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Effect of thiamethoxam on colony development of *Apis mellifera* L.

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Abstract
The present study was carried out at the Govind Ballabh Pant University of Agriculture and Technology Pantnagar. Genus *Apis* is the most studied because of their fascinating and complex lifestyle, communication systems, role as the 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 various crops inluding mustard to which honey bees are attracted largely. The present study tries to find out the possible effect of thiamethoxam on growth, development of *Apis mellifera* colony. The risk to honey bee colonies in the field was investigated by exposing the colonies to thiamethoxam treated mustard crop at rates recommended for insect control. Throughout the study colony strength, average frame weight, pollen, nectar, brood and capped cell area were found to be lower in colonies exposed to thiamethoxam treated fields as compared to control condition.

Keywords: Honey bee, thiamethoxam, colony development

Introduction
Genus *Apis* are well recognized for their role as important pollinators of native as well as wild plants, pollination of agricultural crops which play a crucial role in maintaining ecosystem biodiversity and the valuable hive products that they provide, such as honey, royal jelly, bee wax, pollen, propolis and even bee venom. However, in recent years, honey bee colony declines have reached 10-30 per cent in Europe, 30 per cent in the United States and up to 85 per cent in the Middle East, but such declines are not apparent in South America, Africa, Asia and Australia [1]. Scientists suspect a multiple of factors responsible for the loss of bees, of which pesticides, varroa mite, electromagnetic waves and cell phone, viruses, farming practices, monoculture, habitat fragmentation, use of genetically modified crop, hygiene in the hive and climatic factors are the most widely cited possibilities [2]. Among them the most important cause is the use of various kinds of pesticide on crops to which honeybees are attracted largely. In order to feed the fast growing global population, chemical insecticides are vital to crop productivity in intensive farming systems where they save about one-fifth of the crop yield [3]. Chemical insecticides used to suppress insect populations can affect non-target beneficial insects including pollinators. The yearly estimated cost of pollination losses due to pesticide exposure is $210 million US [4].
Among the 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 [5]. Thiamethoxam, a neonicotinoid compounds have been shown to be highly toxic to bees in very small quantities [6]. It can be translocated into pollen and nectar, the principal food sources for bees [7]. Foraging bees collect insecticide along with pollen and store it in the brood frames. Nurse bees feed the contaminated pollen and nectar to the developing brood. This resulted in the total loss of the colony, foraging bees are killed while collecting and transporting contaminated pollen, nurse bees are killed while storing and feeding pollen and the brood are killed by eating poisoned pollen. Moreover, some of the compounds degrade slowly and are present in the environment, e.g. in soil, water and/or treated plants for months, or even years, after the application [8].

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 was 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 the strength of the colonies in terms of number of frames covered with bees, average frame weight, pollen cell, nectar cell, brood cell and capped cell area 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

The effect of thiamethoxam on overall growth and development of colony in terms of pollen cell area, nectar cell area, brood cell area, capped cell area, average frame weight, and strength of colonies are embodied on table 1. Data recorded at

Table 1: Effect of thiamethoxam on colony development of honey bees *Apis mellifera* L.

Parameter	Treatment	Before exposure (Mean ± Sd)	During exposure (Mean ± Sd)			After exposure (Mean ± Sd)
		24.02.2017	04.03.2017	11.03.2017	18.03.2017	25.03.2017
Pollen cell (cm^2)	Thiamethoxam	70.00 ± 74.53	57.33 ± 65.15	33.66 ± 39.14	26.00 ± 31.43	26.00 ± 31.43
	Control	58.66 ± 12.22	74.00 ± 39.03	86.00 ± 44.13	110.00 ± 29.46	121.33 ± 34.48
Nectar cell (cm^2)	Thiamethoxam	33.33 ± 20.13	27.33 ± 15.53	16.00 ± 11.13	14.66 ± 16.16	6.00 ± 10.39
	Control	123.66 ± 69.21	143.3 ± 68.53	141.33 ± 45.48	155.33 ± 51.31	140.66 ± 8.08
Brood cell (cm^2)	Thiamethoxam	124.66 ± 16.04	61.00 ± 7.92	17.33 ± 6.11	4.00 ± 6.92	11.33 ± 34.00
	Control	122.66 ± 16.04	230.66 ± 42.77	273.33 ± 15.27	272.00 ± 34.87	228.00 ± 74.93
Capped cell (cm^2)	Thiamethoxam	240.33 ± 39.06	206.66 ± 44.07	149.33 ± 88.93	56.00 ± 54.14	31.33 ± 44.28
	Control	286.00 ± 59.02	383.33 ± 112.71	438.00 ± 87.10	448.00 ± 98.85	388.66 ± 36.01
Average frame weight (Kg)	Thiamethoxam	1.11 ± 0.20	0.8 ± 0.06	0.58 ± 0.12	0.53 ± 0.10	0.51 ± 0.90
	Control	1.37 ± 0.05	1.46 ± 0.06	1.54 ± 0.03	1.60 ± 0.07	1.58 ± 0.02
Strength (Number of frame covered with bees)	Thiamethoxam	4.66 ± 0.57	4.66 ± 0.57	3.66 ± 0.57	2.00 ± 1.73	2.00 ± 1.73
	Control	3.33 ± 0.57	3.33 ± 0.57	3.33 ± 0.57	3.33 ± 0.57	3.66 ± 0.55

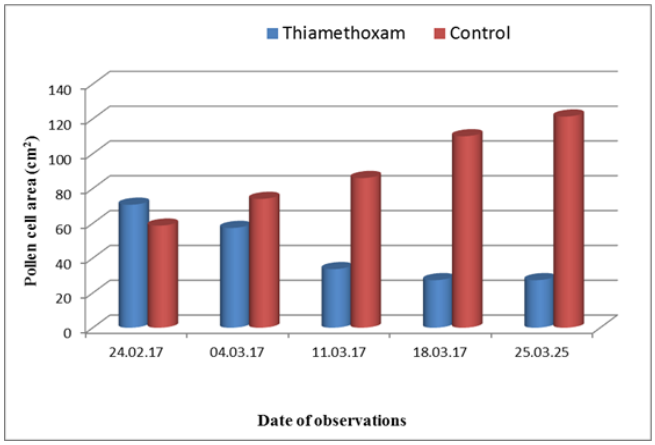

Fig 1: Effect of thiamethoxam on pollen cell area of *Apis mellifera* L.

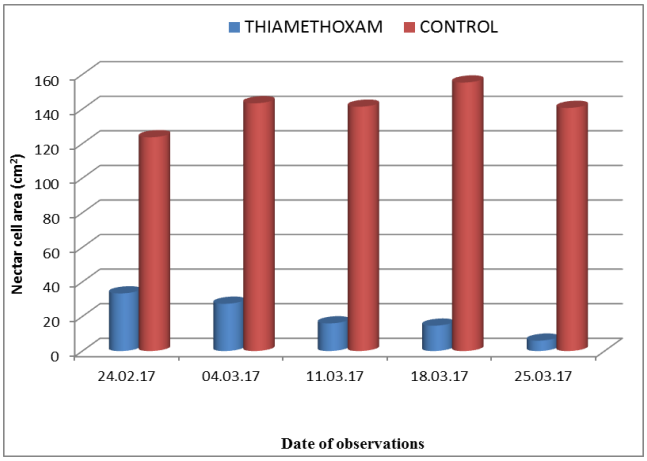

Fig 2: Effect of thiamethoxam on nectar cell area of *Apis mellifera* L.

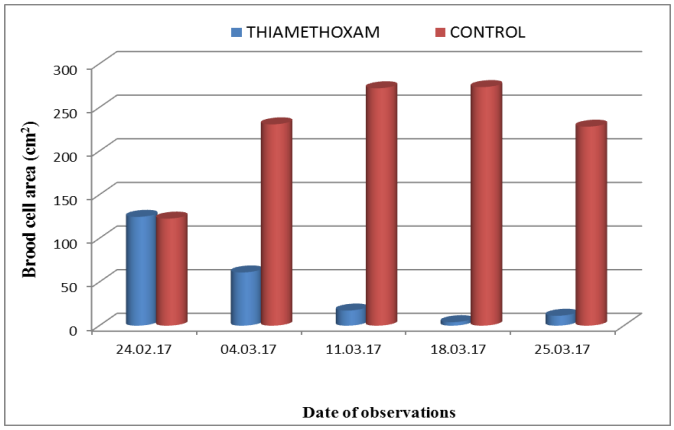

Fig 3: Effect of thiamethoxam on brood cell area of *Apis mellifera* L.

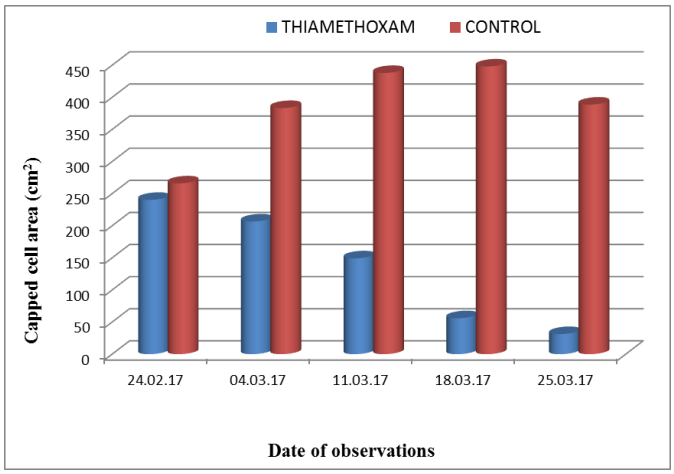

Fig 4: Effect of thiamethoxam on capped cell area of *Apis mellifera* L.

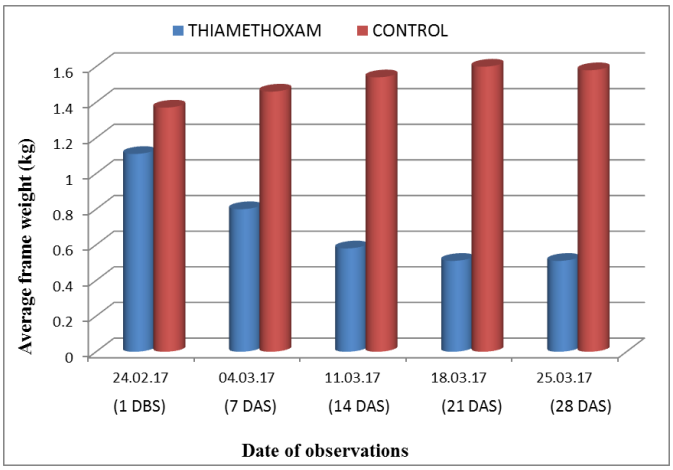

Fig 5: Effect of thiamethoxam on average frame weight of *Apis mellifera* L.

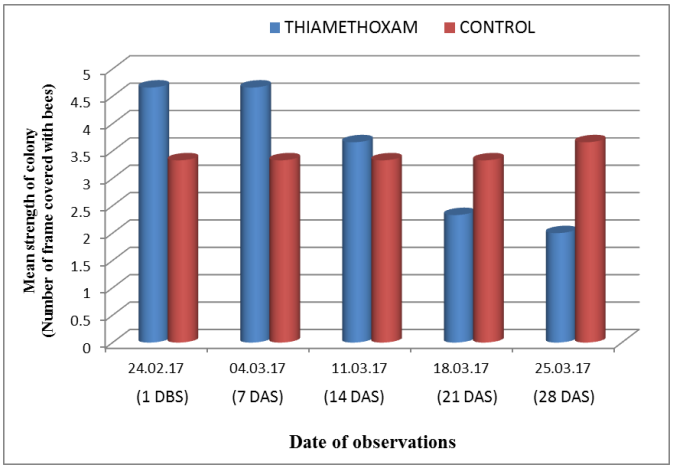

Fig 6: Effect of thiamethoxam on strength of *Apis mellifera* L.

weekly interval clearly implies that the pollen cell area was decreased gradually from 70.00 ± 74.53 (at the start of experiment) to 26.00 ± 31.43 (at the end of experiment) in colonies placed on thiamethoxam treated field while it was increase significantly from 58.66 ± 12.22 (at the start of experiment) to121.33 ± 34.48 (at the end of experiment) in control colonies. Similarly the nectar cell area was decreased gradually from 33.33 ± 20.13 (at the start of experiment) to 6.00 ± 10.39 (at the end of experiment) in colonies placed on thiamethoxam treated field while it was increase significantly from 123.66 ± 69.21 (at the start of experiment) to 140.66 ± 8.08 (at the end of experiment) in control colonies. Similarly the brood and capped cell area was found to be decreased drastically from 124.66 ± 16.04, 240.33 ± 39.06 (at the start of experiment) to 11.33 ± 34.00, 31.33 ± 44.28 (at the end of experiment) in colonies placed on thiamethoxam treated field while it was increase significantly from 122.66 ± 16.04, 286.00 ± 59.02 (at the start of experiment) to 228.00 ± 74.93, 388.66 ± 36.01 (at the end of experiment) in control colonies. Average frame weight means the weight of frame that includes weight of pollen, nectar, brood, honey etc. that the frame contains. Since pollen, nectar, brood and capped brood cell area was decreased day by day, the average frame weight is also decreased gradually from 1.11 ± 0.20 (at the start of experiment) to 0.51 ± 0.90 (at the end of experiment) in colonies placed on thiamethoxam treated field. In contrast it was increase significantly from 1.37 ± 0.05 (at the start of experiment) to 1.58 ± 0.02 (at the end of experiment) in control colonies. Similarly the numberof frames covered with bees was decreased gradually from 4.66 ± 0.57 (at the start of experiment) to 2.00 ± 1.73 (at the end of experiment) in colonies placed on thiamethoxam treated field while it was increase significantly from 3.33 ± 0.57 (at the start of experiment) to 3.66 ± 0.55 (at the end of experiment) in control colonies. It was found that throughout the period of study, condition of colonies such as pollen cell area, nectar cell area, brood and capped brood cell area, average frame weight, number of frames covered with bees were decreased day by day in colonies exposed to thiamethoxam treated mustard field. In contrast, condition of control colonies becomes move to stronger day by day. Regarding the presence of healthy queen bee, it was found that a queen bee in one of the colonies exposed to thiamethoxam treated field was dying on 18th march 2017. From this experiment it was found that thiamethoxan affect the pollen cell area, nectar cell area, brood cell area, capped cell area, average frame weight, health of queen bees and strength of *Apis mellifera* colony. Similar types of results are observed by Sandrock *et* al. [9] who found that exposure of honey bee 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. [10] 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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