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CONTROL OF *AEDES AEGYPTI* BREEDING IN DESERT COOLERS AND TIRES BY USE OF *BACILLUS THURINGIENSIS* VAR. *ISRAELENSIS* FORMULATION

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ABSTRACT. Three different formulations of *Bacillus thuringiensis* var. *israelensis* (*Bti*) were evaluated for their efficacy against immature *Aedes aegypti* in desert coolers and tires. Three formulations, viz., VectoBac tablets, VectoBac granules, and Bacticide powder, at the application rate of 0.75, 2, and 1 g per cooler, respectively, and VectoBac tablets at 0.75 and 0.375 g per tire, were evaluated. In coolers and tires, 100% reduction in the abundance of late larval instars of *Ae. aegypti* was observed for a period of 2 and 3 wk, respectively. The possibility of using tablets and capsules filled with *Bti* granules and powder formulation by individuals or communities for control of *Ae. aegypti* breeding has been discussed in view of the increasing outbreaks of dengue and dengue hemorrhagic fever in India. Use of these formulations over conventional methods is better and more user-friendly.

KEY WORDS *Bacillus thuringiensis israelensis,* formulations, *Aedes aegypti,* mosquito control

INTRODUCTION

In recent years, the epidemics of dengue, including dengue hemorrhagic fever, have become a major concern among the public health experts in India (Yadava and Narasimham 1992). Earlier outbreaks of dengue have been reported in different parts of India (Kalra 1965, Kaur et al. 1996, Sharma and Prasad 1996). Delhi also experienced a severe outbreak of dengue hemorrhagic fever during 1996, when 423 deaths and 10,252 hospitalizations were reported from Health Directorate of the Government of National Capital Territory in Delhi. There is also serious concern among public health experts about the possible outbreak of yellow fever in the Indian subcontinent (Kalra and Sharma 1996). The population of *Aedes aegypti* (L.), which transmits dengue virus, has seen an unprecedented increase because of unplanned rapid urbanization, industrialization, water storage practices, piped water supply in rural areas, and population migration. Mainly, *Ae. aegypti* breeds in desert room coolers, unused tire dumps, and other domestic and peridomestic containers where chemical vector control methods are difficult to use. This study reports the effectiveness of different formulations of *Bacillus thuringiensis* var. *israelensis* (*Bti*) for control of *Ae. aegypti* breeding in desert coolers and tire dumps.

MATERIALS AND METHODS

Laboratory and field trials were carried out using 3 different *Bti* formulations, viz., Bacticide powder, VectoBac tablets (ABG 6499), and VectoBac granules (ABG 6490). The potency (ITU/mg) of these products is 1,000, 1,900, and 3,500 ITU/mg, respectively. Bacticide, a product of Russian origin, was provided by Biotech-International, Delhi, India, and VectoBac tablets and granules, produced by Abbott Laboratories, North Chicago, IL, USA, were provided by AgrEvo India Limited. Application of Bacticide powder and VectoBac granules was carried out after manually packing these 2 formulations in gelatin capsules. For the laboratory trial, laboratory-reared 3rd-stage larvae of *Ae. aegypti* were exposed to different concentrations of *Bti* formulations in 3 liters of water in 5-liter-capacity enamel bowls. Twenty larvae were placed in each bowl at weekly intervals, and larvicidal efficacy was ascertained by counting larval mortality at 24 h of exposure. All tests were carried out in 2 replicates along with parallel untreated control.

Field evaluation of *Bti* formulations was carried out in desert coolers and tires that supported breeding of *Ae. aegypti.* These trials were carried out during the summer (May–June) and after the monsoon months (September–October) in 1997. Areas of field trials were selected after preliminary larval survey of *Ae. aegypti* in domestic and peridomestic breeding habitats. Areas selected were based on high larval populations using parameters, viz., house index, container index, and Breteau index. In all the coolers and tires selected for treatment, *Bti* tablets or capsules were added, and observations on efficacy of the formulations were recorded after 24 h and subsequently at weekly intervals by recording the presence of late instars and pupae in treated and

Table 1. Efficacy of *Bti* formulations against *Aedes aegypti* larvae in the laboratory.[1]

Days after treatment	Control	VectoBac granules, 40 mg/liter	VectoBac tablets, 80 mg/liter	Bacticide powder, 70 mg/liter
0	0	100	100	100
7	0	100	100	100
14	0	100	100	100
21	0	100	80	60
28	0	100	80	60
35	0	80	70	50

[1] Percentage control at days after treatment indicated.

Table 2. *Aedes aegypti* larval breeding survey in Delhi, 1997.

Month	Area	House index (%)	Container index (%)	Breateau index (%)
May	Munirka (South Delhi)	35.92	8.4	47.57
May	Bara Hindu Rao (North Delhi)	20.00	5.1	40.00
June	Chamlion Mohalla Rani Jhansi Road (Central Delhi)	80.00	11.4	8.70
June	Haiderpur (West Delhi)	20.00	4.0	25.00
June	Bara Hindu Rao	—	—	5.14
July	Rani Jhansi Road	—	—	4.63

untreated (control) coolers. The impact of the *Bti* formulation in coolers was determined by calculating the percentage reduction in the positivity of the coolers for the presence of 3rd- and 4th-stage larvae and pupae. The percentage reduction in the positivity of coolers and tires was determined by using the formula of Mulla et al. (1971).

RESULTS

In the laboratory, 100% mortality was observed with *Bti* formulations against *Ae. aegypti* 3rd-stage larvae for at least 2 wk with VectoBac granules, VectoBac tablets, and Bacticide powder used at approximately 40, 80, and 70 mg/liter, respectively (Table 1).

Table 2 gives the result of preliminary larval survey in experimental areas. The house index was between 20 and 80%; the container index, 4.0 to 11.4%; and the Breteau index, between 4.63 and 47.57.

Table 3 presents the results of field evaluation of *Bti* formulations against *Ae. aegypti* in desert water coolers when the coolers were not in use. Coolers treated with VectoBac granules at 2 grams per cooler, VectoBac tablets at 0.75 grams per cooler, and Bacticide powder at 1 gram per cooler showed 100% reduction in the density of 3rd- and 4th-stage larvae after 24 h. Percentage reductions remained at 100% for 2 wk after treatment. In the case of VectoBac tablets, the reduction was greater than 86% for 4 wk after treatment. However, when these tablets were applied in coolers that were in daily use, 100% reduction lasted only 1 wk against larvae of *Ae. aegypti* and *Anopheles stephensi* Liston.

Table 4 presents the evaluation of tablets against *Ae. aegypti* and *Culex quinquefasciatus* Say in unused tires. Results against *Ae. aegypti* with one 0.375-g tablet showed 92.18% control in the 1st week and 100% control in the 2nd week. However, when 2 tablets (0.75 g) were used, 100% control lasted 4 wk, and subsequently no impact was observed. Against larvae of *Cx. quinquefasciatus,* the control persisted for 1 and 3 weeks with 1 and 2 tablets, respectively.

DISCUSSION

In the absence of any vaccine or drug for treatment of dengue, the choice for prevention falls on vector control. Results of the present study revealed that use of *Bti* formulations, viz., Bacticide, VectoBac granules, and VectoBac tablets, in desert coolers and tires showed 100% control of late larval instars of *Ae. aegypti* for 2–4 weeks. Also, the application of *Bti* formulations were more or less equally effective in controlling larvae of *Cx. quinquefasciatus* occurring in some test habitats. The application of *Bti* tablets or capsules has an advantage over other types of formulations because of ease of field application.

Source reduction is the most efficient long-term method for controlling *Ae. aegypti* breeding, but water containers cannot always be emptied for var-

Table 3. Field evaluation of *Bti* formulations against *Aedes aegypti* larvae in desert room coolers.

Time after treatment	Control	Coolers positive for 3rd- and 4th-stage larvae[1] VectoBac granules, 2 g/cooler	VectoBac tablets, 0.75 g/cooler	Bacticide powder, 1 g/cooler
0 h	10	15	65	10
24 h	10	0 (100)	0 (100)	0 (100)
48 h	10	0 (100)	0 (100)	0 (100)
72 h	9	0 (100)	0 (100)	0 (100)
1 wk	9	0 (100)	0 (100)	0 (100)
2 wk	9	0 (100)	0 (100)	0 (100)
3 wk	9	2 (85.2)	1 (98.3)	3 (66.7)
4 wk	8	4 (66.7)	7 (86.5)	6 (25)
5 wk	8	10 (16.7)	20 (61.5)	9 (12.5)
6 wk	8	10 (16.7)	37 (28.8)	9 (12.5)

[1] Percentage reduction compared to control.

Table 4. Field evaluation of VectoBac tablets against *Aedes aegypti* and *Culex quinquefasciatus* larvae in tires.[1]

Time after treatment	*Aedes aegypti*		*Culex quinquefasciatus*	
	One tablet (0.375 g)	Two tablets (0.75 g)	One tablet (0.375 g)	Two tablets (0.75 g)
0 days	35	20	6	70
1 day	2 (93.7)	0 (100)	5 (16.6)	0 (100)
2 days	0 (100)	0 (100)	0 (100)	0 (100)
1 wk	2 (92.2)	0 (100)	2 (100)	0 (100)
2 wk	0 (100)	0 (100)	2 (66.6)	0 (100)
3 wk	8 (75)	0 (100)	6 (0)	0 (100)
4 wk	10 (60.9)	0 (100)	6 (0)	6 (14.3)
5 wk	18 (29.7)	14 (12.5)	6 (0)	7 (0)
6 wk	24 (6.3)	18 (0)	6 (0)	—

[1] Tires positive for 3rd- and 4th-stage larvae (percentage reduction from control).

ious reasons; hence, application of biocontrol agents is the other alternative. The use of biocontrol agents has many advantages over chemical control methods. Application of chemicals for control by community-based programs requires safety measures and supervision. Other problems, such as development of resistance in vectors, can arise. Other biocontrol agents, such as *Mesocyclops* (Mittal et al. 1997) and Neem products (Batra et al. 1998), have also been shown to have effective vector control potential against *Ae. aegypti.* Outbreaks of dengue, when they occur, build up in a short time. Thus early action is required to reduce or eliminate breeding of *Ae. aegypti* vectors. This study is an attempt to highlight the practical community-based application of the biocontrol agent *Bti* that has so far not shown any indication for the development of resistance in vectors.

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