Assessment of foragers visit and mortality of *Apis mellifera* L. under stress of organothiophosphate Quinalphos

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ABSTRACT

Quinalphos is one of the most commonly used organothiophosphate insecticide in agriculture against a number pests in India, especially in west UP, Haryana, and Punjab. However, its effect on beneficial insects such as honeybee *Apis mellifera* L. is not well known. Young adult workers bees called as foragers, perform out-hive duties that are important and very crucial for colony development and their survival. In this study, the effect of sublethal doses of Quinalphos on honeybee foraging activity and mortality was assessed under field conditions. The results showed that quinalphos had a negative impact on foragers visit to treated field and caused mortality substantially of honey bees for a period of five to six days following the spraying in field condition.

Key words: Foragers, *Apis mellifera* L. Quinalphos, Mortality.

INTRODUCTION

Pollination is an environmental service essential for the maintenance of natural ecosystems and agriculture (Costanza *et al*. 1997; Ricketts et al. 2008). Approximately 85% of angiosperm species are pollinated by animals (Ollerton *et al*. 2011). Entomophilic pollination plays an important role in agriculture and environment conservation. Bees are considered the most efficient pollinators (Potts *et al*. 2010) and are responsible for pollinating approximately 70% of cultured plant species (Ricketts et al. 2008). In particular, the honey bee, Apis mellifera L., is a key worldwide pollinator of crops and native plants (Klein *et al*., 2007). The decline of managed honey bee colonies has therefore outstretched concern about ecological influences, crop production, food security and human welfare (Potts et al., 2010). Multiple factors comprising disease and pesticides are responsible for poor honey bee health (Sanchez-Bayo et al., 2016).

Among pesticides, attention has been focused on the organophosphates quinalphos (Arena, M., Sgolastra, F. 2014) a group of neurotoxic insecticides that is globally used on multiple crops for the management of sucking pest (Simon-Delso *et al*., 2014).

Organophosphates are environmentally persistent and systemic *i.e* they can be translocated throughout the plant and present in all plant parts including nectar, pollen, and guttation droplets that bees collect (Bonmatin *et al*., 2014 ; Godfray *et al*., 2015). Moreover, exposure to even low concentrations of organophosphate quinalphos can harm bee health via synergistic interactions between multiple stressors Sanchez-Bayo *et al*., 2016; Godfray *et al*., 2015; Pisa *et al*., 2014). Organophosphates which are systemic pesticides have been widely used for the management of sucking pests such as aphids in mustard crop throughout the world. Being systemic in action, it can remain in the plant parts for several days and affects the insect visitors including honey bees and other pollinators. The current investigation was carried out in order to find out whether organophosphate quinalphos had a negative impact on foragers visit to treated crop fields and mortality of forager *Apis mellifera* L. at field relevant dose or not.

MATERIALS AND METHODS

Experimental Design

The experiment was conducted at Govt. PG College Bisalpur, Pilibhit (UP). In order to evaluate the effect of quinalphos on foragers visit and mortality of *Apis mellifera* L. mustard crop was taken. The experiment was designed as per Giri *et al* 2017. Small healthy colonies with queen containing approximately 4000-5000 bees and at least two full frames containing all brood stages were used. There were 6 number of plots (size 35 m^2), three of which were treated with quinalphos and rest three were considered as control for assessing the foraging activity. Similarly there were about 6 numbers of hives, three of which were kept near (within 95 meter) the treated field and considered as three replications. Rest three colonies were kept five kilometers away from the field and were considered as control colonies for assessing the mortality.

Quinalphos

Quinalphos is organothiophosphate chemical chiefly used as an insecticide. It is a reddish-brown liquid. The chemical formula is $C_{12}H_{15}N_2O_3PS$, and IUPAC name *O*,*O*-diethyl *O*-quinoxalin-2-yl phosphorothioate ranked 'moderately hazardous' in World Health Organization's (WHO) acute hazard ranking, use of quinalphos, classified as a yellow label (highly toxic) pesticide in India, is widely used in the following crops: wheat, mustard, rice, coffee, sugarcane, and cotton.

Treatment, observation and analysis

Quinalphos 25 EC was applied at the recommended dose *i.e* @ 375g per hectare with the help of a battery operated sprayer at the time of plenty of flowering on twenty first February 2018. The observations were recorded during the peak flowering period. Foragers visit to treated field was recorded 3 times each day (at peak foraging times, e.g. morning, early afternoon and late afternoon) for a period of two minutes through visual observations. It was assessed by counting number of bees visited to m^2 area of treated and untreated crop at least one day prior to application and after application on days 1, 2, 3, 4, 5 and 6. Mortality of bees was recorded one day prior to application and after application on days 1, 2, 3, 4, 5 and 6. Mortality was recorded by counting the number of dead bees in front of the hive as well as inside the hive. Dead bee in the field are also counted. Simultaneously data was recorded on control colonies. The analysis of variance of data collected from this experiment was done by randomized block design.

RESULT AND DISCUSSION

Effect on foragers visit

The mean number of forager bees visiting to treated field recorded one day before the application of quinalphos and 1, 2, 3 and 4 day after the application of quinalphos in treated and control fields have been shown in Table1 and Fig. 1. One observation was recorded before the application of quinalphos where the number of forager bees in field to be treated was found to be 13.00 while in control fields the number was 15.33. Second, third, fourth and fifth observations were made on 1, 2, 3, and 4 days after the application of insecticide where 3.66, 7.00, 7.00 and 8.33 forager bees were noticed in treated field while 16.66, 14.33, 15.00 and14.66 numbers of forager bees were noticed in the control fields. Sixth and last observation was recorded after 5th day after of application of quinalphos where 8.66 numbers of forager bees were noticed in the treated field while 17.33 forager bees were noticed in the control fields.

Effect on bee mortality

The mean number of dead bees recorded one day before the application of quinalphos and 1, 2, 3, 4, 5 days after the application of quinalphos are mentioned in Table 1 and Fig 2. One observation was recorded before the application of quinalphos where the number of dead bees in colonies exposed to the field to be treated was found to be 0.00 while in control colonies the number was 0.33. 15.33, 8.33, 5.33, 4.66 numbers of dead bees were noticed in the colonies exposed to treated field and 1.00, 0.33, 1.00, 1.33 numbers of dead bees were noticed in the control colonies at 1, 2, 3 and 4 days after the application of quinalphos. Sixth and last observation was recorded after five days after of application where 2.66 numbers of dead bees was noticed in the colonies exposed to treated field and 0.33 dead bees were noticed in the control colonies.

The results of this study indicated that quinalphos insecticide was hazardous to forager's health; therefore, it is essential to propose measures to minimize the impact of pesticides on pollinators. Preserving any remaining semi-natural woodland or wild vegetation near crop farming areas, identifying and using insecticides with lower toxicity, using integrated pest management approaches, avoiding applications during crop-blooming periods and protecting colonies whenever possible are relevant interventions that can be implemented to mitigate the impact of organophosphates spraying on bees (Pinheiro and Freitas 2010; Kevin, 2005; Roubos *et al.* 2014).

Furthermore, Roubos *et al*. (2014) reported that the negative impacts of insecticides can be reduced when these chemicals are applied directly to the soil. Morales-Rodriguez and Peck (2009) noted that synergistic combinations of biological and chemical insecticides may be promising alternatives for pest control. In addition, Xavier et al. (2010) suggested using botanical insecticides as an alternative because those were not associated with adverse effects on stingless bees in their study. Brown et al. 2016, mentioned actions to mitigate the negative impacts of pesticides through new laws implementing chronic and sublethal trials, as well as field trials with different species of pollinators before the release of new pesticides. Through good agricultural practices, the environment, the profitability of agriculture and food safety will all benefit (Nocelli *et al.* 2011; Goulson *et al.* 2015; Kessler *et al.* 2015).

Thus, we suggest that new analyses of the lethal and sublethal effects of pesticides recommended for use in bee-attracting crops be carried out on honeybees through both field and semi-field experiments with a view toward ensuring the preservation of biodiversity, the safety of native bee species and the sustainability of pollination services.

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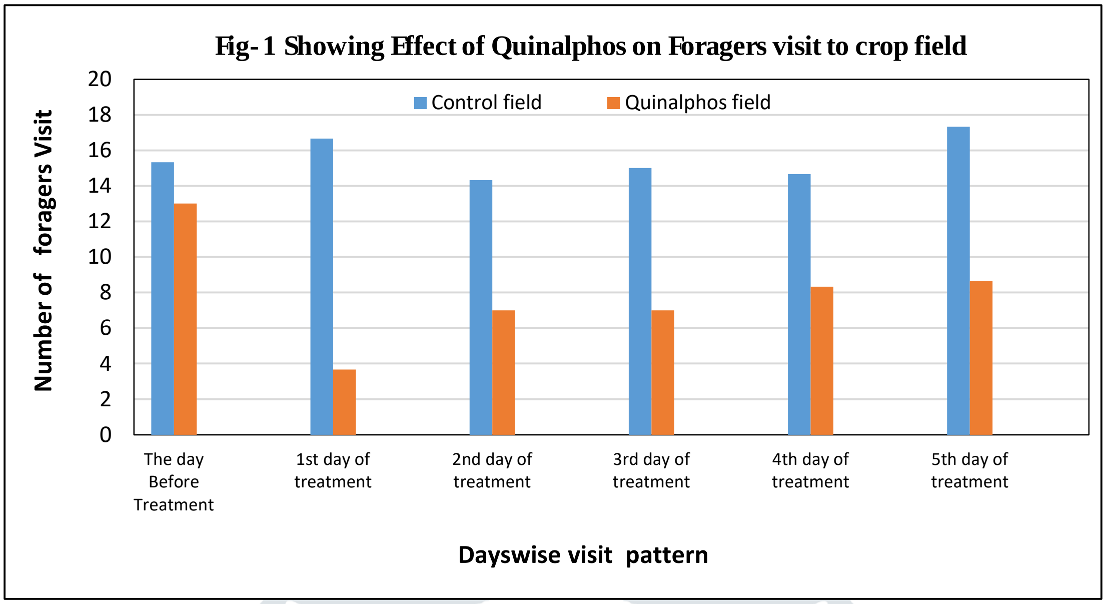
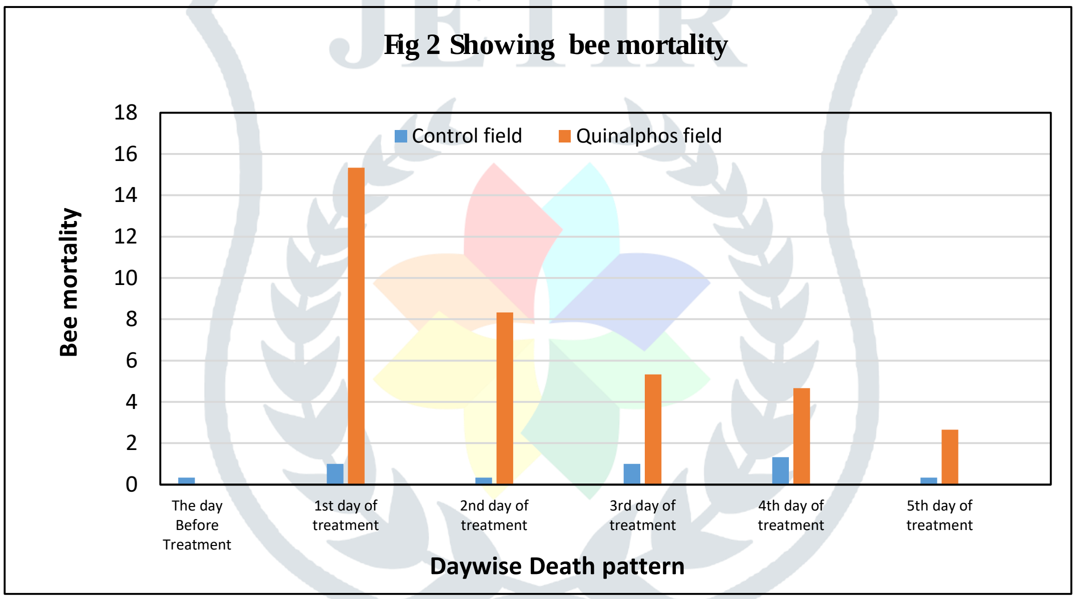
Table 1: Effect of quinalphos on forager's visits to crop field and mortality of *Apis mellifera* L.

Sl No.	Observation Day	Forager's visit (No. of Bees visited to field)		Mortality (Dead Bees)	
		Control field	Quinalphos field	Control field	Quinalphos field
1	The day Before Treatment	15.33	13.00	0.33	0.00
		(3.67)	(3.33)	(0.33)	(0.00)
2	1st day of treatment	16.66	3.66	1.00	15.33
		(3.99)	(1.99)	(1.00)	(3.64)
3	2nd day of treatment	14.33	7.00	0.33	8.33
		(3.78)	(2.64)	(0.33)	(2.87)
4	3rd day of treatment	15.00	7.00	1.00	5.33
		(3.88)	(2.64)	(1.00)	(2.34)
5	4th day of treatment	14.66	8.33	1.33	4.66
		(3.83)	(2.83)	(1.13)	(1.98)
6	5th day of treatment	17.33	8.66	0.33	2.66
		(4.17)	(2.93)	(0.33)	(1.68)

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





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