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Influence of salicylic acid and methyl salicylate applications on pea infestation by *Aphis craccivora* and *Acyrthosiphon pisum* and their main insect predators at Sohag Governorate

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Abstract

The present work was conducted during the successive growing seasons of 2022/2023 and 2023/2024 at the Experimental Farm of Shandweel Agricultural Research Station,in Sohag Governorate, Egypt to estimate the influence of foliar spray applications with salicylic acid(SA) and methyl salicylate(MS) on pea infestation *Aphis.craccivora* and *Acyrthosiphon. pisum* infesting three pea cultivars and their associated main predators (*Coccinella undecimpunctata* and *Chrysoperla carnea*). Data revealed that pea cultivars varied significantly in the infestation of pea plants by the aphid species, however, no significant differences were found in the case of insect predators. The pea infestation with the two aphid species was significantly reduced in SA and MS treatments compared to the control during the two growing seasons. Data revealed that MS showed a great effect on the two previous insect predators in both seasons, however, no effect was observed in the case of SA.

Keywords: *Pisum sativum*, Salicylic, Methyle salicylate, Aphid, Predator.

INTRODUCTION

Pea, *Pisum sativum* L. is considered one of the most economic vegetable plant, it is belonging to Leguminoceae family. Pea cultivate through winter season in Egypt. for local consumption and exportation as fresh pods and frozen or dehydrated seeds. Pea plants are subjected to attack by many dangerous insect pests including cowpea aphid, *Aphis craccivora* (Koch.) and pea aphid, *Acrysithiphon pisum* (Shalaby *et al*., 2021 and Kumari *et al.*, 2025). The use of antioxidants such as SA and MS can induce plant resistance against aphid infestation (Mahmoud and Mahfouz, 2015; Elhamahmy, 2016; Hammam *et al.*, 2019; El-Dakkak *et al.,* 2020; Ali *et al.*, 2023 and Mousa and El-Solimany, 2023), also, MS application attracted many natural enemies and coud be as involved in aphid control (Zhu and Park, 2005; Dong and Hwang, 2017 ; Zarkani and Turanli, 2021). Resistant plant cultivars were one of the most effective tool in Integrated Pest Management Programs of aphid and had attention by many investigators (Khan *et al.*, 2015a; Krishna *et al.*, 2019; Chauhan *et al.*, 2023a; Omar *et al*., 2023). However, a little study were carried out on the effect of plant cultivars on the population density of insect predators (Legrand and Barbosa, 2003 ;Khan *et al*., 2015b). Therefore, the present work was conducted to estimate the influence of foliar spray applications with SA and MS on pea infestation with *A. craccivora* and *A. pisum* infesting three pea cultivars and their associated main predators (*Coccinella undecimpunctata* and *Chrysoperla carnea*) under Sohag governorate conditions.

MATERIALS AND METHODS

The experiment was conducted at out during the successive growing seasons of 2022/2023 and 2023/2024 at the Experimental Farm of Shandweel Agricultural Research Station, Sohag Governorate, Egypt. Nine treatments which consisting of combinations of pea cultivars and antioxidants as foliar applications were evaluated. Three pea cultivars, *i.e.,* Goara, Entesar 1 and Master pea were used,. The antioxidants foliar application treatments consisted of SA and MS at 200 ppm, in addition to the control treatment (water only). The treatments were arranged in a split plot design in a completely randomized block with three replicates. Cultivars were assigned to the main plots, while, the subplots were used for the foliar applications.The experimental unit consisted of 5 ridges spaced 0.6 m apart and 3.5 m in length (10.5 m2). Pea seeds were planted on November 2nd in two seasons and agricultural practices were carried out according to the instructions of the Egyptian Ministry of Agriculture and Land Reclamation. No insecticidal treatments were used during the two seasons. SA and MS were sprayed twice on November 30th and December 14th using a hydraulic sprayer. The compounds were dissolved in 10 ml of 70% ethanol and then dispersed in water to achieve the required rates, while, the control plots were treated with ethanol and water only. Sampling conducted weekly from November 16th to March 15th and 14th during the two seasons, respectively. Ten leaves were randomly selected from the lower, middle and upper parts of the pea plant, placed in polyethylene bags and examined for the presence of *A. craccivora* and *A. pisum* were examined using a stereomicroscope. Additionally, ten plants were randomly examined in the field on the same day, and the numbers of adults and larvae of *C. undecimpunctata* and *C. carnea* were recorded.

Data of insect pests and insect predators were statistically analysed by one – way analysis of variance. 'F' test used to evaluate the differences' significance between pea cultivars, foliar spray treatments and their interaction. The Duncan's Multiple Range Test at P = 5% was used to separate the means (Gomez and Gomez, 1984).

RESULT AND DISCUSSION

1. Effect of salicylic acid (SA) and methyl salicylate on infestation by *A craccivora* and *A. pisum* in pea plants

The susceptibility of the three tested pea cultivars to infestation by *Aphis craccivora* and *Acyrthosiphon pisum* during the two studied seasons is shown in Table 1. It is evident that Goara, Entesar 1 and Master pea differed

significantly between the two seasons, except for *A. craccivora* in the first season. The highest mean number of *A. craccivora* was observed in Master pea with an average of 31.91 and 39.96 aphids/ 10 leaves in the two seasons, respectively.,However, Entisar1 appeared as the least susceptible cultivar with an average of 27.80 and 31.10 aphids/ 10 leaves in the two seasons, respectively. Similarly, in the case of *A. pisum*, the highest average number was recorded in Master pea with an average of 3.71 and 14.73 aphids/ 10 leaves in the two seasons, respectively, however, Goara had the lowest infestation with averge of 2.94 and 9.02 aphids/ 10 leaves in the two seasons, respectively, showing insignificant differences with Entesar 1 in both seasons.

The present results are in coincide with Khan *et al.* (2015a), Krishna *et al.* (2019), Chauhan *et al.* (2023a) and Omar *et al*. (2023) who studied the susceptibility of some pea cultivars to infestation with *A. craccivora* and *A. pisum*. They found that the variation in pea genotype influenced significantly on the population density of aphid.

From the same data in Table 1, the pea infestation with the two aphid species was significantly reduced in the SA and MS treatments compared to the control during the two growing seasons of 2022/2023 and 2023/2024. SA had the lowest average numbers of *A. craccivora* with 23.25 and 27.16 aphids/ 10 leaves and *A. pisum* with 2.72 and 8.20 aphids/ 10 leaves during the two seasons, respectively.This was followed by MS with 25.38 and 30.62 aphid/ 10 leaves for *A. craccivora* and with 2.92 and 11.02 aphids/ 10 leaves for *A. pisum* during the two seasons, respectively. However,the control recorded 42.86 and 50.63 for *A. craccivora* and with 4.14 and 15.00 aphids/ 10 leaves for *A. pisum* during the two seasons, respectively. No significantly difference was observed between SA and MS in the first season for both aphid species.

The effect of resistance inducers on aphid infestation were studied by many investigators, SA was investigated by Mahmoud and Mahfouz (2015) on aphid infesting wheat, Elhamahmy (2016) on aphid infesting canola, Hammam *et al.* (2019) on *Aphis gossypii* Glover infesting marjoram plants and Mousa and El-Solimany (2023) on *A. craccivora* infesting pea plants. Also, MS was found as effective resistance inducer against mint aphid, *Eucarazzia elegans* infesting common sage plants (Zarkani and Turanli, 2021) and *Myzus persicae* infesting *Brassica rapa* (Ali *et al.* 2023).

Table (1): Effect of pea cultivars and foliar spray with SA and MS on infestation with *A. craccivora* and *A. pisum* during 2022/2023 and 2023/2024 seasons.

Main effect	Mean number/ 10 leaves			
	Aphis craccivora		*Acyrthosiphon pisum*	
	2022/2023 season	2023/2024 season	2022/2023 season	2023/2024 season
Pea cultivar				
Goara	31.78 a	37.35 b	2.94 b	9.02 b
Entesar 1	27.80 a	31.10 c	3.12 b	10.46 b
Master pea	31.91 a	39.96 a	3.71 a	14.73 a
F. value	**4.98 NS**	**126.45***	**46.79***	**22.77***
Spray treatment				
Salicylic acid	23.25 b	27.16 c	2.72 b	8.20 c
Methyl salicylate	25.38 b	30.62 b	2.92 b	11.02 b
Control	42.86 a	50.63 a	4.14 a	15.00 a
F. value	**186.74***	**328.48***	**89.99***	**18.49***

Means in each column followed by the same letter are not significantly different at the 5% level according to Duncan ,s Multiple Range Test.

Data illustrated in Figure (1) revealed that pea infestation with *A. craccivora* was reduced by 45.74% and 46.35% in the two seasons, respectively, in plots treated with SA, however, *A. pisum* infestation was reduced by 34.33% and 45.35% in the two seasons, respectively. In regard to MS, the infestation with *A. craccivora* reduced by 40.79% and 39.53% in the two seasons, respectively, and *A. pisum* infestation was reduced by 29.40% and 26.54% in the two seasons, respectively. It is clear that SA was more effective than MS as an induced resistant agent in regard to *A. craccivora* and *A. pisum* control in pea production.

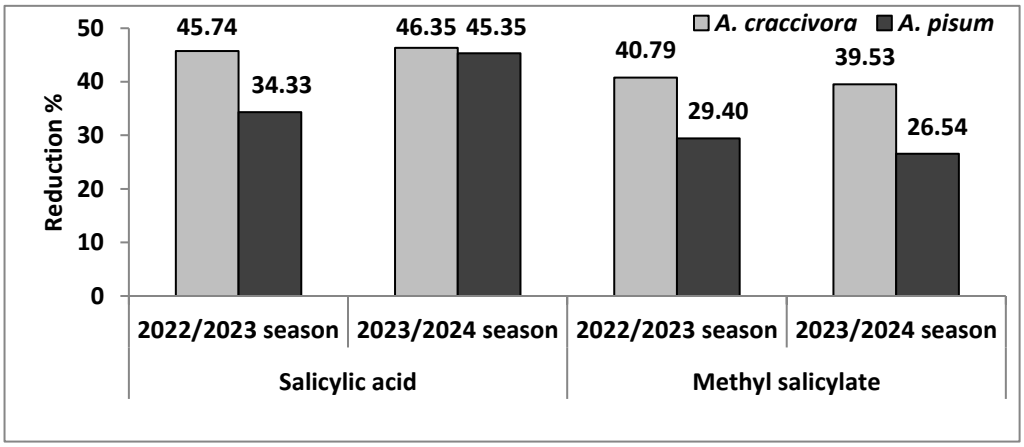

Fig. 1. Effect of salicylic acid (SA) and Methyl salicylate on infestation with *A craccivora* and *A. pisum* infesting pea plants during 2022/2023 and 2023/2024 seasons

Data in Table 2 show the effect of interaction between pea cultivars and foliar spray applications on the infestation of pea plants by *A. craccivora* and *A. pisum*. The interaction between the two factors was insignificant for *A. craccivora* in both seasons, and the same result was obtained for *A. pisum* in the second season, however it was significant in the first season. This indicats that the effects of pea cultivars and foliar spray applications were independent of each other.

For *A. craccivora*, Entesar 1 treated with SA recorded the lowest average numbers of 21.00 and 23.26 aphids/ 10 leaves in the 2022/2023 and 2023/2024 seasons, respectively.However, the highest average numbers of 46.31 and 56.07 aphids/ 10 leaves in the 2022/2023 and 2023/2024 seasons, respectively, were recorded in the untreated (control) Master pea.

For *A. pisum*, Entesar 1 and Goara treated with SA recorded the lowest average numbers of 2.09 and 6.89 aphids/ 10 leaves, respectively, in the 2022/2023 and 2023/2024 seasons, respectively.However, the highest average numbers of 4.41 and 19.50 aphids/ 10 leaves in the 2022/2023 and 2023/2024 seasons, respectively, were recorded in the untreated (control) Entesar 1 and Master pea, respectively.

In the same line, El-Dakkak *et al*. (2020) stated that the interaction between pea cultivars and foliar application of SA was insignificant in the case of *A. craccivora*. In contrast, Mahmoud and Mahfouz (2015) showed that the effect of SA varied according to wheat cultivar, also, Mony *et al.* (2017) stated that the interaction between mustard varieties and SA was significant in both seasons of the study. This may due to the difference in aphid species and kind of plant crop.

Table (2): Effect of the interaction between pea cultivars and spraying treatments on infestation with *A.craccivora* and *A.pisum* during 2022/2023 and 2023/2024 seasons.

Pea cultivar	Spray treatment	Mean number/ 10 leaves			
		Aphis craccivora		*Acyrthosiphon pisum*	
		2022/2023 season	2023/2024 season	2022/2023 season	2023/2024 season
Goara	Salicylic acid	23.81 **a**	27.39 a	2.56 **c**	6.89 a
	Methyl salicylate	26.70 **a**	33.93 a	2.57 **c**	8.28 a
	Control	44.83 **a**	50.72 a	3.69 **b**	11.91 a
Entesar 1	Salicylic acid	21.00 **a**	23.26 a	2.09 **d**	7.63 a
	Methyl salicylate	24.96 **a**	24.96 a	2.87 **c**	10.17 a
	Control	37.43 **a**	45.09 a	4.41 **a**	13.59 a
Master pea	Salicylic acid	24.94 **a**	30.83 a	3.50 **b**	10.07 a
	Methyl salicylate	24.46 **a**	32.96 a	3.31 **b**	14.61 a
	Control	46.31 **a**	56.07 a	4.31 **a**	19.50 a
F. value		**3.16 NS**	**2.28 NS**	**8.21***	**0.75 NS**

Means of among of each column followed by the same letter are not significantly different at the 5% level according to Duncan, s Multiple Range Test.

Insect predators:

The main effects of pea cultivars and foliar spray application by SA and MS on *C. undecimpunctata* and *C. carnea* associated with *A. craccivora* and *A. pisum* infesting pea plants during the two studied seasons are shown in Table 3. No significant differences were found between the three cultivars in relation to the two insect predators during the two seasons. For foliar spray application, it is clear that MS application significantly increased the incidence of the two insect predators compared to SA and control, however,an insignificant effect was observed for the SA treatment.

A few studies conducted in respect of effect of plant cultivars on insect predators, Legrand and Barbosa (2003) reported that *Coccinella septempunctata* L. affected by the type of pea cultivar morphology, however, Khan *et al.* (2015b) indicated that no specific effect of varieties of pea on the population dynamics of all studied natural enemies. They suggested that population density was depending on its host's (prey) density.

The highest average number of *C. undecimpunctata* was observed in MS with averge of 1.12 and 1.27 predators/ 10 plants in the two seasons, respectively, compared to 0.95 and 0.94 predators/ 10 plants in the two seasons, respectively, in SA and 0.92 and 0.87 predators/ 10 plants in the two seasons, respectively, in control. The same results were obtained for *C. carnea*, where the highest average number of 0.93 and 0.56 predators/ 10 plants in the two seasons, respectively, were recorded in MS compared to 0.46 and 0.38 predator/ 10 plants in the two seasons, respectively, in SA and 0.47 and 0.35 predator/ 10 plants in the two seasons, respectively, in the control.

Table (3): Effect of pea cultivars and foliar spray with SA and MS on *C. undecimpunctata* and *C. carnea* inhabiting pea plants during 2022/2023 and 2023/2024 seasons.

Main effect	Mean number/ 10 plants			
	Coccinella undecimpunctata		*Chrysoperla carnea*	
	2022/2023 season	2023/2024 season	2022/2023 season	2023/2024 season
Pea cultivar				
Goara	1.02 a	1.09 a	0.61 a	0.43 a
Entesar 1	1.03 a	0.99 a	0.65 a	0.43 a
Master pea	0.93 a	1.01 a	0.59 a	0.43 a
F. value	**1.56 NS**	**3.68 NS**	**2.82 NS**	**0.01 NS**
Spray treatment				
Salicylic acid	0.95 b	0.94 b	0.46 b	0.38 b
Methyl salicylate	1.12 a	1.27 a	0.93 a	0.56 a
Control	0.92 b	0.87 b	0.47 b	0.35 b
F. value	**6.05***	**21.34***	**96.67***	**21.08***

Means in each column followed by the same letter are not significantly different at the 5% level according to Duncan, s Multiple Range Test.

Data illustrated in Figure (2) show the effects of foliar application with SA and MS on *C. undecimpunctata* and *C. carnea* inhabiting pea plants.The data revealed that SA had a very weak effect on the attraction of the two insect predators in both seasons. *C. ndecimpunctata increased by 3.25% and 7.84% in the two seasons, respectively. In the same line, C. carnea increased by 9.68% in the second season, however, in the first season, its number decreased by 2.70.* On the other hand, MS showed a great effect on the two previous insect predators in both seasons and can be used as an attractive compound in integrated pest management. *C. undecimpunctata* increased by 22.10% and 31.55% in the two seasons, respectively, while, *C. carnea* increased by 62.67% and 38.46% in the two seasons, respectively in plots treated with MS. Many investigators have studied the effect of MS on populations of certain insect predators attacking aphids. They reported that MS application attracted many natural enemies and could be involved in aphid control (Zhu and Park, 2005; Dong and Hwang, 2017 and Zarkani and Turanli, 2021)

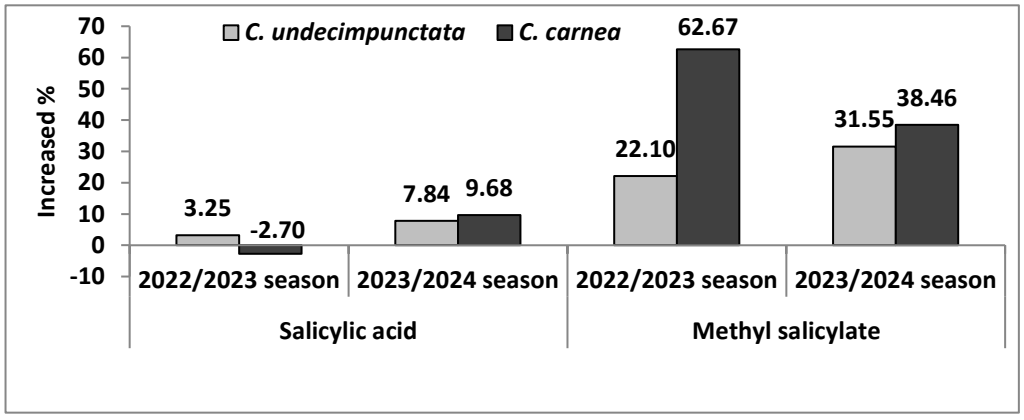

Fig. 1. Effect of SA and MS on *C. undecimpunctata* and *C. carnea* inhabiting pea plants during 2022/2023 and 2023/2024 seasons

Data in Table 4 show the effect of interaction between pea cultivars and foliar spray applications on *C. undecimpunctata* and *C. carnea* inhabiting pea plants infested by *A.*

craccivora and *A. pisum*. The interaction between the two factors was insignificant for the two insect predators in both seasons. This indicated that the pea cultivars and foliar spray applications effects were independent from each other. For *C. undecimpunctata*, Goara treated with MS recorded the highest average numbers of 1.19 and 1.30 predators/ 10 plants in 2022/2023 and 2023/2024 seasons, respectively, however, the lowest average numbers of 0.87 and 0.81 aphid/ 10 leaves in 2022/2023 and 2023/2024 seasons, respectively, were recorded in untreated (control) Master pea. For *C. carnea*, Entesar 1 and Master pea treated with by MS recorded the highest average numbers of 1.04 and 0.59 predators/ 10 plants, respectively, in 2022/2023 and 2023/2024 seasons, respectively, however, the lowest average numbers of 0.43 and 0.33 predators/ 10 plants in 2022/2023 and 2023/2024 seasons, respectively, were recorded in Goara treated with SA and untreated (control) Master pea, respectively.

Table (4): Effect of the interaction between pea cultivars and spray treatments on C. undecimpunctata and C. carnea inhabiting pea plants during 2022/2023 and 2023/2024 seasons.

Pea cultivar	Spray treatment	Mean number/ 10 leaves			
		Coccinella undecimpunctata		*Chrysoperla carnea*	
		2022/2023 season	2023/2024 season	2022/2023 season	2023/2024 season
Goara	Salicylic acid	0.91 **a**	0.96 **a**	0.43 **a**	0.39 **a**
	Methyl salicylate	1.19 **a**	1.30 **a**	0.94 **a**	0.54 **a**
	Control	0.98 **a**	1.00 **a**	0.46 **a**	0.35 **a**
Entesar 1	Salicylic acid	1.07 **a**	0.94 **a**	0.44 **a**	0.41 **a**
	Methyl salicylate	1.11 **a**	1.24 **a**	1.04 **a**	0.56 **a**
	Control	0.91 **a**	0.80 **a**	0.48 **a**	0.33 **a**
Master pea	Salicylic acid	0.87 **a**	0.93 **a**	0.50 **a**	0.35 **a**
	Methyl salicylate	1.06 **a**	1.28 **a**	0.80 **a**	0.59 **a**
	Control	0.87 **a**	0.81 **a**	0.46 **a**	0.35 **a**
F. value		**0.86 NS**	**0.49 NS**	**2.94 NS**	**0.47 NS**

Means of among of each column followed by the same letter are not significantly different at the 5% level according to Duncan, s Multiple Range Test.

CONCLUSION

The previous results concluded that the foliar spray application with SA and MS significantly decreased pea infestation by *A. craccivora* and *A. pisum*. On the other hand, MS showed a strong attractive effect on the two insect predators in both seasons, while SA had no effect.

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