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Effect of Some Chemical and Biorational Compounds Against Chickpea pod borer, *Helicoverpa armigera* (Lepidoptera: Noctuidae)

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Abstract

Chickpea *Helicoverpa armigera* is one of the most destructive insect pest which causes both quantitative and qualitative loss. Therefore, to study the effect of Deltamethrin® 2.5% EC, Imidaclopride® 50% SC, Indoxacarb® 15% SC, Lambdacyhalothrine® 10% SC, Ozoneem® 1% and Tondexir® against gram pod borer (*Helicoverpa armigera* H.) on chickpea (*Circer arietinum* L.) variety Kabuli. The experiment was conducted in randomized complete block design (RCBD) with four replication at research and teaching field No. one, Gorgan University of Agricultural Science and Natural Resource. Regarding the pod borer in chickpeas, the results showed that the most effective insecticides against pod borer in all three times of spraying in chickpea cultivation was indoxacarb (38.82, 74.40, and 86.89% respectively 1, 3 and 5 days after spraying) which shows a significant difference with other treatments, deltamethrin® and lambdacyhalothrin® were in the second place and showed a significant difference with indoxacarb®. The interesting thing to note is that ozoneem®, which is a botanical insecticide, had the same effects 5 days after spraying with lambdacyhalothrin® and deltamethrin®, and no significant difference was observed between them. By observing this result, there is hope that biorational insecticides will replace chemical insecticides for pest control, and one of the goal of this study was that.

Keywords: *Helicoverpa Armigera*, Chemical Insecticides, Tondexir®, Ozoneem®

1. Introduction

Chickpea (*Cicer arietinum* L.) is a plant that is relatively resistant to drought and can produce a satisfactory yield in areas with low rainfall where many crops cannot be cultivated. Among legumes, the chickpea is in the first rank in Iran with 43.25% production. More than 529,000 hectares of agricultural land in Iran is dedicated to chickpea cultivation, from which about 268,000 tons of chickpeas are produced, and they are cultivated in most parts of Iran, except for the Caspian coast. According to the available statistics, chickpea is the most important agricultural product of Kurdistan province after wheat, the cultivated area of which is 100,510 hectares and the amount of production is 32,726 tons (Kochaki and Banyan, 2013) [14]. Considering the growing trend of the world's population and increasing demand for food, two strategies are recommended to increase performance in the agricultural sector. The first way is to develop arable land and the second way is to increase the 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 possible to a limited extent (Mozaheri and Majnoon, 2004) [19]. Legumes are the second most important source of human food after cereals. The dry and ripe seeds of legumes have high nutritional value, chickpea is one of the most important legumes, which is rich in protein and starch and is very important in the human diet (Bagheri *et al*., 2015) [2].

The major insect pests attacking chickpea are gram pod borer *Helicoverpa armigera*, leaf feeding caterpillar *Spodoptera exigua* (Hubner), black cutworm *Agrotis ipsilon*, aphid *Aphis craccivora*, and semilooper *Autographa nigrisigna*. *H. armigera* is the major damaging pest in area where chickpea is grown. The attack of this pest begins right from vegetative stage and continue upto maturity. Young larvae of *H. armigera* feeds on leaflets, buds, flowers, and pods of chickpea (Mandal and Roy, 2012) [17]. Adult female lays 300-500 eggs on host plants. The eggs hatch in 2-5 days and caterpillars bore in pods. Single caterpillar can damage up to 40 pods. Full-grown larvae drop to the ground for pupation. The life cycle is completed in 30-37 days. There are 5-7 generations in a year (Malik, 1994) [16]. Today, the use of insecticides against pests has become a common control method, so that the side effects caused by synthetic organic pesticides have undesirable residues in food products

(Regnault-Rogar *et al.*, 2004) [26]. For this reason, during the last years, researchers have been searching for the technology to produce safe insecticides that have characteristics such as how to act on natural enemies and humans, as well as reducing the probability of resistance (Isman, 1994) [12].

The third-generation insecticides, such as insect growth regulators and biorational insecticides, have attracted the attention of researchers during the last few decades. One of the characteristics of such pesticides is that they are natural, or they are made based on the physiology, biochemistry and ecology of insects. These compounds disrupt the normal activity of the internal secretory systems and disrupt the growth and development of insects. Most of these compounds are effective in the embryonic, larvae, nymph, reproduction behavior and diapause stages of insects (Talebi, 2006) [27]. Investigating the effect of insecticides on pests is often limited to investigating their mortality rate, but today it is known that the sublethal effects of these compounds can effect the physiology and behavior of pest insects and their natural enemies, which is an important issue in the pest control. (Johnson and Tabashnik, 1999) [13]. In the present study, the effect of several chemical compounds including deltamethrin 2.5% EC, imidacloprid 50% SC, indoxacarb 15% SC, lambdasaihalothrin 10% SC, and botanical compounds including Ozoneem 1%, and Tondexir were studed against chickpea pod borer.

2. Materials and Methods

A field experiment was conducted 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 Rabi 2020-21. The trial was laid out in randomized complete block design with seven treatments including a control and four replications. The chickpea seeds were sown at 60cm spacing between the rows and 10cm distance between the plants. The plot size was of 4.5m^2 (spacing 3m x 1.5m), 2-meter block to block distance and 1.5-meter plot to plot distance. In the present study, deltamethrin 2.5% EC, with a concentration of 1.5 per thousand, Imidaclopride 50% SC with a concentration of 1 per thousand, indoxacarb 15% SC, with a concentration of 0.5 per thousand, lambdacyhalothrin 10% SC, with a concentration of 1.5 per thousand, Ozoneem 1%, with a concentration of 1.5 per thousand, Tondexir with a concentration of 2 per thousand were used. In order to facilitate the preparation of the solution and its spraying, 20 liters of solution were prepared and used for all the treatments with the considered concentration. The insecticides were sprayed at their recommended doses with knapsack sprayer (10-liter capacity) at the economic threshold level of pod borer, ten plants randomly were selected from each plot and the population of pod borer was recorded at 1 day before spraying and 1, 3 and 5 days after spraying. The population of natural enemies was counted and recorded as observations. All the agronomical practices were followed for the cultivation of the crop uniformly in the field throughout the cropping season. The effect of each treatment in controlling chickpea pod borer was modified using Henderson- Tilton formula (Henderson and Tilton, 1955) [11], the mean of the treatments was compared with the one-way analysis of varience (ANOVA) with Duncan's multiple test by SAS® software (Razaq *et al.*, 2005) [25].

Damage and host plants

Chickpea *Helicoverpa armigera* is considered omnivorous, with the larvae attacking at least 60 cultivated and 67 wild host plants from numerous families including Asteraceae, Fabaceae, Malvaceae, Poaceae, and Solanaceae (Pogue, 2004; Fitt, 1989) [24, 7]. Gram pod borer is very notorious pest, causing 37-50% crop losses. This pest also attacks cotton, tomato, maize, cabbage, peanuts and other pulses. In tomato, unripe fruits are attacked early in the season and secondary contamination by microorganism rots the fruit. In corn, it fed on stalks and ears. In peas and chickpeas, larvae enter the pod and feed on the seed. In cotton fields, the larvae first feed on the parenchyma of the leaves and then on the buds and flowers. When the larvae enter the bolls, by feeding of the bolls, they cause shortening, dirt and decrease in the economic value of the fibers (Fitt and Wilson, 2000; Tay *et al*, 2013) [6, 28].

Chemical control

Chemical control is one of the important strategies in integrated pest management (IPM), because it has advantages such as easy application, availability, and decisive and effective control for insects (Endo and Tsurumachi, 2001) [5]. Chickpea pod borer control is done in most regions of the world with the use of insecticides. Effective control of *H. armigera* species with the use of insecticides depends on the correct identification of the target pest on the crop. *H. armigera* and *H. punctigera* species have different sensitivities to pesticides. So that *H. Punctigera* can be controlled to a great extent with the common registered insecticides, that the *H. armigera* species has shown resistance to. Applying insecticides at the right time and creating uniform coverage are important factors in the success of chemical control operations. When the size of the larvae is around 1-7 mm and the larvae have not penetrated the covered parts of the plant, it is the best time to use insecticides. During the past years, various insecticides from different groups, including chlorine, organic phosphorus, carbamate and pyrethroid insecticides, have been used all over the world. The use of these common groups of insecticides on a wide scale has caused resistance in cotton bollworms in Pakistan, Australia, Spain and most African countries. (Martin *et al.*, 2003; Ahmad *et al.*, 2002) [18, 1].

Lethal and sublethal effects

Pesticides are synthetic or natural compounds used to control or eliminate pests. In fact, a pesticide is a combination or a mixture of several chemical compounds that are used to prevent, destroy, remove or reduce the population of insects, rodents, nematodes, fungi and weeds or any type of aquatic plants and animals as well as viruses and bacteria. The fastest effect of pesticides on pests is the resulting mortality in the short time, which is considered as acute effects (Croft and Brown, 1975) [4]. Although pesticides are usually applied at concentrations that will result in rapid death of pest species, residues degrade over time on plants, animals, water, and soils, resulting in sublethal exposures. Furthermore, nontarget species, including secondary arthropod pest species, can be exposed to sublethal effects of pesticides for long periods, leading to unforeseeable consequences such as pest outbreaks (Guedes *et al.*, 2015) [8]. Although the importance of the lethal effects of pesticides on target pests cannot be ignored, knowing the sublethal effects of pesticides on target organisms and their effect on their ecological capacity can help us in creating an appropriate integrated pest management plan. Although pesticides are usually applied at recommended lethal concentrations that result in rapid death of target pests, the breakdown of pesticide residues over time in plants, water, and soil exposes surviving pests to sublethal effects of pesticides that may result in unpredictability on the physiological, biochemical and biological parameters of pests and affect the size of the pest population in the next generations (Pineda *et al.*, 2007) [23]. sublethal effects of synthetic insecticides, including effects on reproductive potential, behavior, enzyme induction, heart rate, and excretion (Haynes, 1988) [10]. Also, Sublethal effects such as suppression of larval weight, insect malformations, and reproductive capacity reduction observed in the survivors could have a negative impact on insect population dynamics (Pineda *et al.* 2004) [22].

3. Result and Discussion

Results showed that all the insecticides significantly reduced the pod borer larval population. The most effective insecticides against pod borer in all three times of spraying in chickpea cultivation was indoxacarb (38.82%, 74.40%, and 86.89% respectively 1, 3 and 5 days after spraying). Which shows a significant difference with other treatments, deltamethrin® and lambdacyhalothrin® were in the second place and showed a significant difference with indoxacarb®. No mortality was observed in the untreated plots at 1, 3 and 5 DAS. The interesting thing to note is that ozoneem®, which is a botanical insecticide, had the same effect 5 days after spraying with lambdacyhalothrin® and deltamethrin®, and no significant difference was observed between them. By observing this result, there is hope that botanical insecticides will replace chemical insecticides for pest control. Thus, it is revealed that indoxacarb® is the most effective insecticides to give high mortality of pod borer on chickpea under field condition. It was also observed that the efficacy of all insecticides was gradually increased with the passage of time (Table 2).

Table 1: Statistically time-laps on the effect of different insecticides to control chickpea pod borer by ANOVA

Source Sampling days	DF	MS	F	P-*value*
Day 1	7	17.21	7.00	0.002
Day 3	7	29.93	15.05	0.001
Day 5	7	39.93	28.42	0.001

Table 2: Effect of several insecticides applied as foliar treatment against Helicoverpa armigera of chickpea, during 2020-21 mortality rate was modified by the formula of Henderson and Tilton, 1955 [11]

Treatments	Percentage of initial mortality	Percentage of mortality due to residual insecticides in treatments		Average reduction	Average reduction due to residual (%)
	1 DAS	3 DAS	5 DAS		
Deltamethrin®	27.75 a	54.50 bc	79.02 bc	66.76	53.75
Imidaclopride®	25.09 a	48.81 bc	70.03 bc	59.42	47.97
Indoxacarb®	38.82 a	74.40 c	86.89 c	80.64	66.70
Lambdacy-halothrine®	23.09 a	52.22 bc	76.69bc	64.45	50.66
Ozoneem®	21.95 a	42.86 b	68.29 bc	55.57	44.36
Tondexir®	23.53 a	46.68 b	67.23 b	56.95	**45.81**
control	-	-	-	-	-

DAS: Days after spray, treatments marked by the same letter/letters are non-significant between insecticides at $p \leq 0.05$

These results are in conformity with those of (Nishapuri *et al.*, 2008) who also reported that the effect of indoxacarb, thiodicarb and profenofos insecticides on cotton bollworm in field conditions. The highest larval mortality was related to indoxacarb treatment. (Liu *et al*., 2002) [15] argue that the effects of indoxacarb on the growth and development of cabbage leaf-eating larvae *Trichoplusia ni*. Who had infected leaves with indoxacarb, with a residue of 18-20 days. The growth and development of larvae was prolonged compared to untreated insects, and pupae emerged 1-2 weeks later treated larvae were much smaller compared to untreated larvae. Some larvae did not molt and pupae were not formed. (Bird, 2015) [3] reported that Emamectin benzoate had the highest toxicity with a median lethal concentration (LC50) of 0.01 mg/ml, The LC50 for chlorantraniliprole was 0.03 mg/ml, while indoxacarb had the lowest relative toxicity with an average LC50 of 0.3 mg/ml. (Mahmoudvand *et al*., 2012) [20] demonstrated that sublethal doses of indoxacarb can profoundly affect the survival and reproduction parameters of *P. xylostella*. (Hamed *et al*., 2007) [9] reported that the effect of indoxacarb on different ages of cotton bollworm at different times. The results of these tests showed that indoxacarb at a concentration of 200 ppm caused 100%, 93.3 and 93.3% mortality after 48 hours of exposure on larvae of ages two, three and four, respectively. In these experiments, the mortality rate increased with increasing concentration and the passage of time.

4. Conclusion

In this work, chemical and biorational insecticides were tested against *H. armigera* to determine their level of effectiveness. In spite of the fact that they are capable of providing efficient pest management for chickpea if they are administered at the right time and in sufficient volume to provide optimal coverage. According to the findings of this study, indoxacarb was the most effective pesticide against pod borer. deltamethrin and lambda-cyhalothrin were placed in second ranking and did not show a different significant.Therefore, the above compounds are recommended to control *Helicoverpa armigera.*

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