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Gouri Shankar Giri
Department of Entomology and Agrilcultural Zoology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Pramod Mall
Department of Entomology, G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Renu Pandey
Department of Entomology, G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Correspondence
Gouri Shankar Giri
Department of Entomology and Agrilcultural Zoology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India

Effect of thiamethoxam on average frame weight and strength of *Apis mellifera* L. exposed to thiamethoxam treated mustard crop

Gouri Shankar Giri, Pramod Mall and Renu Pandey

Abstract
Genus *Apis* is the most studied because of their fascinating and complex lifestyle, communication systems, role as keystone and the valuable hive products that they produce. Recently a sharp decline in population of *Apis mellifera* has been observed throughout the World. Among the various factors, the major one is the use of different classes of pesticides, neonicotinoids in particular. Thiamethoxam, a neonicotinoids, is widely used against sucking pest in svarious crops inluding mustard to which honey bees are attract largely. The present study tried to find out the possible effect of thiamethoxam on average frame weight and strength of *Apis mellifera* colony exposed to thiamethoxam treated mustard field. Detailed examination demonstrated that colonies exposed to the treated crop were unable maintain strength as well as average frame weight throughout the experimental period.

Keywords: honey bee, thiamethoxam, average frame weight, strength

Introduction
Honeybees play a crucial role in the pollination of agricultural crops. Bees are estimated to pollinate over 66 per cent of the world's 1,500 crop species. They also contribute directly or indirectly to 15–30 per cent of global food production. Less than eleven of the 20,000–30,000 bee species are used for agricultural purposes worldwide. Out of above species, the honeybee is used intensively to enhance the agricultural productivity in developed nations (Kremen *et al.*, 2002) [1]. The economic role of honeybees in pollination has been valued to be around 153 billion worldwide in the year 2005 (Gallai *et al*., 2009) [2] that makes 9.5 per cent of the total value of food production (Kremen *et al.*, 2002) [1]. Genus *Apis* is the most studied because of their fascinating and complex lifestyle, communication systems (Nieh, 1998; Nieh and Roubik, 1995) [6, 7]. Role as keystone pollinators of native as well as wild plants, pollination of agricultural crops and the valuable hive products that they produce, such as honey, royal jelly, bee wax, bee pollen, propolis and even bee venom, are well established by several research findings.. However, in recent years, honeybee colony declines have reached 10-30% in Europe, 30% in the United States and up to 85% in Middle East, but such declines are not apparent in South America, Africa and Australia (Kluser, 2010) [4].
Factors belived to contribute to the decline of managed honeybee populations include the introduction of parasitic mites, pathogens, monoculture that results in malnutrition, genetically modified crops, electromagnetic radiation, application of pesticides and many others (Morse and Flottum, 1997) [5]. Among them the most important cause is the the use of various kind of pesticide on crops to which honeybees are attract largely. In order to feed the fast growing global population, chemical insectisides are vital to crop productivity in intensive farming systems where they save about one-fifth of the crop yield (Oerke and Dehne, 2004) [8]. Chemical insecticides used to supress insect populations can affect non-target benificial insects including pollinators. The yearly estimated cost of pollination losses due to pesticide exposure is $210 million USD (Pimental, 2005). Among different classes of chemical insecticide, the use of neonicotinoid insecticides has been specifically pointed out as a key factor that might contribute to a sharp decline of both managed and wild bee population (Goulson *et al.*, 2013) [3].

Materials and Methods
The experiment was conducted at G. B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand). The observations were recorded during the peak flowering period i.e.

from last week of February to last week of March, 2017. Semi field test involving cages having area of 40 m^2 were used. Small healthy queen-right colony per cage containing approximately 3000-5000 bees and at least three full frames containing all brood stages was used. The condition of the colonies such as average frame weight and strength in terms of number of frames covered with bee was assessed on the day before introduction into the cage and on day 7, 14, 21 and 28 after spraying of thiamethoxam.

Results and Discussion

Average frame weight (Kg)

The average frame weight recorded in colonies placed on treated and control field at seven days interval are embodied in table 1. One observation was recorded before application of thiamethoxam. The bee colonies placed in the field to be treated had the average frame weight of 1.11 kg while control colonies had average frame weight of 1.37 kg. Second observation was made seven days after the spraying of thiamethoxam on 4th march where average frame weight of 0.80 kg was noticed in colonies placed on treated fields and average frame weight of 1.46 kg was reported in control colonies. Third observation was recorded on 15 days of application on 11th march where average frame weight of 0.58 kg was noticed in colonies placed on treated fields and average frame weight of 1.54 was reported in control colonies. Fourth observation was recorded in 21 day of application and it was noticed that average frame weight was confused with decline trend in colonies placed on treated field (0.51 kg). In contrary the control colonies was able to maintain increased average frame weight (1.60 kg). Fifth and last observation was made on 25th march, where the colonies placed in treated field was able to maintain the same average frame weight of 0.51 kg as noticed in previous observation while in control colonies there was slight decreased in average frame weight from 1.60 kg to 1.58 kg.

Strength of colony (Number of frame covered with bees)

The strength of the colonies in terms on number of frame covered with bees recorded in treatment and control colonies at seven days interval are embodied in table 1. One observation was recorded before application of thiamethoxam. The bee colonies placed in the field to be treated had 4.66 numbers of frame covered with bees while control colonies had strength of 3.33 frames. Second observation was made seven days after the spraying of chemicals on 4th march where 4.66 numbers of frame covered with bees was noticed in colonies placed on treated fields and 3.33 numbers of frame covered with bees was reported in control colonies. Third observation was recorded on 15 days of application on 11th march where strength of 2.33 frames was noticed in colonies placed on treated field and strength of 3.33 frames were noticed in control colonies. Fourth observation was recorded in 21 day of application and it was noticed that number of frame covered with bees was confused with decline trend in colonies placed on treated field.

Table 1: Effect of thiamethoxam on average frame weight and strength of *Apis mellifera* L. colony.

Date of observation		Average frame weight (kg)		Strength of the colony (number of frame covered with bees)	
		Thiamethoxam	Control	Thiamethoxam	Control
Before exposure	24.02.2017	1.11 (1.05)	1.37 (1.17)	4.66 (2.15)	3.33 (1.82)
During exposure	04.03.2017	0.80 (0.89)	1.46 (1.20)	4.66 (2.15)	3.33 (1.82)
	11.03.2017	0.58 (0.76)	1.54 (1.24)	3.66 (1.91)	3.33 (1.82)
	18.03.2017	0.51 (0.71)	1.60 (1.26)	2.33 (1.24)	3.33 (1.82)
After exposure	25.03.2017	0.51 (0.71)	1.58 (1.25)	2.00 (1.15)	3.66 (1.91)
	GM	0.82	1.22	1.72	1.83
	SEM	0.19	0.66	0.35	0.39
	CD	0.64	0.21	1.15	0.13
	CV	4.11^{s}	0.92^{s}	5.43^{ns}	3.76^{ns}

*Data presented in parentheses are square root transformed values √N+0.

(2.33 frames). In contrary the control colonies was able to maintain constant strength of 3.33 numbers of frame. Fifth and last observation was made on 25th march, where the number of frame covered with bees was found to be 2.00 in colonies placed in treated field while the number of frame covered with bees was increased to 3.66 as compared to the previous observation. It was observed that during the exposure period one of the colonies on treated plot was dying because of death of the queen whereas an additional frame was built by worker bees in one of the control colony at the end of the exposure period.

Similar types of results are observed by Sandrock *et al.* (2014) [11] who found that exposure of honeybee colonies to thiamethoxam and clothianidin resulted in significantly less adult worker populations compared to the control populations. Other significant effects included reduce long term colony growth in terms of pollen, nectar, brood cell area and reduced honey production. On the contrary, Pilling *et al.* (2013) [9] reported that there was no effects on colony strength, brood development, food storage level such as pollen cell area and nectar cell area in colonies that are repeatedly exposed to thiamethoxam treated rape seed and mustard crops.

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