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Effect of chemical insecticides on black bean aphid, *Aphis fabae* Scopoli (Hemiptera: Aphididae)

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Abstract

Chemical insecticides are one of the tools in integrated pest management programs. It is necessary to investigate their effect against *Aphis fabae*. In this research, effect of four insecticides, Flonicamide® 50% WG, Deltamethrin ®, Imidacloprid® 50% SC, and Indoxacarb® 15% SC were investigated against adults of *Aphis fabae.* The statistical design used in this research is considered as the randomized complete block design (RCBD) with four replications. In the present study of broad bean cultivation, Flonicamide® 50% WG, and Imidacloprid® 50% SC had the highest reduction on aphid population and showed a significant difference with other treatments Therefore, the above insecticides are recommended to control *Aphis fabae.*

Keywords: *Aphis fabae*, Flonicamide® and Imidacloprid®

1. Introduction

The black bean aphid (*Aphis fabae*) is spread almost worldwide (Ismaili and Radanjani *et al*. 2013). It occurs throughout Europe, Western Asia, Africa and South America (Meradsi and Laamari, 2018) [17]. It attacking all the aerial parts of the plant, especially the young growing parts, it stops the growth and dwarfism, deforms the leaves and significantly reduces the yield (Ismaili and Radanjani, 2012) [1]. Thirty years ago, *A. fabae* was identified as one of the most harmful insect pests in broad bean in Lithuania (Tamošiūnas, 1993) [26]. The intense infestation can stimulate dropping or shrivelling of immature pods causing a large loss in yield (Subedi *et al*. 2018) [24]. *A. fabae* is the main reason for the transmission of plant viruses (Dedryver etal., 2010) [4]. It is the main vector for more than 30 plant viruses including the non-persistent viruses in faba bean, peas, beets and potato, and also the persistent viruses like potato leafroll virus (PLRV) and beet yellow net virus (BYNV) (Blackman and Eastop, 2017) [1].

Most aphids have very high reproduction rates in the absence of natural enemies due to their fertility, viability and polymorphism. These insects mature in a short time, so they can increase their population dramatically. Among the aphids, the black bean aphid (Aphis fabae Scop) has more than 2,000 hosts in the world. In Iran, more than 50 species of host plants have been identified for this aphid. The spread of this pest is wide and it is spread in all parts of the country. The black bean aphid is prevalent throughout Iran and worldwide in the temperate regions of the Northern Hemisphere. It is a polyphagous, dicotyledonous pest that affects many important crops on secondary hosts, including sugar beet, peas, beans, potatoes, and many other harmful crops. (Ismaili and Radanjani, 2012) [1]. With the introduction of insecticides, widespread and numerous resistance was revealed in many pests, including aphids. Insects have naturally been exposed to a wide range of plant toxins throughout their evolutionary history and have succeeded in detoxifying natural toxins to evolve these environmental hazards as well as to preserve their life by mechanisms, and just as inactivating compounds. Man-made toxins have also been effective. Today's resistance of insects to consumer insecticides is the result of such a confrontation. It is believed that insects have already received and been equipped to deal with the challenges posed by the use of new synthetic insecticides. Different species of insects use the three main mechanisms of biochemical resistance, physiological resistance and behavioral resistance due to exposure to toxic chemical compounds. Insects may simultaneously use all three of these mechanisms in opposition to toxic compounds (Pedigo, 2004) [18].

Due to the growing population of the world and increasing demand for food, two strategies to increase yields in the agricultural sector are recommended. The first way is to develop arable land and the second way is to increase yield per unit area. Regarding the first solution, it should be noted that land is one of the limited resources of the agricultural sector and the development of this resource is slightly possible (Mazaheri and Majnoon Hosseini, 2005) [16]. Legumes are the second most important source of human food after cereals. Dried and ripe seeds of legumes have high nutritional value and good storage capacity and are one of the most important and rich sources of protein (18-32%) (Majnoon Hosseini, 2004) [15]. Today, the use of pesticides in the control of pests has become a common method of control, so that the side effects of pesticides in food are the destructive effects of pesticides (Regnault-Rogar *et al*. 2004) [19]. For this reason, in recent years, researchers have been looking for technology to produce harmless insecticides that have properties such as how they affect natural and human enemies, as well as reducing the likelihood of resistance (Isman, 1994) [12]. Third-generation insecticides such as insect growth regulators and bio-derived insecticides have come to the attention of researchers over the past few decades. One of the characteristics of such pesticides is that they are natural or quasi-natural compounds or they are made based on the physiology, biochemistry and ecology of insects. These compounds disrupt the normal developmental process of insects by disrupting the normal functioning of the internal secretory systems. Most of these compounds are effective in embryonic, larval, nymphal, reproductive and behavioral stages and diapause of insects (Talebi Chermi, 2007) [25].

The study of the effects of insecticides on pests is often limited to the study of mortality on them, but today it has been shown that the non-lethal effects of these compounds can affect the physiology and behavior of pests and their natural enemies, which is an important issue in pest control. (Johnson and Tabashnik, 1999) [13]. In the present study, the effect of several new and common chemical compounds including flunicamide 50%, WG, deltamethrin 2.5% EC, imidacloprid 50%, and indoxacarb 15% SC were tested against bean aphids. Therefore, the insecticides should be applied at the proper rate and at the correct time for controlling aphids successfully (Roy *et al*., 2014) [20]. On the other hand, genetic resistance of aphids to insecticides can be delayed by reducing application frequency and treating only when aphid population override the economic threshold (Hodgson *et al*., 2012) [10].

2. Materials and method

Experimental site. The experiment was carried at the educational research farm No. 1, Gorgan University of Agricultural Sciences and Natural Resources (36 N lat., 54 E long., 49 m g.n.i.) Gorgan, Kordkoy distr., during the period 2020-2021.

2.1 The experiment

The field trial was conducted in a RCBD with four replications and plot size of 4.5m^{2}2.25 m^2 (spacing 3m x 1.5m), 2-meter block to block distance and 1,5-meter plot to plat distance. The population of aphids was counted 1 day before and 1, 3 and 5 days after spraying. In bean counting, aphids were randomly selected from the middle row of 10 leaves and the number of aphids in each leaf was counted and recorded separately. Field counting with the help of a hand-held magnifying glass and samples that were difficult to count were placed separately in nylon bags and transferred to the laboratory and then counted using a stereomicroscope. The population of natural enemies was counted and recorded as observations.

2.2 Insecticides

In the present study, flunicamide (Tepki) was 50% WG, with a concentration of 0.25 per thousand, deltamethrin 2.5% EC, with a concentration of 1.5 per thousand, imidacloprid 50% SC, with a concentration of 1 per thousand, Indoxacarb with 15% SC, with a concentration of 0.5 per thousand were used. Appropriate statistical software was used to analyze the data. In order to facilitate the preparation of the solution and its spraying, 20 liters of solution were prepared and used from all the treatments with the intended concentration. These toxins were purchased from reputable stores in Gorgan.

2.3 Damage of aphids

The black bean aphid attacks all the aerial parts of the host plants and feeds on the sap by dipping the snout into the leaves of the host plant, causing the leaves to wither, wither, turn yellow and dry out. Bean black aphid shortens the plant and reduces the number of pods and crops. This aphid secretes honey on different parts of the plant and causes the growth of fumagine on the leaves and other aerial parts and reduces the bean yield by 40%. It also causes indirect damage by transmitting plant viruses to the host plant. This aphid is an important pest of beans and beets in Poland and the rate of crop reduction depends on the colony density of aphids, the time of initial infestation and the time of plowing. The presence of several aphids on each leaf for 3 weeks reduces root growth and plant nitrates (Khanjani, 2008, Sabbaghian and Soleiman Nejadian, 2006 [21]).

2.4 Imidacloprid

Imidacloprid, chemically known as [1- (6-chloro-3-pyridylmethyl) -N-nitroimidazolidine-2-ylidine amine] and with the molecular formula (C9H10CIN5O2), is a neonicotinoid group with a contact-stimulating effect. Nicotinic receptors are acetylcholine. This insecticide causes the insect to become paralyzed and eventually die. Imidacloprid shows little affinity for mammalian neuroreceptors while strongly binding to insect neuroreceptors; Therefore, it is slightly toxic to humans and highly toxic to pests (Guan, *et al*., 2008; Zhou *et al*., 2006; Gervais *et al*., 2012) [8, 28, 6].

2.5 Indoxacarb

Indoxacarb, with the chemical name [(S) - methyl 7-chloro-2, 5-dihydro-2 - [[(methoxycarbonyl) [4- (trifluoromethoxy) phenyl] amino] carbonyl] indeno [1, 2- e] [oxadiazine-4 a (3H) -carboxylate] and with molecular formula (C22H17 CIF3 N3O7) is a non-systemic and effective insecticide against butterfly larvae of the indeno-oxadiazine group. When indoxacarb enters the insect's body and absorbs it, the insect's feeding stops. The pesticide also paralyzes and eventually kills insects by attaching to one of the sodium channel sites and blocking the flow of sodium ions to nerve cells (Brugger, 1997; Tillman *et al*., 2002) [2, 27].

2.6 Sub-lethal effects

Today, pest control in agriculture is largely dependent on the use of chemical pesticides. Assessing the biological effects of pesticides on pests from the beginning, the focus has been on estimating mortality and less attention has been paid to the long-term effects of pesticides on pests. Recent research has shown that non-lethal doses of these compounds can affect the physiology and behavior of target and non-target arthropod species (Haynes, 1988) [9].

It is often thought that if a pesticide does not cause the death of a natural enemy, it is harmful to it, which is not true; Because it may have effects on the natural enemy and disrupt its efficiency; Therefore, it is important to understand the difference between lethal and non-lethal effects, as well as the difference between direct and indirect effects of pesticides, as well as information about possible ways in which natural enemies are exposed to these compounds (Stark and Wennergren, 1995; Stark and Banks, 2003) [23, 22].

Subcutaneous effects are effects that do not lead to the death of a living being in the short term, but the question arises as to whether the death may be due to poisoning or delayed poisoning; Therefore, there is no clear boundary between the lethal and sub-lethal effects. As a result, the most important method to study the sub-lethal effects of effective factors in the life table of people surviving the effects of pesticides. In integrated pest management programs, the sub-lethal effects of pesticides are the most important issue in relation to changing the efficiency of an insectivorous organism to regulate host or hunting populations (Croft, 1990; Desneux *et al*., 2007) [3, 5].

3. Results of comparing the mean effect studied treatments on the number of dead aphids in bean cultivation

Table 1: Comparing the mean effect studied treatments on the number of dead aphids in bean cultivation

Treatments	Before spring	1 day after spring	3 days after spring	5 days after spring
Flonicamide®	207.25ab	81.00d	38.25d	19.50c
Deltamethrin ®	188.00ab	140.50bc	105.50b	92.75b
Imidacloprid®	199.25ab	123.25c	73.00c	36.75
Indoxacarb®	192.00ab	153.75bc	123.50b	99.0b

4. Results and discussion

The efficacy of imidacloprid has been reported by (Guan *et al*., 2008; Zhou *et al*., 2006; Gervais *et al*., 2012) [8, 28, 6]. flonicamide (Tepki) in bean cultivation reduces the population in this way one day After foliar application 62.2%, after 3 days 79.77% and after 5 days 87.50% population reduction.Of course, as the results show, imidacloprid also had a very high effect on reducing the pest population. There are other reports that confirm the effectiveness of imidacloprid. The reason why flunicamide is so effective is that it is a new insecticides and resistance to this pest has not been yet reported. Second, the insecticide has been marketed as a proprietary insecticide. The excellent effect of this toxin against the green peach aphid has also been recorded. Show, in mixed cultivation the population of aphids on beans is less than its population in bean cultivation alone. The reason for this difference must probably be two factors (planting date is December 6, 2020). And the second factor may be the natural enemies of pests, lack of adverse effects in close-co-cultivation of plants, there is no antagonist effect between host plants and common nutritional needs between plants. Therefore, these factors and possibly other factors have been involved in reducing the pest population, in which case more research should be done.

5. Conclusion

In the present study of broad bean cultivation alone, flonicamid and imidacloprid had the highest reduction on aphid population and showed a significant difference with other treatments. Therefore, the above compounds are recommended to control *Aphis fabae* and *Helicoverpa armigera.*

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