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Efficiency of chemical treatment in management of wax moth infestation of *Apis mellifera*

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Abstract : Beekeeping is an integral part of livestock based livelihood system in Bihar. Despite of its importance, the Bihar regions are challenged by colony strength and honey yield due to pests including wax moths. To overcome these challenges different treatments were suggested by researchers. The present study was thus intended to evaluate the efficiency of chemical treatments on infestation level with wax moths in Bihar. Data were analysed using ANOVA and weighted ranking matrix. Results revealed that fumigation with Bromopropylate @ 1 strip/ colony should be used to control wax moth infestation. Another finding indicated that the raised frames should be stored with sulphur @ 300 g/ m^3 space will prevent damage to raised combs by wax moth during storage.

Key words:Beekeeping, Bromoproylate, Sulphur, wax moths

INTRODUCTION

Bee keeping is an art of keeping bee colonies for economic benefit and has been practice for a long time. Bee colonies suffer from various maladies. These maladies include contagious diseases, non-contagious diseases and malfunctions, pests' parasite and predators. Among the pests parasites and predators are such diverse groups of animals as mite, warps, wax moths, spider and ants are the most important. The wax moths are extremely damaging and can cause absconding and even death of a colony. The total number of insect's species having association with honeybees is very large and their records in India are incomplete, therefore, wax moth will be discussed here that play a significant role in the practice of beekeeping.

Wax moth- The wax moth is a pest of all honeybees in India viz., *Apis cerana*, *Apis dorsata* and *Apis florea*.[1]

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Wax moths are world- wide distributed causing a major concern whenever beekeeping is being practised. It affects beekeeping industry more in the plains and lower hills than at higher altitude. There are two types of wax-moth, which are major concern to the beekeeping industry. The greater wax moth (*Galleria mellonella* L.) is the most serious problem in the combs, whereas lesser wax moth (*Achroia grisella* fabr.) is a minor pest they feed on pollen, wax and protein of the pupal skins.[2]

Wax moth, especially greater wax moth (*Galleria mellonella* L.) is the most serious problems and of major concern of the beekeeping industry. The larvae destroy raised combs in storage as well as in hives by tunnelling through the midrib of a comb. They feed on pollen, wax and protein of the pupal skins. The insect breed on combs and in tropical and subtropical areas they often cause death of the colony. Observations on the seasonal infestation in *Apis mellifera* epidemics showed that it was devastating during and after the monsoon when colony strength was low due to shortage of bee flora.[3]

According to Sharma and Garg (1984)[4] the damage is caused by caterpillars which eat combs and interfere with brood-rearing by making silken galleries through the cells. In case of severe infestation, the whole comb become a mass of webbing in which excreta of the caterpillars is enmeshed. Severe damage is caused in bee colonies which are weak and some combs are not covered by bees. The infestation colonies often abscond. In the off season, when the combs are stored, the caterpillars also damage them. Atwal (2000)[2] found ramification of galleries on combs when a frame was held against height. In the late stage the comb looked like a tangled mass of silken galleries, frass and handly a sign of cells. According to Ramchandran and Mahadeven (1951)[5], Brar *et al.* (1985)[3], Gupta (1987)[6] and Atwal (2000)[2] peak activity of wax moth is from June to November whereas, Viraktamath (1989)[7] recorded the peak population during May to August which coincides with dearth period in south India.

Management practices for control of wax month

Preventive measures

Preventive measures include ensuring that the colonies, whether of *Apis cerana indica* or *Apis mellifera* are strong and have adequate food stores, reducing the hive entrance and sealing cracks and crevices in the hive wall, protecting the colonies against pesticide poisoning and controlling pests and diseases that might otherwise weaken them and removing wax debris accumulated on the bottom boards of the hives (Sharma and Garg. 1984)[4]. Ramchandran and Mahadevan (1951)[5] reported that minimising the cracks and crevices of hives and crushing the moth egg masses gave effective control of wax moth. The spare combs should be removed from the hives and stored in the moth proof hives. Kapil and Sihan (1983)[8] observed effective control of all stages of wax moth when combs where kept at high temperature (less than 49^{0}C) for 5 to 6 hours and freezing of queen cups. Cleaning of hives and creation of good sanitation conditions helped to save the colonies from wax moth damage.

Chemical control measures

Chemical control measures can be taken to prevent or control the wax moth infestation of stored combs. Fumigation is often necessary. The most commonly used fumigants was PDCB (Para- dichlorbenzene) crystal which evaporated slowly. Aluminium phosphide, naphthalene, ethylene dibromide and methyl bromide had also been used for wax moth control.[4]

Sulphur: Ramachandran and Mahadevan (1951)[5] recommended sulphur fumes for the control of wax moths in stored combs. Various remedial measures have been suggested, including the use of sulphur, besides observing strict Cleaners in bee hives.[9]

Ethyl dibromide: Kapil and Sihag (1983)[8] reported one table spoon of EDB very effective to kill all stages of wax moth in stack of eight supers. Ethylene dibromide (EDB) is heavier than air and is placed on the super in small containers. One table spoon of EDB was found to be effective to kill all the stages of wax moth in a stack of eight supers.[8] They further reported that PDCB evaporates slowly and acts as repellent as well as toxic substance to wax moth and its larvae. Two to four table spoon of the crystal of PDCB are placed between every other super in stack.

Aluminium phosphate: Atwal (2000)[2] advised to raise frames in 4-5 ft tall polythene bag of thick plastic sheet and to put ¼ tablet of aluminium phosphide, before tightly closing the open end with a string.

MATERIALS AND METHOD

The monitoring and identification of prevailing major natural enemies is this area namely wasp, mite and wax moth during dearth period in this ecological region of Bihar were done. Different chemical treatment strategies were tested such as manipulation of beehives. The present investigations were evaluated during dearth period (June to October) for selection of better management strategies against wax moths in the two consecutive years 2009 and 2010.

Chemical control of wax moth within the hive

Experiments were conducted in the Randomised block design with three replications and seven treatment during two consecutive years, 2009 and 2010. The details of the experiments were as under.

Treatment	Formulation	Dose
T_1-	Kelthane-spray	0.05%
T_2-	Formicacid Evaporation agent	5ml/colony
T_3-	Naphthaline ball crystal	3.6g
T_4 -	PDCB - crystal	5g/colony
T_5 -	Bromopropylate – Fumigants	one strip/colony
T_6 -	Sulphur Dust	5 g/hive
T_7 -	Control	………………..

Three beehives of *Apis mellifera* in each Treatment were selected for the experimental trial. All the fumigants as mentioned above applied at different doses on all the combs at 1.30 pm. The treatment was repeated after 15 days.

Therefore, the present study was undertaken to determine appropriate management tactics which would be ecologically sound, economically viable and socially acceptable. The experiments were carried out during dearth period (June to October) of the years, 2009 and 2010.

RESULT

Chemical control of wax moth within the hive

The results on the effect of different chemical application (T_1 to T_6) besides control (T_7) on the infestation of wax moth (mean no. of larval/colony) have been summarised in Table 1 and depicted in Fig 1. The data revealed the data revealed the superiority of all the chemicals (T_1 to T_6) over control (T_7) in minimising the larval population of wax moth in both the years (2009 and 2010).

In 2009, before the chemical application, the mean larval population of wax moth/colony of all the treatments (T_1 to T_6) were found non- significant and ranged between 13 to 19 larval population per colony (table 1). Although all the treatments (T_1 to T_6) were found significant over control (T_7) after chemical application in the hives. The minimum larval population of wax moth (8.0 and 8.0) was found per colony treated with Bromopropylate @1 strip/colony (T_5) and sulphur @ 5 g/hive in the treatment (T_6), respectively and were at par with treated hives with PDCB (T_4) having larval population (9.0). The treatments Viz., T_2 (12.0) and T_3 (12.0) were found statistically at par with each other, but significantly inferior over T_1 (15.0). Further all of these treatments (T_1 to T_6) were proved significantly superior in minimising the larval population of wax moth over T_7 as control having maximum larval population (20.0). the maximum reduction of the larval population of wax moth (55.55) was recorded per colony in the application of Bromopropylate fumigants @ 1 strip/colony treated hive (T_5) and it was found significantly superior in reduction of the larval population over the rest of the treatments (table 13). The treatments Viz., T_1 (21.05), T_2 (25.00), T_3 (29.41), T_4 (30.76) and T_6 (46.66) were found significantly superior over T_7 (-25.00) as control in percentage reduction of the larval population per colony. Among these treatments T_1 had the minimum percentage reduction of larval population (21.05) per colony.

In the following year 2010, almost a similar trend of the effectiveness after the chemical applying treatment on wax moth larval population was inferred. All the chemical treatments (T_1 to T_6) were recorded significantly superior in lowering the larval population over T_7 as control which have the maximum (22.00) larval population per colony. Whereas, the minimum larval population (8.0) was observed per colony in the application of Bromopropylate @ 1 strip/ colony treated hives (T_5) which have at par with the fumigation of sulphur @ 5g/hives treated hives (T_6) and have relatively lower larval population (11.00) per colony. The rest of the treatments Viz., T_1(15.00), T_2 (13.00), T_3 (16.00) and T_4 (15.00) were found statistically at par to each other and significantly superior over T_7 as control which had maximum larval population (22.00). Although, before the chemical application all the treatments (T_1 to T_6) were found non-significant having 17.00 to 21.00 larval population of wax moth.

The maximum percentage reduction of the larval population (60.00) was observed per colony in the application of Bromopropylate fumigants @ strip/colony treated hive (T_5) and followed by the treated hive with sulphur fumigants @5g/hive (T_6) which had the percentage reduction of the larval population (38.88). the remaining treatments Viz., T_1 (21.05), T_2 (23.52), T_3 (23.80) and T_4 (25.00) were also found significantly superior in percentage reduction of the larval population over (T_7) (-29.41) as control. The findings suggested that wax moth infestation could be effectively managed by the application of bromopropylate fumigant @ 1 strip/colony.

Chemical control of wax moth in storage condition during dearth period

The observation on chemical control of wax moth infestation on the comb infestation area during dearth period were recorded and presented in table 2 and depicted in Fig. 2

The result indicated that he chemicals used were significantly superior to reduce wax moth infestation in storage condition over century (T_7) during the years 2009 and 2010 and when pooled data of two years were statistically analysed.

In 2009, the data further revealed that the treatment T_2 resulted the minimum comb area infestation (180 cm^2) which did not. Differ significantly to the treatments T_1 (350 cm^2) and T_4 (350 cm^2), where as the treatment T_6 had the maximum comb area infestation (1200 cm^2) which was followed by T_5 (900 cm^2). The treatments T_3, T_5, T_6 and T_7 were found differ significantly among themselves and these treatments also showed significant impact in reduction the comb infestation area T_7 (2000 cm^2) as control.

In the second year 2010, almost a similar trend of the comb infestation area was found. Overall the treatments, T_1 to T_6 were found significantly superior over control T_7 (1800 cm^2) in minimising the comb infestation area. The treatment T_2 resulted the minimum comb area (200 cm^2) which did not differ significantly to the treatment T_4 (375 cm^2) the treatments T_1 (417 cm^2), T_3 (765 cm^2), T_5 (1050 cm^2) and T_6 (1300 cm^2) were differed significantly among themselves and were also found significantly superior in decreasing the comb infestation area over T_7 (control) which had recorded maximum comb infestation area (1800 cm^2). But the treatment T_4 (375 cm^2) did not differ significantly with T_1 (417 cm^2) in reducing the comb infestation area.

The pooled data of both years (2009 and 2010) when statistically analysed revealed that all the six treatments (T_1 to T_6) were found significantly superior over control T_7 (1900.00 cm^2) in minimising the comb infestation area. The treatment T_2 resulted the minimum comb area infestation (190.00 cm^2) which was followed by T_4 (362.50 cm^2). The treatments, viz. T_1 (383.50 cm^2), T_3 (720.00 cm^2), T_5 (975.00 cm^2) and T_6 (1250.00 cm^2) differed significantly among themselves. Among the treatments T_6 had the maximum comb infested area (1250.00 cm^2) which too, differed significantly to the rest of the treatments (Table 2). The findings showed that application of sulphur @300g/m^3 space in storage condition have been found better in preventing wax moth infestation.

Table 1- Effect of different chemical application on infestation of wax moth (Mean no of larvae/ colony) in during dearth period during two consecutive years 2009 and 2010.

Treatment	Formulation	Dose	2009			2010		
			Infestation before App.	Infestation After App.	% reduction	Infestation before App.	Infestation After App.	% reduction
T_1Kelthane	Spray	0.05%	19	15	21.05	19	15	21.05
T_2 Formic Acid	Evaporation agent Crystal	5ml/colony	16	12	25.00	17	13	23.52
T_3 Nephaline ball	Crystal	3.6g	17	12	29.41	21	16	23.80
T_4 PDCB	Crystal	5g/colony	13	09	30.76	20	15	25.00
T_5Bromopropylate	Fumigatns	1 strip/colony	18	08	55.55	20	08	60.00
T_6 Sulphur	Dust	5g/hive	15	08	46.66	18	11	38.88
T_7 Control	-	-	16	20	-25.00	17	22	-29.41
S.Em. ($\pm$)	-	-	-	1.03	-	-	1.06	-
CD at 5%	-	-	Ns	2.95	-	Ns	3.04	-

*** Mean of three replications**

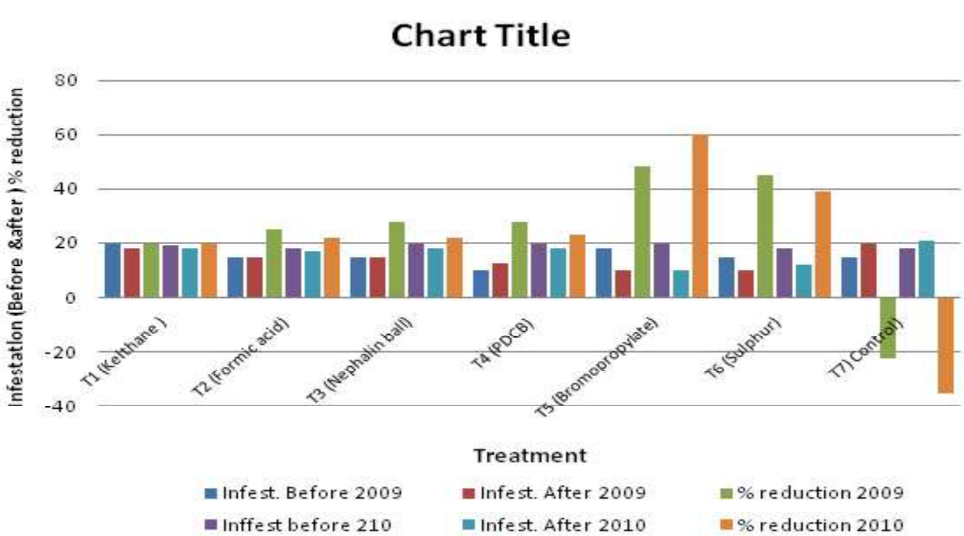

Fig. 1 : Effect of different chemical application on infestation of wax moth (Mean no. larvae/colony) in dearth period during two consecutive years, 2009-2010

Table 2- Effect of chemical treatments on infestation of wax moth in storage condition in dearth period during two consecutive years, 2009 and 2010.

Treatments	Dose	2009	2010	Pooledmean
		Mean area infestation (cm^2)	Mean area infestation (cm^2)	
T_1 Sulphur	200 g/m^3 space	350	417	383.50
T_2 Sulphur	300g/m^3 space	180	200	190.00
T_3 Aluminium phosphide	3g/m^3 space	675	765	720.00
T_4 Aluminium phosphide	10g/ m^3 space	350	375	362.50
T_5 EDB	25 ml/m^3 space	900	1050	975.00
T_6Falbex strip	5-7 fumigations at weekly intervals	1200	1300	1250.00
T_7 Untreated (control)		2000	1800	1900.00
S.Em. (±)		61.27	58.14	26.26
CD at 5%		188.82	179.18	74.62

***Mean of three replications.**

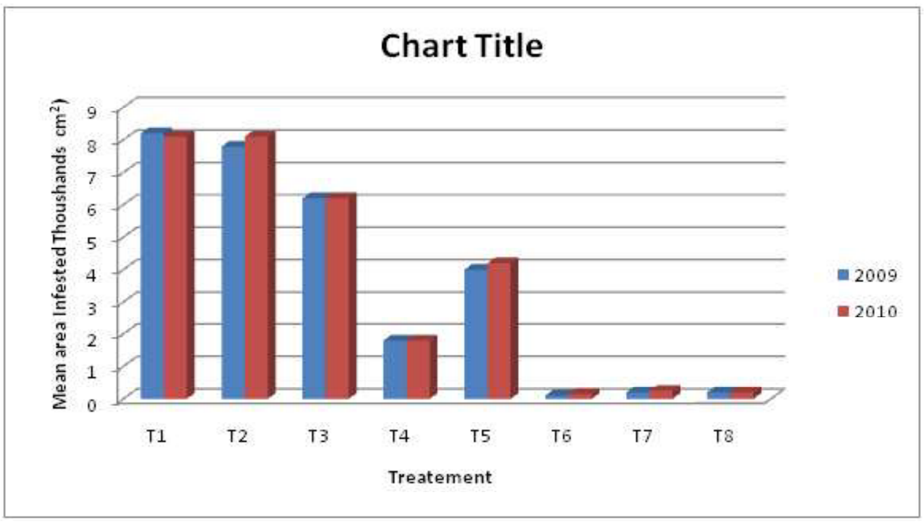

Fig 2.- Effect of different storage methods of raised combs on Gelleriamellonella L infestation in dearth period during two consecutive years, 2009- 2010

DISCUSSION

The Italian honeybee, *Apis mellifera* colonies were successfully introduced a few decades ago in Bihar but their colonies suffers from few natural enemies during dearth period. Wasps, mite and wax moth are very important natural enemies which affects the honeybee health in ecological region. Management of these natural enemies have become very important aspects for honey production technology and successful beekeeping.

The findings of the present investigation revealed that various chemical like sulphur, kelthane, formic acid, nephthalin ball, PDCB, and Bromopropylate have been reported to be ideal insecticides against mites and wax moth. Chemical controls were dominant hive protection methods in many apiaries having high honey yielding colonies of *Apis mellifera*. In the present studies, efforts were made to evaluate, the effectiveness of insecticides in the hives and storage condition during dearth period in both the years (2009 and 2010). Different chemical viz., Sulphur, kelthane, formic acid, nephalene ball, PDCB and Bromopropylate were used against wax moth in the hives during dearth period (June to October) of 2009 and 2010. The results revealed that the maximum percentage reduction on mite population (41.72 and 56.40) was recorded per hive in the Bromopropylate fumigants @ 1 strip/colony treated hive (T_5) followed by the treated hive with sulpur fumigants @5g/hive (T_6) which have the percentage reduction of mite population (29.72 and 44.54). The minimum percentage reduction of mite population as 11.03 and 4.62 per colony were recorded in treated hive with kelthane @ 0.05% (T_1) during 2009 and 2010, respectively. There were significant variation ($p<0.05$) among all the variation and their interaction.

The result revealed that the maximum percentage reduction of wax moth larval population (55.55 and 60.00) was recorded per colony in the application of Bromopropylate fumigant @1 strip/colony treated hive (T_5) followed by the treated hive with sulphur fumigants @ 5 g/ hive (T_6) which have the percentage reduction of wax moth population (46.66 and 38.88). The percentage reduction of mite population as 21.05 and 21.05 per colony were recorded in treated hive with kelthane @ 0.05% (T_1) during 2009 and 2010, respectively. There were significant variation ($p<0.05$) among all the treatment and their interaction. The result indicated that fumigation of honeybee colonies with Bromopropylate 1 strip/colony would effectively reduce the population of wax moth within the hive. Thus, it might be used for managing the infestation of mite and wax moth within the hive.

CONCLUSION

The results suggested that sulphur @ 300g/m^3 space might be used for managing the wax moth infestation during storage was found most effective. Another results indicated that fumigation of honey bee colonies with Bromopropylate 1 strip/colony would effectively reduce the population of wax moth within the hive. Thus it might be used for managing infestation of wax moth within the hive.

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CONFLICT OF INTEREST

Authors declare no conflict of interest regarding publication or any other activity related to this article.

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