Evaluation of the Efficacy of Commercial Plant Extracts of Palazin and Tondxier Against the Red Flour Beetle *Tribolium castaneum* (Herbest) Under Laboratory Conditions

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Abstract

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The Effect of Tondxier and Palazin plant extracts on the mortality of the flour beetle *T. castaneum* (Herb) was investigated. Plant extracts were separately tested under laboratory conditions against the beetles using a topical spray. Beetles were sprayed with plant suspensions at different concentrations (1, 2 and 3 ml/L) for both Tondxier and Palazin. Mortality was recorded daily for 15 days while beetles were kept on wheat flour. Both Tondxier and Palazin had an impact on *T. castaneum*. Commercial Tondxier was more effective than Palazin at the same concentrations tested. Nevertheless, significant differences in the mortality rate at the end of the experiments between second, and 5th instar larvae and adults treated with Palazin and Tondxier extracts were observed. Second and 5th instar larvae were more susceptible, and adults were more resistant to Palazin and Tondxier treatments. This study showed that mortality rate increases with increased concentration and length of exposure times. Results obtained suggested that the two plant extracts of Palazin and Tondxier used in this study can be used as potent insect control agents.

Keywords: Palazin, Tondxier, *Tribolium castaneum*, larvae.

Introduction

Wheat (*Triticum aestivum* L.) is a vital food grain crop that is planted refined annually in an area of 220,000,000 ha across the world and produces around 21% of the food calories and 20% of the protein for more than 4.5 billion people in most countries (Magan & Aldred, 2007). The target of wheat crop yield in Iraq is for consumption and export. It is important to increase efforts not only for enhancing productivity but also to minimize huge postharvest losses across the food supply chain to achieve this target. Stored product pests, especially insects can cause postharvest losses around 9% in developed countries and more than 20% in developing countries (Pimentel, 2009).

Wheat is seriously infested by several insects during storage, such as the Flour red beetle, *Tribolium castenium* Herbst. Granary weevil, *Sitophilus granarius* L., Khapra beetle, *Trogoderma granarium* Everts. Rice weevil, *Sitophilus oryzae* L., Angoumois grain moth, *Sitotroga cerealella* (Olivier) and Lesser grain borer, *Rhyzopertha dominica* L. The red flour beetle, *T. castenium* is the most important insect of stored cereals, including wheat, causing significant losses of up to 18.30% (Rashid *et al.*, 2012). Adults and larvae of *T. castenium* are internal feeders, affecting the quantity and quality of grains (Shankar & Abrol, 2012).

The adult beetles are responsible for increasing the temperature of the grain heaps in storage, leading to the development of mould (Shankar & Abrol, 2012), which destroys the quality of grains. Chemical insecticides are commonly used to control stored grain pests; however, indiscriminate use has resulted in resistance and toxic residues in food grains (Popović *et al.* 2014). In addition, many synthetic fumigants used for stored grain protection, are being phased out due to ozone layer depletion and control failures, and some insects have gained resistance to insecticides (Zettler, 1991). These problems and the growing awareness of environmental hazards have attracted attention to the use of products of plant origin that are biodegradable, environment friendly, and safe for human health (Isman & Seffrin, 2014).

In recent years, there have been positive reports on the use of commercial plant extracts as grain protectants with a good degree of success against insects and other stored grain pests. Plant extracts partially replaced synthetic insecticides, and many natural commercial products have been well recognized to possess multiple useful biological features against insect pests (Isman, 2000; Mousa *et al*., 2013).

The objective of this study was to assess the use of Palazin and Tondxier extracts against adult and larval stages of *T. castaneum*.

Materials and Methods

Tribolium castaneum rearing

T. castaneum was collected from infested wheat for rearing in the lab. *T. castaneum* was collected and placed wide jars then covered with muslin cloth. For rearing purposes, beetles were kept in the lab for three months. *T. castaneum* adults were kept in the breeding jars in an uninfested wheat medium. The beetle samples were placed in an incubator at a temperature of 28±2°C and a relative humidity of 70±5% for 24 hours, then the beetles were moved from the containers to new jars. The wheat media in which the

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T.castaneum adults were firstly retained for 72 h contained sufficient eggs laid by adult females. In containers, the highest larvae number was reached after eight days. Same size progeny and age were transferred from the stocks. It was additionally held for another period before testing (Sagheer *et al.,* 2014).

Preparation of plant extracts

Commercial formulations of Plant extracts (Palazin and Tondxier) were obtained from different outlets in Baghdad, Iraq (Table 1). Three different concentrations of each commercial plant extract were prepared. From the stock solution (Palazin and Tondxier) 1, 2, and 3 ml/L concentrations were prepared. 10 adults were placed in each Petri dish (9 cm). Plant extracts were spread uniformly on the adults. Insect mortality was recorded 1, 3, 5, 7, 9, 11 and 15 days after treatment. For each concentration, five replicates were tested. Corrected mortality was calculated using the following formula (Abbott, 1925):

$$\% \text{ Mortality} = \frac{\text{Samples mortality-control/mortality}}{\text{100-control/mortality}} \text{x100}$$

Table 1. Details on the commercial formulations of plant extracts Palazin and Tondxier and dosage used in this study.

Trade name	Plant extracted from	Dosage rate /L.	Company
Palazin	*Eucalyptus*	1.0 ml	Kimia
65% SL		2.0 ml	Sabaz
Tondxier	Garlic &pepper	1.0 ml	Kimia
80% EC		2.0 ml	Sabaz

Effect of different concentrations of Plant extracts Palazin and Tondxier against *T. castaneum* adults

Five plate replicates, each with 10 adults were treated with either Palazin or Tondxier plant extracts. Individuals of each replicate were treated with 2 ml of each concentration (1, 2, 3 ml/L) using a hand sprayer. Controls were treated with distilled water only. After 10 min at room temperature, the dishes each with 5 g of sterilized wheat were covered with lids and incubated at 28±2°C and 70±5% RH. After 24 h, insect mortality was recorded until 15 days later. Dead adults were removed from the dishes and mortality was documented 1, 3, 5, 7, 9, 11 and 15 days after treatment.

Statistical analysis

The mortality rate was corrected using the Abbott formula (Abbott, 1925). Experiments were statistical analyzed using GenStat (version 16). Data were transferred using arcsine square root transformation when it was needed to meet the assumption of normality. The effect of the life stage of *T. castaneum* on the efficacy of either Palazin or Tondxier, was analysed using two-factor repeated measurement analysis ANOVA. The effect of the concentration of each plant extracts Palazin and Tondxier on the mortality of *T. castaneum* was statistically analyzed separately by using ANOVA analysis (two-factor repeated measurement). The LSD test was used at a probability level of 5% to compare means.

Results and Discussion

The effect of Tondxier extract on the mortality of different larval instars and adults of *T. castaneum*

In the first experiment with the Plant extract of Tondxier, significant differences ($P < 0.01$) in *T. castaneum* mortality rate were noted with different concentrations for each of the three different insect stages 15 days after treatment. The highest mortality level was noted with the highest Tondxier dosage of 3 ml/L for the three different insect stages (Table 2), suggesting that all the larval stages and adults were susceptible to Tondxier at the highest concentration used. On the other hand, susceptibility decreased with the age of the beetle indicating that older larvae and adults were more tolerant to the treatment when incubated at 28±2°C. 2nd instar larvae mortality rate was 96.56% and 90%, for 5th instar larvae in comparison with 80.62% for adults (Table 2).

Table 2. The effect of Tondxier extracts concentrations on the corrected mortality of larval instars and adults of *T. castaneum* at different time periods after application.

Insect stages	Conc. ml/L	Corrected mortality (%) after different periods (days) following application							
		1	3	5	7	9	11	13	15
2nd instar larvae	1	32.5	65.0	77.5	100.0	100.0	100.0	100.0	100
	2	70.0	87.5	97.5	100.0	100.0	100.0	100.0	100
	3	80.0	92.5	100.0	100.0	100.0	100.0	100.0	100
5th instar larvae	1	10.0	15.0	30.0	55.0	80.0	97.5	100.0	100
	2	30.0	35.0	75.0	75.0	100.0	100.0	100.0	100
	3	60.0	72.5	87.5	100.0	100.0	100.0	100.0	100
Adults	1	10.0	15.0	22.5	35.0	40.0	45.0	52.5	55
	2	20.0	27.5	40.0	55.0	62.5	70.0	80.0	85
	3	30.0	40.0	82.5	92.5	100.0	100.0	100.0	100

$LSD_{0.05}$ for stages= 2.8; for time = 5.5; for concentration = 3.3

The period time effect after Tondxier application on *T. castaneum* mortality was significant (P< 0.01), in all treatments, and the highest mortality rate was achieved 15 days post-treatment (Table 2). Furthermore, the control mortality of *T. castaneum* larval and adult stages did not exceed 5.0%. The results agreed with what has been reported by Tatun *et al.* (2014) who found that some plant extracts had inhibitory effects on growth and development of *T. castaneum* and other storage products insects. Ahmad (2019) also found that *Z. officinale* (ginger) and *A. sativum* (garlic) were effective against the beetle.

It has been suggested by Mostafa *et al*. (2012), Mislit *et al.* (2020) and Abbas (2022) that the different plant products and bioagents which showed toxicity against storage insects is likely due to the presence of different types of bioactive products. The results obtained were consistent with those from a previous study (Khan *et al*., 2016) which tested the efficacy of several plant acetone and ethanol extracts of *Calotropis procera*, *Verbena tenuisecta*, *Azadirachta indica* and *Parthenium hysterophorus*, as growth inhibitors against red flour beetle, *T. castaneum*. Whereas, petroleum ether extracts of *V. tenuisecta* exhibited growth-inhibiting effects against the flour beetle adults of *T. castaneum*, whereas the highest larvicidal effect was against *C. procera*. These plant extracts studied showed that the commercial plant products used in the study had an insecticidal characteristic that could be applied for the control of stored grain insects.

The effect of Palazin extract on the mortality of different larval instars and adults of *T. castaneum*

The result for using Palazin extract showed that high levels of mortality rate were obtained for 2nd and 5th instar larvae 15 days after treatment compared with the adult stage at the highest Palazin extract dosage (Table 3). The highest concentration of 3 ml/L was more effective at the end of the experiment and significant differences were noted with Palazin doses for each stage. The adults were less susceptible than larvae; and the mortality rate at the concentration of 3 ml/L for adults were 79.37% and 87.81% and 93.12% for 5th, 2nd instar larvae, respectively. These mortality rates meant that the old larvae and adults were more tolerant to Palazin extract than young larvae. The mortality of *T. castaneum* larval stages and adults in the control treatment did not exceed 5.0%.

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Table 3. The effect of Palazin extracts concentrations on the corrected mortality of larval instars and adults of *T. castaneum* 1, 3, 5, 7, 9, 11, 13 and 15 days after extract application.

Insect stages	Conc. ml/L	Corrected mortality (%) after different periods (days) following application							
		1	3	5	7	9	11	13	15
2nd instar larvae	1	20.0	35.0	40.0	52.5	70.0	77.5	97.5	97.5
	2	35.0	55.0	90.0	95.0	100.0	100.0	100.0	100.0
	3	52.5	92.5	100.0	100.0	100.0	100.0	100.0	100.0
5th instar larvae	1	10.0	25.0	32.5	35.0	45.0	72.5	77.5	87.5
	2	27.2	45.0	62.5	67.5	75.0	100.0	100.0	100.0
	3	42.5	85.0	87.5	92.5	95.0	100.0	100.0	100.0
Adults	1	0.0	12.5	22.5	35.0	40.0	45.0	47.5	55.0
	2	12.5	25.0	40.0	50.0	60.0	67.5	75.0	85.0
	3	27.5	50.0	70.0	87.5	100.0	100.0	100.0	100.0

$LSD_{0.05}$ of stages= 2.9; for time = 5.7; for concentration = 3.4

الملخص

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تمّت دراسة تأثير المستخلصين النباتيين Tondxier و Palazin في نسبة موت خنفساء الطحين (الدقيق) *T. castaneum* (Herb). أُختبرت المستخلصات النباتية بشكل منفصل على الخنافس باستخدام مرشة صغيرة تحت ظروف المختبر. تمّ رش الخنافس بتراكيز مختلفة (1، 2 و 3 مل/ليتر) بكلٍ من Tondxier و Palazin. سُجّلت الحشرات الميتة يومياً لمدة 15 يوماً أثناء تغذية الخنافس على دقيق القمح. بيّنت نتائج معاملات Tondxier و Palazin وجود تأثير معنوي على *T. castaneum*. كان المستخلص النباتي التجاري Tondxier أكثر فعالية مقارنة بنظيره Palazin عند التراكيز المختبرة نفسها؛ ومع ذلك لوحظت فروق معنوية في معدلات موت الحشرة في نهاية التجارب بين يرقات العمر الثاني والخامس والبالغات المعاملة

بمستخلصي Palazin و Tondxier. كانت يرقات الطور الثاني والخامس أكثر حساسية، في حين كانت البالغات أكثر مقاومة للمعاملات Palazin و Tondxier. أظهرت هذه الدراسة أن معدل موت الحشرة يزداد مع زيادة التركيز وطول فترة التعرض. ومع ذلك، أشارت النتائج المتحصّل عليها إلى إمكانية استخدام المستخلصين النباتيين Palazin و Tondxier المختبرين في هذه الدراسة كعوامل فعالة لمكافحة هذه الحشرة.

كلمات مفتاحية: بلازين، توندكسير ، *Tribolium castaneum*، يرقات.

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