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# Integration of the predatory bug *Deraeocoris lutescens* with some conventional insecticides and plant-derived chemicals to manage *Aphis fabae*

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## Abstract

The black bean aphid, *Aphis fabae* Scopoli (Hemiptera: Aphididae), is one of the most important pests of several cultivated crops throughout the world. The predatory bug *Deraeocoris lutescens* (Schilling) (Hemiptera: Miridae) have privileged position in biological control of aphids such as the black bean aphid, *A. fabae*. The other method to control aphids is the usage of insecticides and plant-derived chemicals. Integrated Pest Management (IPM) is an ecosystem approach to crop production and protection that combines different management strategies and practices to grow healthy crops while minimizing the use of pesticides. Recently, there has been a growing interest in research concerning the possible use of plant extracts as alternatives to synthetic insecticide. In this study, the integration of *D. lutescens* ($N_1$ and $N_5$ instar) with plant extracts of *Peganum harmala* L. and *Melia azedarach* L. and two conventional insecticides (pirimicarb and abamectin) is surveyed to manage *A. fabae* (1-2 and 5-6 days old), and also study the impacts on the predatory bug. Among different treatments, integration of $N_5$ instar of the predatory bug with *P. harmala* has the highest aphid (1-2 days old) mortality rate (%95.33±0.60), and integration of $N_5$ instar as the natural enemy with pirimicarb has the highest effect to manage 5-6 days old aphids (%94.00±0.71).

**Key words:** *Aphis fabae*, *Deraeocoris lutescens*, pirimicarb, abamectin, plant-derived chemicals

## Introduction

The black bean aphid, *Aphis fabae* Scopoli (Hemiptera: Aphididae), is one of the most important pests of several cultivated crops throughout the world (Völkl and Stechmann, 1998). *A. fabae* has a very wide host range, more than 200 host plant species in the world and about 50 plant species are susceptible to get attacked by this aphid in Iran (Khanjani, 2004; Azimi *et al.*, 2021). Host plants are damaged either directly by aphid feeding or indirectly by transmission of viruses and excretion of honeydew (Mills, 1989; Schepers, 1989).

Many species have been successfully used in biological control programs of various host aphids (Azimzadeh *et al.*, 2011). *Deraeocoris lutescens* Schilling (Hemiptera: Miridae) is a predatory bug found commonly on a wide variety of plants across Middle East and Europe, that feeds on a wide range of arthropod pests such as aphids, small caterpillars, mites and insect eggs (Lamine *et al.*, 2005). Biological control requires patience. Even an effective natural enemy is almost always slower in acting compared to an insecticide (Valizadeh *et al.*, 2020; 2021).

Nowadays, the black bean aphid is mainly managed with broad spectrum insecticides. This can be followed by the target pest resurgence, secondary pest outbreaks, and the development of insecticide resistance in target pest (Valizadeh *et al.*, 2013; 2020; Oftadeh *et al*., 2020). Organic or botanical compounds might be effective in controlling the population of the pests. Plants may provide an alternative to currently used pesticides for the control of plant pests, as they constitute a rich source of bio-active chemicals (Daoubi *et al.*, 2005). In recent years, many researchers have focused on research in this field. Salari *et al.* (2012) Studied the insecticidal activity of methanol seed extracts of *Peganum harmala* on three aphid species *Aphis fabae*, *Aphis gossypii* and *Myzus persicae***.** Toxic effects of some pesticides on *Deraeocoris lutescens* in the laboratory has been investigated (Azimzadeh *et al.*, 2012). Also, Kim *et al.* (2006) tested lethal and sublethal effects of abamectin, spinosad, methoxyfenozide and acetamiprid on the predaceous plant bug *Deraeocoris brevis* in the laboratory.

IPM has been defined as a pest population management system that utilizes all suitable techniques in a compatible manner to reduce pests' population and maintain them at levels below those causing economic injury (Frisbie and Adkisson, 1985; Valizadeh *et al.*, 2021). IPM is a systematic approach to protect crops that uses increased information and improved decision-making paradigms to reduce purchased inputs and improve economic, social and environmental conditions on the farm and in society (Boughton *et al*., 2017).

In this research, the integration of the predatory bug, *D. lutescens*, and some of the plant extracts and insecticides on *A. fabae* control were investigated.

## Materials and Methods

### ∗ Insect rearing and colony maintenance

### - Aphids rearing

The initial population of *A. fabae* was collected from the experimental greenhouse of Shahid Bahonar University of Kerman, Kerman, Iran (30.252122, 57.105407). The colony was mass reared on broad bean plant in insect netting cage (60×60×60 cm) in the modern experimental greenhouse (temperature: 25±2 °C, relative humidity: 60±5% and photoperiod: 14h).

### -Predatory bug rearing

The predatory bug *D. lutescens* was collected from experimental teaching garden of Shahid Bahonar University of Kerman, Kerman, Iran. This specie was identified by Department of Insect Taxonomy Research, Iranian Research Institute of Plant Protection, Tehran, Iran. The females of the predatory bug were placed on broad bean leaves for oviposition which were placed in plastic petri dishes (5 cm diameter) containing 0.7% agar gel. Every two days, females were transferred to new plastic petri dishes and the eggs were incubated until egg hatching. These leaves and first nymphs were placed into new Plexiglas cages (7.5 × 15 × 4.5 cm), with a mesh-covered hole in the lid, to start the pre-imaginal rearing. Food (eggs of *Sitotroga cerealella* Olivier as well as black bean aphid nymphs as prey) and water were supplied till adult emergence.

## * Ethanolic extracts preparation

*Peganum harmala* (seed) and *Melia azedarach* (fruit) from Kerman, Iran (130°15' 15.39″ N, 57°06″14.38″E) were collected. After drying, it was powdered with steal blender and mixed with ethanol (96%) in Erlenmeyer flask. Then the Erlenmeyer flask was covered with aluminum foil and was sealed with Parafilm® layer and it was placed into the refrigerator at 4 °C. After 24 hours the extract was filtered by filter-paper and packed in a proper glass. Then the glass was covered with an aluminum foil to prevent the effect of light on the extract. The extracts were kept in a freezer until day of the experiment. The extract was used in 10 mg $mL^{-1}$ concentration for the experiments.

## * Conventional insecticides

Pirimicarb and abamectin were applied respectively in 500 gr and 9 mg active ingredient per litter corresponding to the maximum recommended rate on the label which is generally used by farmers in the field condition.

## * Experiment procedure

The black bean aphids (1-2 days old) were placed on broad bean leaves in plastic petri dishes containing 0.7% Agar gel (60 aphids/leaf) and were sprayed with every one of the extracts and insecticides with concentration mentioned above. One predatory bug *D. lutescens* ($N_1$) was placed in every petri dish. All experiments were carried out under the same laboratory conditions, at 25±1°C temperature, relative humidity of 60±10% and 16:8 (L:D) photoperiod in the growth chamber. After 48 hours, the mortality of natural enemy and aphids in every petri dish was recorded.

Similar experiment was conducted with $N_5$ nymphs of *D. lutescens*. The experiments continued with a similar procedure for integration insecticides and plant extracts with every one of $N_1$ and $N_5$ nymphs of *D. lutescens* to control 5-6 days old aphids. The experiments were replicate at least 10 times in the same laboratory conditions.

## * Statistical analysis

In order to affirm the basic assumptions of the data to be analysed, they were first tested for the normal distribution and the homogeneity of variance using the Bartlett-test (Köhler et al. 2002). The data that had not conformed to the assumptions of normal distribution were transformed to conform to the assumptions, using the Box-Cox formula:

$$Y = X2 - 1/\lambda \text{ if } \lambda \neq 0,$$

$$Y = \ln X \text{ if } \lambda = 0,$$

where: $Y$ – the transformed value, $X$ – the untransformed value, and $0 < \lambda < 1$ (Anonymous 1996).

Mortality rate of aphids and survival rate of the predators were calculated and for the statistical comparison of the mortality rate of the biotests, the data was subjected to a one-way analysis of variance (ANOVA) followed by a Fisher LSD method (Statplus version 4.9, 2007).

## Results

### * Effect of integration of natural enemy with insecticides and plant extracts on A. fabae (1-2 days old) mortality

The highest mortality rate of 1-2 days old aphids (without the predator) was recorded in pirimicarb treatment (94.17%) that has significant differences with other treatments (df= 4, P<0.00001) (Figure 1). The extract of *P. harmala* caused high mortality (53.33%) so that there were no significant differences between mortality with this plant-derived chemical and abamectin.

The highest aphids' mortality rate in integration of $N_1$ instar of the predator with insecticides and plant extracts was caused by pirimicarb (%89.83±1.09) and *P. harmala* (86.83%±3.58). Among different treatments, the highest mortality of the first instars of the natural enemy was recorded with the extract of *P. harmala* treatment (50%).

In integration of $N_5$ instar with insecticides and plant extract experiments, the highest mortality (%) of 1-2 days old aphids was detected with *P. harmala* (95.33%± 0.60) and *M. azedarach* (91.67%±1.27) treatments. The result has shown that pirimicarb caused the highest mortality in $N_5$ instars of the predatory bug (30%).

In total, there were no significant differences in the mortality rates of the aphid (1-2 days old) caused by integrated pirimicarb and $N_1$ instar or $N_5$ instar. Integration of $N_1$ and $N_5$ instars with one of the compounds (abamectin, *P. harmala*, *M. azedarach*) had increased significantly the morality (%) of the aphid (df= 4, P<0.0001).

### * Effect of integrating natural enemy with insecticides and plant extracts on *A. fabae* (5-6 days old) mortality

According to the results in the experiments without the predator which are presented in figure 2, the most significant mortality percentage of the aphids (5-6 days old) was recoded with pirimicarb (87.17%±1.67) and *P. harmala* extract (86.50%±1.80) treatments (df= 4, P<0.00001). There is no significant difference in the aphid mortality (%) between *M. azedarach* and the other two treatments.

Integration of $N_1$ instar of the predator with insecticides and plant extracts experiments showed that the most significant mortality (%) in aphids is caused by pirimicarb (90.67%±1.47) (df= 4, P<0.0003) and *P. harmala* (86.50±2.36) treatments (df= 4, P<0.00001). Moreover, in this part of the experiments, survival rates (%) of the predator were more than 80%.

Integrating $N_5$ instars of the natural enemy with both insecticides and both plant-derived chemicals caused high aphid mortality, higher than 80%, and high survival rates (%) of the predator (~100%).

Integration of $N_1$ and $N_5$ instars with both pesticides and *M. azedarach* had increased the morality (%) of the aphid.

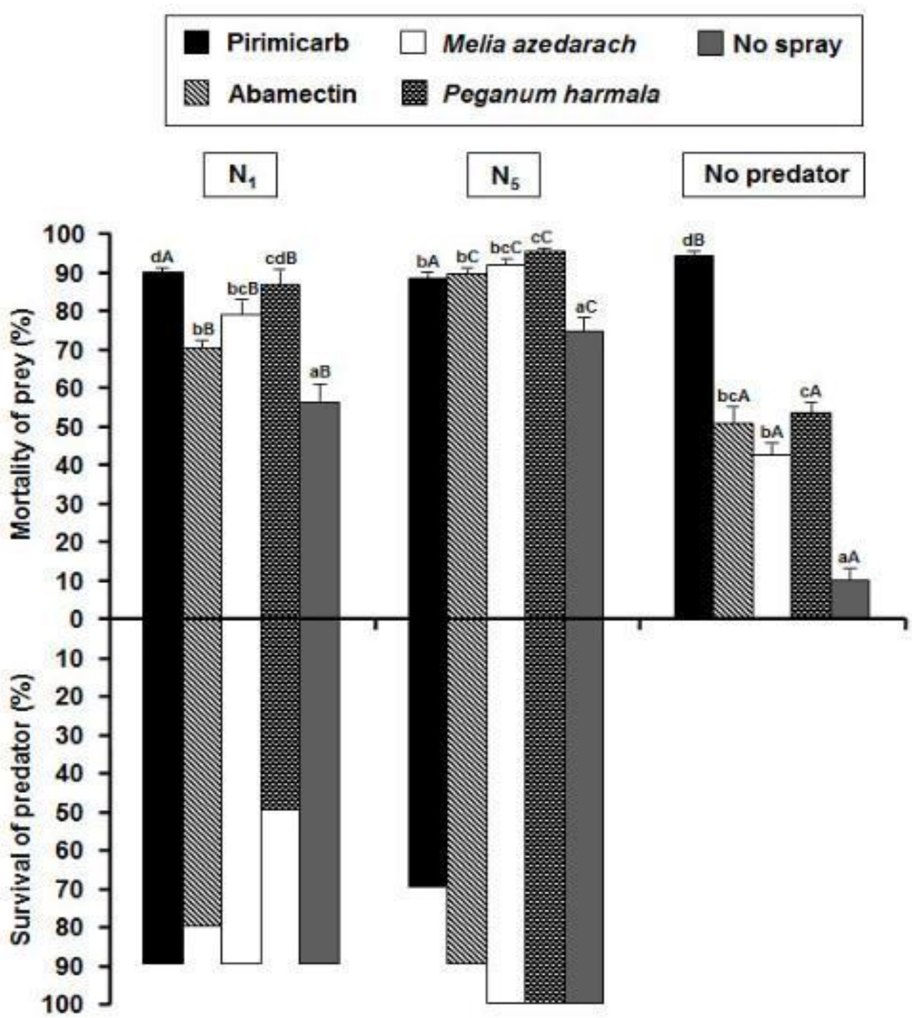


**Figure 1**. Effect of integration of $N_1$ and $N_5$ instar of predatory bug *Deraeocoris lutescens* with conventional insecticides and plant extracts, on mortality percentage of *Aphis fabae* 1-2 days old [Different small letters indicate significant difference between each of insecticides and plant extracts in the certain conditions, integrated with $N_1$ or $N_5$ instar of the predator or absence of natural enemy. Different capital letters indicate a significant difference between different conditions, integrated with $N_1$ or $N_5$ instar of the predator or absence of natural enemy in the certain chemicals by Fisher LSD test ($P \leq 0.05$) (one-way ANOVA)]

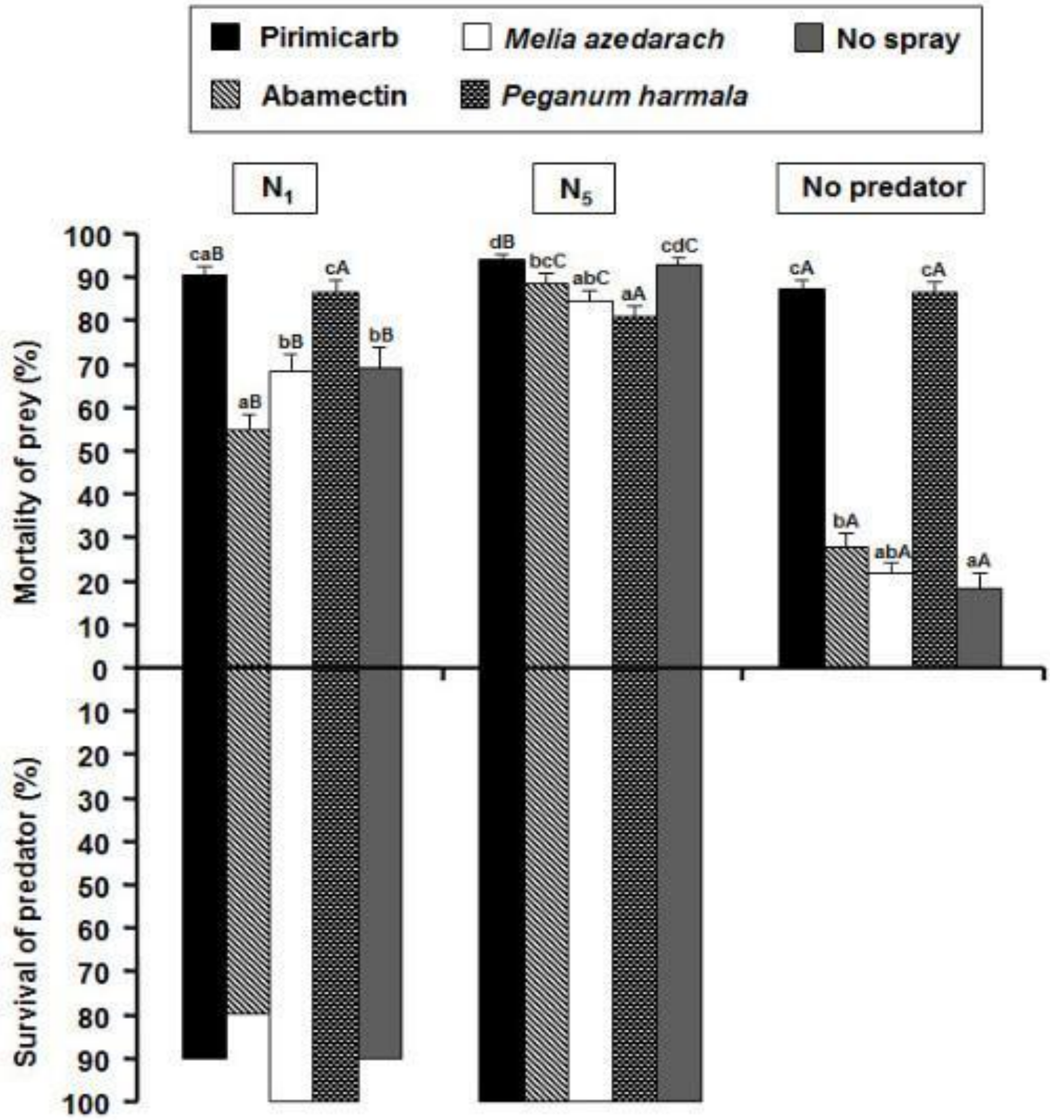


**Figure 2**. Effect of integration of $N_1$ and $N_5$ instar of predatory bug *Deraeocoris lutescens* with conventional insecticides and plant extracts, on mortality percentage of *Aphis fabae* 5-6 days old [Different small letters indicate significant difference between each of insecticides and plant extracts in the certain conditions, integrated with $N_1$ or $N_5$ instar of the predator or absence of natural enemy. Different capital letters indicate a significant difference between different conditions, integrated with $N_1$ or $N_5$ instar of the predator or absence of natural enemy in the certain chemicals by Fisher LSD test ($P \leq 0.05$) (one-way ANOVA)].

## Discussion

In this study, it is shown that managing aphids' population by only insecticide or plant extract (pirimicarb and *P. harmala*) is effective, especially in 5-6 days old aphids. This may be due to toxic compounds. According to the results of Salari *et al.* (2012), insecticidal effects of methanolic extract of *P. harmala* on three genus of aphids is shown that methanolic extract of *P. harmala* caused high mortality on *A. fabae* and *A. gossypii*.

According to the results, the integration of predatory bug with every one of plant extracts and insecticides have suitable results in reducing aphids' population. Integration of natural enemy with abamectin, *M. azedarach* and *P. harmala* caused more acceptable aphid (1-2 days old) mortality compared to the usage of only natural enemy treatment. This is more tangible in integration of $N_5$ instar. Moreover, integration of natural enemy with abamectin and *M. azedarach* led to an increase of aphids (5-6 days old) mortality compared with using only natural enemy and use of only insecticides or plant extracts treatments.

Among insecticides and plant extracts, the highest mortality in natural enemy was recorded with $N_1$ natural enemy that was in the vicinity of sprayed aphids with *P. harmala*. It is probably for toxic compounds of *P. harmala* and also weak and incomplete immune system of natural enemy in this instar. Azimzadeh *et al.* (2012) showed the mortality of $N_5$ instars of *D. lutescens* was 100% in the fenpropathrin treatment 24 hours after exposure, while pirimicarb was harmless after 96 hours. Abamectin was slightly harmful to $N_5$ instars, while penconazole, pirimicarb and spirodiclofen residues were harmless. pirimicarb was moderately harmful to $N_1$ instars of the predator within the 96 hours after treatment according to IOBC ratings for laboratory assays. The residue of pirimicarb was moderately harmful to $N_1$ instars and it was harmless to $N_5$ instars, females and males of the predator. Kim *et al.* (2006) showed that abamectin at the full field rate did not affect the hatching rate but had moderate to high toxicity to nymphal instars of predaceous plant bug, *Deraeocoris brevis*.

Finally, good integrated pest management practices encompass the use of chemical, cultural, and natural controls in managing pests. Often the use of a chemical insecticide negates the benefits of any natural enemy in the field. The impact of a pesticide on a natural enemy must be known in order to properly utilize both the pesticide and the natural controls on the predator. Results of present research based on application of the predatory bug, *D. lutescens*, with insecticides and plant extracts that have a low toxicity for natural enemy and managed population of pest, can be a big step in IPM program.

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# تلفیق سن شکارگر *Deraeocoris lutescens* با برخی آفت کش‌های رایج و مواد شیمیایی مشتق شده از گیاهان جهت مدیریت *Aphis fabae*

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**چکیده**

شته سیاه باقلا *Aphis fabae* Scopoli یکی از مهمترین آفات محصولات زراعی در سرتاسر جهان است. سن شکارگر *Deraeocoris lutescens* (Schilling) (Hemiptera: Miridae)، جایگاه ممتازی در کنترل بیولوژیکی شته‌هایی از قبیل شته سیاه باقلا دارد. روش دیگر برای کنترل شته ها استفاده از حشره کش ها و مواد شیمیایی مشتق شده از گیاهان است. در دهه‌های اخیر در جوامع رو به رشد، گرایش به مصرف هر چه کمتر سموم شیمیایی و استفاده از مشتقات گیاهی به عنوان جایگزین سموم مصنوعی بوده است. مدیریت تلفیقی آفات (IPM) یک رویکرد بر اساس زیست بوم برای تولید و حفاظت محصول است که ترکیبی از استراتژی های مختلف مدیریت و شیوه ها برای رشد محصولات سالم با به حداقل رساندن استفاده از آفت کش ها است. در این پژوهش، تلفیق *Deraeocoris lutescens* (سنین پورگی اول و پنجم) با عصاره های گیاهی اسپند (*Peganum harmala*) و زیتون تلخ (*Melia azedarach*) و دو آفتکش تجاری (پیریمیکارب و آبامکتین) برای کنترل شته سیاه باقلا (۲-۱ و ۵-۶ روزه) بررسی شده است. و همچنین اثرات ترکیبات اخیر روی دشمن طبیعی مورد مطالعه قرار گرفته است. از میان تیمارهای مختلف، تیمارِ تلفیق پوره سن پنجم دشمن طبیعی با عصاره ی *Peganum harmala*، روی شته های (۱-۲ روزه) بیشترین میزان مرگ و میر را داشت (۹۵/۳۳±۰/۶۰ درصد). همچنین تیمار تلفیق پوره سن پنجم دشمن طبیعی با پیریمیکارب، بیشترین اثر را در کنترل شته های (۶-۵ روزه) دارا بود (۹۴/۰±۰۰/۷۱ درصد).

**واژه‌های کلیدی:** شته سیاه باقلا، پیریمیکارب، آبامکتین، مواد شیمیایی مشتق شده از گیاهان، *Deraeocoris lutescens*.