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Effect of the Exogenous Foliar Sprays of Micro-Doses of Fructose and Glucose, on Egg-Laying of Cydia Pomonella L. and its Oviposition Site Selection in Apple Orchard

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EFFECT OF THE EXOGENOUS FOLIAR SPRAYS OF MICRO-DOSES OF FRUCTOSE AND GLUCOSE, ON EGG-LAYING OF *CYDIA POMONELLA* L. AND ITS OVIPOSITION SITE SELECTION IN APPLEORCHARD

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ABSTRACT

A better understanding of the new concept of 'sweet immunity', represented by the use of sugars to reduce the susceptibility of plants to pests, would help implication of this knowledge within a new apple orchard protection strategy against *Cydia pomonella*. Behavioral and effect of two sugars, fructose (100 ppm), glucose (100 ppm), and chemical insecticide (deltamethrin) on egg-laying of *C. pomonella* were evaluated on two varieties (*Golden delicious* and *Royal gala).* The spraying of the two sugars, besides the insecticide, during the first, the third flight on the *Golden delicious* variety and the fourth flight on the *Royal gala* variety reduced significantly the number of eggs laid on leaves and fruits compared with control. Preferred oviposition sites for moths of all flights were leaves than fruits, whereas no eggs were found on branches. Between six studied sites, more eggs were laid on upper surface of the corymb leaves (51.67 %) in all flights of two varieties than fruit with 8.2 %, and none on the branches. Our results indicate that the responses of the codling moth egg-laying to foliar sprays of sugars are probably due to gustatory cues that reduce *C. pomonella* egg-laying, and they may have their importance in the signaling pathways of plant resistance to Lepidoptera.

Keywords: *Cydia pomonella*, glucose, fructose, *Golden delicious*, *Royal gala.*

INTRODUCTION

Among the assorted interactions that occur between insects and plants, host-plant- specific phenomena are significantly advanced and vital. An understanding of the mechanisms of host choice and specificity in plant-feeding insects is very important in explaining the ecological relationships among specific insects and plants. Such understanding is also essential in developing practical ways to manipulate the two groups of organisms to our advantage (Hsiao, 1974). Sugars on the leaf surface were previously thought to be of no importance for insect-host plant interactions when selecting an egg-laying site (Derridj et al., 2012). Host plant selection occurs in three successive phases governed by volatile cues, visual cues (color) and non-volatile cues (Finch and Collier, 2000). Plant metabolites have a function as cues for females. Besides volatiles components, Lombarkia and Derridj (2002) found that primary metabolites present on the surface of leaves and fruits of apple, have the role of kairomones. Furthermore, researchers (Derridj et al., 2012; Ondet and Gorski, 2015; Arnault et al., 2015, 2016; Brahim and Lombarkia, 2018) have shown an increased interest in the concept of foliar sprays of sugars on apple trees to reduce damage of codling moth in commercial orchards.

The relationship between preference of ovipositing females for certain plant species and growth, survival, and reproduction of offspring on those plants has been a central problem in the theory of insect/plant interactions (Thompson, 1988). Fruit odor from apples has a wide range of effects on codling moth behavior like distribution of eggs by *Cydia pomonella* females on plants (Wearing, 2016). Longer survival of *C. pomonella* offspring isn't solely ensured by the choice of an appropriate oviposition site by females, however, by the correct adhesion of the deposited eggs to the current oviposition sites (Al Bitar et al., 2012). Wood (1965) has showed that the distribution of eggs wasn't stricken by aspect and trees with the foremost fruit cared-for have the foremost eggs. Geier (1963) agree that in uniformly infested, homogenized orchards, egg and damage distribution area unit just about random between trees. Furthermore by stimulating oviposition in *C. pomonella* females. Jackson (1979) and Blomfield et al., (1997) indicated that the scale of fruit clusters and the numbers of eggs deposited are positively correlated.

The hypothesis about the effect of foliar sprays of sugars in ppm to reduce egg- laying of *C. pomonella* on two apple varieties in orchard and explore oviposition behaviour, seeks to help future research into this idea.

MATERIALS AND METHODS

Treatments

The effect of fructose, glucose, and conventional insecticide (deltamethrin) on egg-laying of *C. pomonella* was evaluated in two different study sites located in Beni Fedhala, province of Batna- Eastern Algeria (2019) : 35°21′21,6″ N, 006°01′ 16,5″ E, *Royal gala*, 2ha; 35°21′12,4″ N, 006°01′ 19,1″ E, *Golden delicious*, 0.8 ha. In each site, the orchard (the age of trees is 9 years and managed below common practices of the zone) was divided into four homogeneous randomized Latin square plots and each plot contained three trees (Table 1). The experimental data was based upon studies of Derridj et al., (2012) focused on treatments with an interval of twenty days in the morning.

Table 1: Tested modalities and their dose.

Treatments	Producing firm	Doses
Control (Untreated)		Control (Untreated)
Fructose	Fluka Biochemika	100 ppm (10 g 100 l-1)
Glucose	Fluka Biochemika	100 ppm (10 g 100 l-1)
Decis 25 EC containing 25g/l Deltamethrin	Bayer	(0.5 l) 1000 l1

The treatments were applied using an electrical pressure sprayer (12 V-12 Ah), capacity 16 L, from flowering to harvest.

Oviposition Site Selection

Three types of sampling units were used in the study, fruits, branches, and leaves (upper surface corymb leaves, lower surface corymb leaves, upper surface out corymb leaves, lower surface out corymb leaves). We sampled four trees per variety per period of laying (knowing that the peaks of egg-laying periods on *Golden delicious* and *Royal gala* varieties were determined in the studies of Tiffrent and Lombarkia (2021); Tiffrent and Lombarkia (in press) in the same sites and during the same year. Two branches of 10 to 20 cm long were removed from the bottom zone (Z1) and two from the top zone (Z2) at each of the four compass points of the sampled trees (Blomefield et al., 1997; Lombarkia et al., 2013). The presence of eggs on leaf surfaces, branches and fruits were confirmed using a binocular.

Statistical Analysis

Statistical analysis for mean number of eggs per apple tree was performed by ANOVA and Kruskal-Wallis test, using SPSS software. The percentage of eggs in all flights of the two varieties was analysed with χ2 test and the preferred oviposition sites for the four modalities were compared by the analysis of variance (two way ANOVA followed by Scheffe test).

RESULTS AND DISCUSSION

Sugars Effects on the Intensity of Cydia Pomonella Egg-Laying

Spraying of sugars reduced the number of eggs during first flight in *Golden delicious* variety. The ANOVA analysis and Kruskal-Wallis test, identifies two bands, control (7.25 ± 0.63, "a" group), fructose, glucose and insecticide 1.25 ± 0.62, 0.5 ± 0.5 and 1.75 ± 0.85 respectively ("b" group), (Figure 1).

In addition foliar sprays of each sugar type (fructose and glucose) alone influenced significantly the mean of eggs during the third flight in *Golden delicious* variety compared to the control. The analysis of variance identifies two groups, control (10.5 ± 0.5, "a" group), fructose, glucose, and insecticide 5.75 ± 0.75, 5.75 ± 0.47 and 5.25 ± 1.1 respectively ("b" group), (Figure 2).

However, foliar application of fructose and glucose didn't reduce the mean number of eggs during the second flight in *Royal gala* variety. The statistical analysis identifies three groups: control (2.75 ± 0.47) and glucose (2.5 ± 0.86) form the first group; whereas fructose (8.25 ± 0.75) constitutes the second group and the insecticide (0.75 ± 0.75) the third group (Table 2).

On the other hand, the treatments of sugars and insecticide stimulated a decrease in the number of eggs during the fourth flight in *Royal gala* variety. ANOVA analysis followed by Kruskal-Wallis test, identifies two bands: control (9.25 ± 0.2 form alone the "a" group, while fructose (1.25 ± 0.47, glucose (2.0 ± 0.91) and insecticide (1.25 ± 0.97) represent the "b" group (Figure 3).

Interestingly, the concept of the exogenous foliar application at doses 100 ppm of glucose and fructose was observed to reduce significantly eggs number during all flights (exception the second) on the two studied varieties (*Royal gala* and *Golden delicious*) compared to the untreated. This finding is supported by the study of Lombarkia and Derridj (2008) which confirmed in bioassays that fructose, sucrose, and sugar alcohols found on the leaf surface may influence preference of codling moth as well as their egg-laying. Similarly, Lombarkia et al., (2013) were tested the link of the sugars in metabolite blend of the leaf surface on codling moth egg-laying behavior. This study found that applications of Madex® (granulovirus) reduced egg-laying and it revealed the effects of active substance blends from leaf surface in reducing the percentage of egg-laying females and egg-laying stimulation (number of eggs per egg-laying female).

Oviposition of C. Pomonella on Leaves, Fruits, and Branches

The preferred oviposition site in the untreated control was the upper surface corymb leaf USCL, with an average of 51.67 % of the eggs in all flights of the two varieties, then fruit with 8.2 %, and none on the branches (the percentages of eggs was analyzed with χ2 test, Table 3).

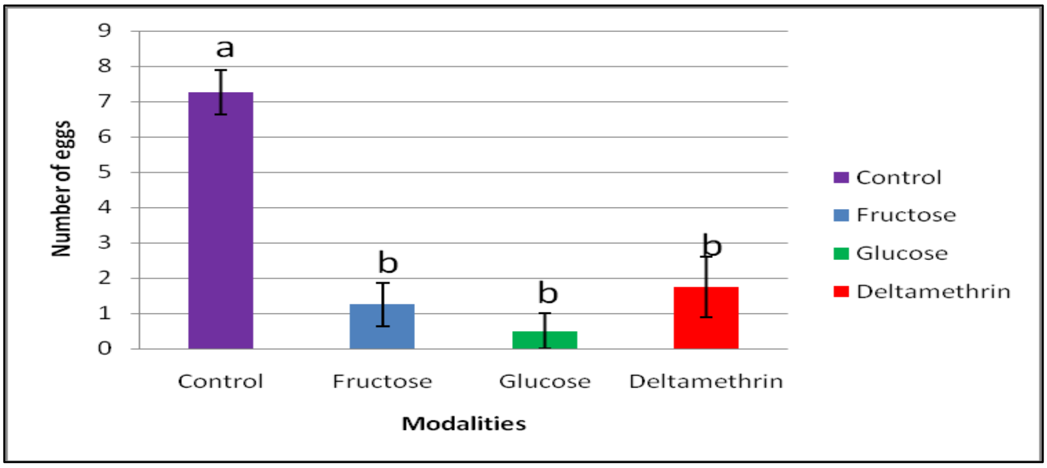

Figure 1: Mean number of eggs per apple tree in *Golden delicious* orchards (n = 4) on different modalities (control, fructose, glucose, insecticide) during the first flight. Different letters indicate a significantly different mean number of eggs at P < 0.05.

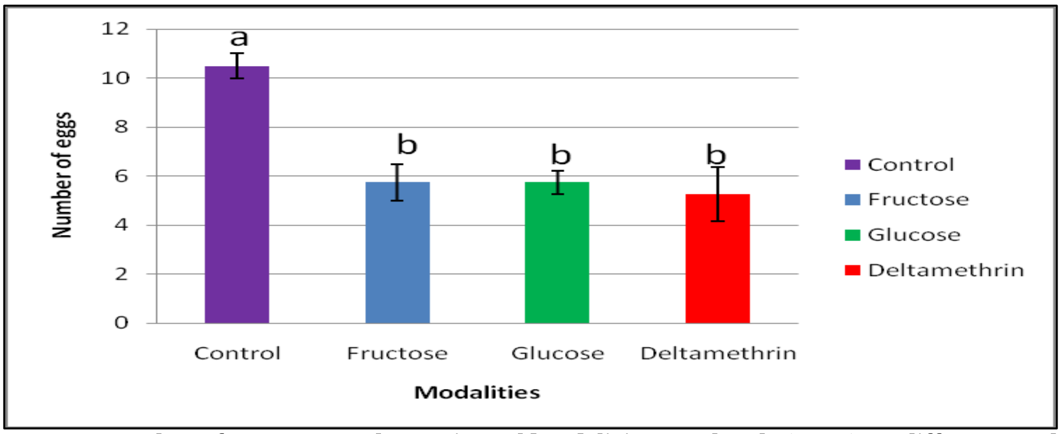

Figure 2: Mean number of eggs per apple tree in *Golden delicious* orchards (n = 4) on different modalities (control, fructose, glucose, insecticide) during the third flight. Different letters indicate a significantly different mean number of eggs at P < 0.05.

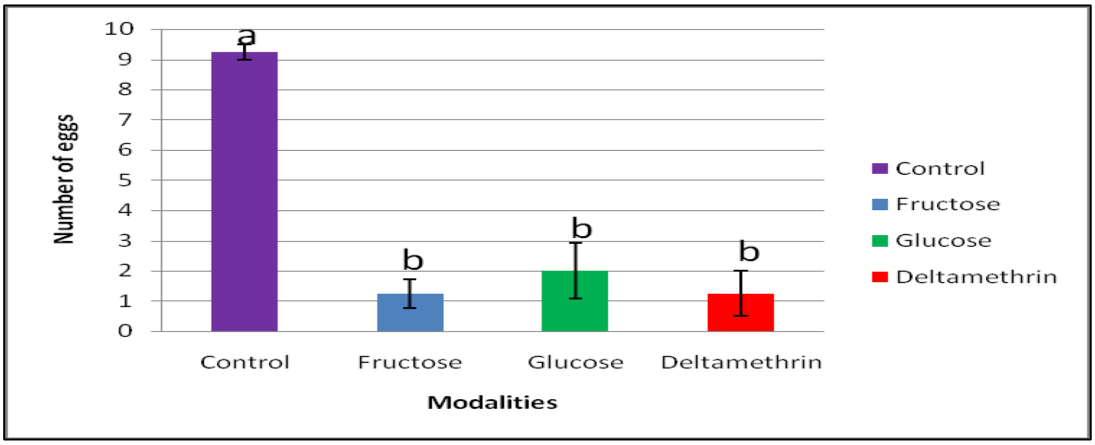

Figure 3: Mean number of eggs per apple tree in *Royal gala* orchards (n = 4) on different modalities (control, fructose, glucose, insecticide) during the fourth flight. Different letters indicate a significantly different mean number of eggs at P < 0.05.

Table 2: Mean number of eggs per apple tree in *Royal gala* orchards (n = 4) on different modalities (control, fructose, glucose, insecticide) during the secondflight.

Treatments	**ean number of eggs (Mean +/- SEM*)**
Control (untreated)	2.75 ± 0.47 a
Fructose 100 ppm	8.25 ± 0.75 b
Glucose 100 ppm	02.5 ± 0.86 a
Insecticide (Deltamethrin)	0.75 ± 0.75 c

** Values indicated with different letters are significantly different at P < 0.05.*

Table 3: Percentages of eggs per oviposition site in orchards (n = 16) on two varieties, *Golden delicious* and *Royal gala* during the first, second, third, and fourth flights in the untreated control.

Oviposition site	**Percentage of eggs**				
	GD first F	GD third F	RG second F	RG fourth F	average
USCL	51,7	38,1	81,8	35,1	51,67
LSCL	3,4	21,4	00	32,4	14,3
USOCL	31,0	14,3	9,1	21,6	19,0
LSOCL	0,0	7,1	9,1	10,8	18,9
Fruit	13,8	19,0	00	00	8,2

USCL: Upper Surface Corymb Leaf; LSCL: Lower Surface Corymb Leaf; USOCL: Upper Surface Out Corymb Leaf; LSOCL: Lower Surface Out Corymb Leaf; GD: Golden Delicious; RG: Royal Gala; F: Flight.

Table 4: Mean number of eggs per oviposition site in orchards (n = 16) on two variety, *Golden delicious* and *Royal gala* during the first, second, third and fourth flights.

Oviposition site	**Mean number of eggs**			
	GD first F	GD third F	RG second F	RG fourth F
USCL*	1,12 a	2,94 a	1,31 a	1,31 a
LSCL*	0,06 b	1,25 b	00 b	1,00 b
USOCL*	0,87 a	1,31 b	1,12 a	0,69 b
LSOCL*	0,31 b	0,44 c	1,12 a	0,44 c
Fruit*	0,31 b	0,87 b	00 b	00 d

** Values indicated with different letters are significantly different at P < 0.05; USCL: Upper Surface Corymb Leaf; LSCL: Lower Surface Corymb Leaf; USOCL: Upper Surface Out Corymb Leaf; LSOCL: Lower Surface Out Corymb Leaf; GD: Golden Delicious; RG: Royal Gala; F: Flight.*

This oviposition site (USCL) was significantly preferred in comparison with other oviposition sites. The two-way ANOVA analysis and the test of Scheffe, identifies four groups (Table 4).

The findings of the current study are consistent with those of Wearing (2016) who confirmed that excessive probabilities of eggs discovered singly inside 10 to 15 cm of the fruit, with maximum eggs on leaves, and the preference of oviposition site among fruit and the adaxial or abaxial leaf surface become variable and cultivar related. Similarly, Blomefield et al., (1997) argues that the preferred oviposition sites on

Granny smith and *Golden delicious* cultivars, in order of preference, were leaves, fruit, and wood. Jackson (1979) noted that most eggs were laid on leaf surfaces (57 % on upper and 35 % on lower), with only 8 % on apples. Maclellan (1962) showed that females lay their eggs in the following order of preference: on leaf surfaces (upper followed by lower) than on fruits.

CONCLUSION

This finding has important implications for developing exogenous sprays of sugars to reduce *C. pomonella* damage by reducing egg laying and stimulate research as an eco-friendly control method for apple trees.

Future researches on chemical analyze of metabolites of the preferred oviposition site selection upper surface corymb leaf were recommended for understanding this effect of sugar in the apple trees' resistance.

AUTHORS CONTRIBUTION

The supervisor of this research work was Prof. Lombarkia Nadia.

CONFLICT OF INTEREST

The authors declare that there is not any conflict of interest regarding the publication of this manuscript.

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