiveness (Table 2). Insect body cells treated with indoxacarb and wood vinegar showed significantly ($P \leq 0.05$) longer tails than control insect body cells (Figure 1, Table 2). When pre-pupa were treated with indoxacarb and wood vinegar, adult body cells (male and female) emerged with mean tail lengths of 7.7, 5.9, 7.9 and 8.1, respectively, compared to 6.8 and 8.5 for the control. In addition, 1-day-old pupae treated with indoxacarb and wood vinegar had tail length values of 8.9, 6.11, 8.4 and 8 compared to 6.8 and 8.5 for the control. The tail lengths of pupae that had received indoxacarb and wood vinegar treatment were 6, 4.2, 6.9 and 8.2 at 7 days old, as opposed to 6.8 and 8.5 for the control. It was found that the tail length results in insect body cells from males and females of different developmental stages treated with indoxacarb and wood vinegar were typically close to each other when using ANOVA to compare the tail length results between those treated with indoxacarb and those treated with wood vinegar. The percentage of DNA in the tail region (DNA tail%) was assumed to be the most visible measure of DNA damage.

Table 1. Lethal effect of indoxacarb and wood vinegar against 3rd larval instar, 1-day- old pupae and 7-day- old pupae of *B. zonata* under laboratory conditions.

				Confidence limits							
	LC_{25}	LC_{50}	LC_{90}	LC_{25}		LC_{50}		LC_{90}			
Stage	[ppm]	[ppm]	[ppm]	Lower	Upper	Lower	Upper	Lower	Upper	Slope±SD	Chi Square
indoxacarb											
3rd larval instar	0.04	0.36	12.10	0.02	0.11	0.24	0.45	5.53	52.73	0.84±0.14	0.072
1-day old Pupae	0.05	0.44	28.43	0.01	0.12	0.21	0.67	11.18	209.90	0.71±0.14	3.010
7-day old Pupae	0.52	3.95	196.54	0.14	0.99	2.64	5.54	69.66	1369.61	0.77±0.14	1.340
wood vinegar											
3rd larval instar	0.48	0.87	2.71	0.36	0.58	0.75	1.00	2.71	6.02	2.60±0.33	1.810
1-day old Pupae	0.53	0.98	3.18	0.40	0.63	0.85	1.13	2.44	4.89	2.510±0.33	1.100
7-day old Pupae	0.56	1.25	5.78	0.41	0.69	1.05	1.46	4.34	8.72	1.90±0.20	4.160

Table 2. DNA damage analysis, assessed as tail length (TL) (µm) in the body cells of male and female adults of *Bactocera zonata* treated with LC_{50} of indoxacarb and wood vinegar in 3rd larval instar, 1-day-old and 7-day old pupal insect stages.

	Indoxacarb		Wood vinegar	
Treatment	**Male**	**Female**	**Male**	**Female**
Tail length (TL) (µm)				
Control(untreated)	6.8 a	8.5 a	6.8 a	8.5 a
3rd larval instar	7.7 b	5.9 ab	7.9 b	8.1 a
1-day old pupae	8.9 c	6.1 ab	8.4 c	8.0 a
7-days old pupae	6.0 a	4.2 b	6.9 a	8.2 a
Tail DNA %				
Control(untreated)	7.9 a	6.90 a	7.9 a	6.9 a
Pre-pupa- 3rd larval instar	24.8 b	9.96 b	28.0 b	26.9 b
1-day old pupae	23.4 b	18.0 c	29.4 b	8.8 a
7-days old pupae	22.0 b	13.0 b	16.0 a	21.4 c
Tail moment				
Control(untreated)				
Pre-pupa- 3rd larval instar	2.4 b	0.6 a	2.7 b	2.80 b
1-day old pupae	2.7 c	1.6 b	2.4 b	0.73 a
7-days old pupae	1.6 d	0.6 a	1.5 c	2.00 c
% total damage (% of number of damaged DNA cells /total number of tested cells)				
Control(untreated)	13.7 a	11.9 a	13.7 a	11.9 a
Pre-pupa- 3rd larval instar	11.5 b	13.8 b	19.1 b	9.9 b
1-day old pupae	17.0 c	16.8 c	10.5 c	16.5 c
7-days old pupae	11.0 b	11.5 a	9.3 c	11.3 a

Values followed by the same letters in the same column are not significantly different at P=0.05, Values are expressed as means of three replicates.

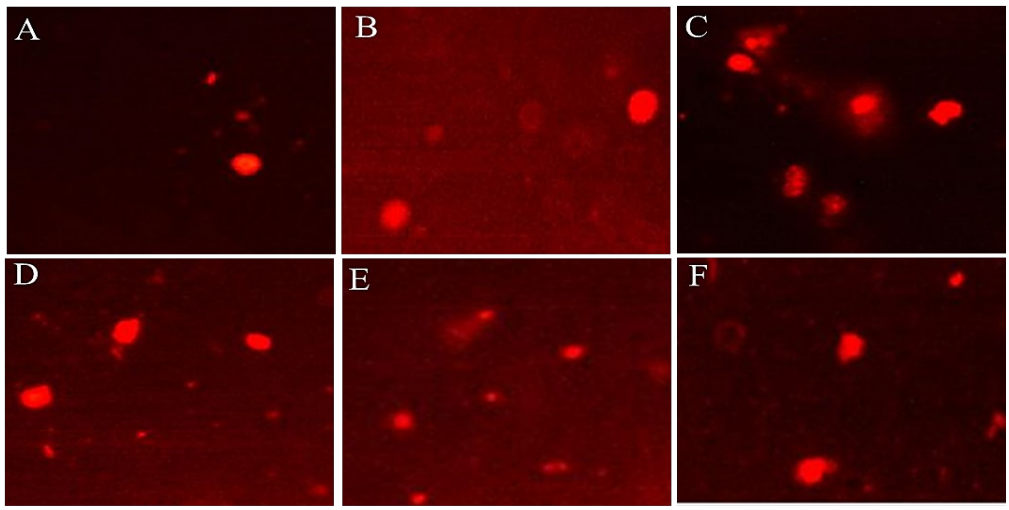

Figure 1. Typical DNA comet from the body of *B. zonata* adults. (A and B) represent males and females control, respectively, C and (D) represent males and females that emerged from 3rd larval instar treated with indoxacarb, respectively, (E and F) represent males and females that emerged from 3rd larval instar treated with wood vinegar, respectively.

On the other hand, the tail lengths of pupae that had been treated with indoxacarb and wood vinegar at 7 days old were 6, 4.2, 6.9 and 8.2, compared to 6.8 and 8.5 for the control. Using ANOVA to compare the tail length results between insect body cells from males and females of three different developmental stages treated with indoxacarb and those treated with wood vinegar were generally close to each other. The most presentable parameter of DNA damage was thought to be the percentage of DNA in the tail region (DNA tail%). Table 2 demonstrate that, when compared to control insect body cells, insect body cells treated with indoxacarb and wood vinegar have considerably higher DNA tail% and TM values. Additionally, the results of DNA tail% and TM tests showed that insect body cell samples treated with indoxacarb and wood vinegar were close to each other.

The above-mentioned results indicated that while having different mechanisms of action, the two investigated chemicals, indoxacarb and wood vinegar, possessed a comparable genotoxic effect on the insect body cells. Additionally, the results obtained (Table 2) that, when insect body cells of different stages were treated with indoxacarb, and by using the ANOVA test, the values for DNA tail length, DNA tail %, and tail moment in males were significantly higher than in females. If DNA migration is not increased or decreased, the comet assay may identify cells with DNA cross-linking defects. The results of this study (Table 6) showed that there was a lower significant difference between the three stages of the insect's body cells treated with indoxacarb and wood vinegar (pre pupae, 1-day-old pupae, and 7-day-old pupae), which indicates the effectiveness of both indoxacarb and wood vinegar on the three stages in controlling the insect throughout its life cycle.

Identification of polyphenol by HPLC

The results obtained on the phenolic compounds fraction are presented in Table 3. The most abundant monocular compounds in the plant were Pyro catechol (4313.41 µg/ml), Catechin (2451 µg/ml), Naringenin (2451.91 µg/ml) and Chlorogenic acid (919.90 µg/ml).

Table 3. Polyphenols identified and quantified by HPLC.

Compound	Area	Concentration (µg/ml)
Gallic acid	345.39	280.87
Chlorogenic acid	701.68	919.90
Catechin	996.12	2451.74
Methyl gallate	1216.58	757.98
Coffeic acid	487.86	414.73
Syringic acid	164.82	164.35
Pyro catechol	3459.98	4313.41
Rutin	431.74	536.02
Ellagic acid	20.32	51.47
Coumaric acid	28.08	8.42
Vanillin	130.26	76.58
Ferulic acid	12.97	9.56
Naringenin	2287.93	2450.91
Daidzein	129.86	78.51
Querectin	216.58	239.96
Cinnamic acid	498.60	117.61
Apigenin	622.80	441.66
Kaempferol	0.00	0.00
Hesperetin	73.17	36.26

Discussion

This study tested the susceptibility of the 3rd larval instar, 1-day-old pupae, and 7-day-old pupae of the peach fruit fly, *B. zonata,* to wood vinegar and indoxacarb in sandy soil under laboratory conditions. Results obtained showed that vinegar caused larval and pupal mortality before adult emergence at different tested concentrations, which is in agreement with previous studies (Sapindal *et al.,* 2018; Tarasin, 2013). Wood vinegar has compounds which can interfere with the insect endocrine system and thus can interrupt many larval physiological activities such as homeostasis, behavior and insect growth (Mordue & Nisbet, 2000). Consequently, insect adults cannot emerge from the pupal stage and finally die.

The structure, function, and repair mechanisms of DNA are comparable across all organisms. Because of this similarity, the comet assay can be used to evaluate the genome toxicity of different chemicals in different organisms and identify how they can affect humans and the environment. The comet assay allows researchers to examine DNA damage without prior knowledge of the karyotype or genome structure, making it a viable technique for studying non-model species (Afify & Negm, 2018).

Based on the analysis of variance of the comet test data, the LC_{50} of indoxacarb or wood vinegar used in the control of *B. zonata* had an obviously significant effect on DNA damage compared to the control, which is in agreement with previous findings (Ghazawy *et al.,* 2021; Mona *et al.,* 2022). Traditional pesticides are poisonous, which has an impact on both humans and the environment. Consequences such as apoptosis which include DNA damage and the suppression of DNA repair processes have been reported (Eid *et al.,* 2017). Additionally, chromosomal abnormalities, reproductive issues, genetic illnesses, and cancer may result from prolonged exposure to these substances (Augustyniak *et al.,* 2016). The results obtained in the current study indicated the presence of genotoxic impact of the tested indoxacarb and wood vinegar on *B. zonata*. Despite having an insect repellent effect, wood vinegar can be used to kill mollusks in a safe, inexpensive, and environmentally acceptable manner (Bouket *et al.,* 2022). Wood vinegar has a similar genotoxic effect of indoxacarb on *B. zonata*. Considering that most non-target aquatic and soil organisms are either not affected by wood vinegar at all or are not affected by it, using it in a pest management programme may reduce the environmental risk associated with synthetic pesticides. (Dewi *et al.,* 2020). Therefore, additional research is required to assess the side effects of wood vinegar.

Additionally, the current study showed that rice husk-derived wood vinegar had larvicidal efficacy against peach fruit flies. Wood vinegar's biochemical method of action is recognised to be used as a natural insecticide due to its chemical components. Acetic acid, is one of the chemical components of wood vinegar, proved useful for promoting growth and preventing pest infestation and plant diseases. Likewise, methanol is known as a growth promoter and phenols and their derivatives as insect and plant disease inhibitors (Dewi *et al.,* 2020). Furthermore, the effectiveness of wood vinegar against peach fruit flies may be due to the high concentration of bioactive and highly antioxidant polyphenolic chemicals it contains, as demonstrated by the presence of gallic acid identified by HPLC analysis of a wood vinegar extract, and reported earlier as an effective insecticide (Huang *et al.,* 2011; Marques *et al*., 2016). Likewise, cinnamic acid was reported earlier to have a high insect larvicidal and growth inhibition activity against *Tribolium castaneum* (Buxton *et al.,* 2020). Many other compounds identified in this study to be present in the wood vinegar has been reported earlier to have toxicity against insects (Acheuk & Doumandji-Mitiche, 2013; Bahrami *et al.,* 2018; Goławska *et al.,* 2004; 2008; Hassan *et al.,* 2021; Huang *et al.,* 2011).

It can be concluded from this study that indoxacarb and wood vinegar were equally effective in eradicating *B. zonata* because of their ability to cause DNA damage. Using wood vinegar is a safe approach to controlling pests and providing healthy, environmentally friendly, and sustainable food while reducing greenhouse gas emissions. According to the study's findings, both wood vinegar and indoxacarb are genotoxic pesticides. In subsequent investigations, the genotoxic effects of wood vinegar and indoxacarb against insects or other species with a closer genetic relationship to humans will be evaluated.

الملخص

نجم، أميرة أحمد كامل حسن، بلال علي عبد الحميد علي، هيثم محمود جاد الشرقاوي وأميرة عفيفي. 2025. استخدام خل الخشب كمبيد طبيعي لتقليل غازات الدفيئة في مواجهة التغيرات المناخية ومقارنة تأثيره مع الإندوكساكارب ضدّ ذبابة الدراق. مجلة وقاية النبات العربية، 43(3):353–360. https://doi.org/10.22268/AJPP-001334

في إطار البحث عن طرائق آمنة لإنتاج غذاء صحي ومستدام وصديق للبيئة ومواءمتها مع تقليل انبعاثات غازات الدفيئة لتحقيق الحياد المناخي بما يتماشى مع أهداف التنمية المستدامة، هدفت الدراسة الحالية إلى تقييم فعالية خلّ الخشب، وهو مبيد طبيعي مصنوع من قشّ الأرز، والإندوكساكارب ضدّ يرقات العمر الثالث والعذارى بعمر يوم واحد وسبعة أيام لذبابة الدراق. أظهرت المركبات المختبرة (خلّ الخشب والاندوكساكارب) سميّة ضدّ المراحل العمرية المختلفة لذبابة الدراق. بالإضافة إلى القدرة السميّة الجينية للإندوكساكارب، كمبيد حشري صناعي، وخلّ الخشب كمنتج طبيعي ناتج عن الانحلال الحراري للمخلفات الزراعية، ضدّ يرقات العمر الثالث، والعذارى بعمر يومٍ واحد وسبعة أيام لذبابة الدراق. تمّ استخدام طريقة اختبار المذنّب/كوميت (comet test) على الطور اليافع الخارج من معاملة يرقات العمر الثالث وعذارى بعمر يوم واحد وسبعة أيام لذبابة الدراق في الرمل لمعرفة مدى التشوه في الحمض النووي المجيني. وقد أثبتت التجارب أنه بالمقارنة مع الشاهد، فإن الحشرات المعالجة بالإندوكساكارب وخلّ الخشب زادت بشكل كبير من طول الذيل، عزم الذيل، نسبة الحمض النووي في الذيل وعلى جميع قيم الحمض النووي المعبر عنها في خلايا جسم الحشرة.

كلمات مفتاحية: ذبابة الدراق، اختبار كوميت، إندوكساكارب، خلّ الخشب، غاز الدفيئة، التغير المناخي.

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