FINAL REPORT

Studies on susceptibility of *Helicoverpa armigera* (Hübner) to Cry1Ac *Bacillus thuringiensis* protein

Sponsored by: Mahyco, Mumbai

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Report on the baseline susceptibility of geographical populations of old world bollworm, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) to *Bt* Cry1Ac insecticidal protein

Final Report

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INTRODUCTION

Cotton is the most important commercial crop of India. It is grown in 9.3 million ha area with production of 13.1 million bales (Singhal, 1999). Cotton is infested by 162 insect species, of which about a dozen are economically important pests causing considerable yield reduction (Sundaramurthy, 1986; Dhawan *et al.*, 1988; Satpute *et al.*, 1988). The Old World bollworm, *Helicoverpa armigera* (Hübner) is a important bollworm of cotton in India. The crop losses due *H. armigera* in India is estimated around US$ 350 millions annually (King, 1994). Sheng (1997) reported *H. armigera* as most serious pest of cotton causing considerable yield loss in China. Due to the high commercial value of cotton, it is subjected to intensive plant protection measures for 3 - 4 months against all the stages of different bollworms. In India, cotton receives about 55% of the total pesticide used on various crops. Such a high usage of pesticide often results in frequent outbreaks of sucking pests and bollworms mainly due to development of resistance (many folds) in these pests. Extensive usage of insecticides has also resulted in diminution of natural enemies, normally present in the cotton ecosystem. Under the traditional system, where pesticides were not used indiscriminately, the natural enemies were primarily responsible for keeping pests population below economic injury level. *Helicoverpa armigera* has developed resistance to almost all-conventional insecticides including synthetic pyrethroids used for its management (Castle *et al.*, 1994; Armes *et al.*, 1996). It is, therefore, natural that an integrated approach is favored, including use of *Bt* transgenic cotton as one of the components, so that unilateral dependence on pesticides is avoided.

Transgenic cotton, expressing Cry1Ac, is likely to get approval for commercial use in India. The advantage of transgenic cotton is that it is tolerant to bollworms due to expression of Cry1Ac toxins. However, resistance to *Bt* toxins expressed in plants is likely to develop in bollworms when they are continuously exposed to *Bt* cotton.

ABSTRACT

The baseline susceptibility, of fourteen different geographical populations of *Helicoverpa armigera* (Hübner) collected from 6 major cotton growing states of India *viz.* Madhya Pradesh (Barwah and Khandwa), Gujarat (Rajkot and Vadodra), Maharashtra (Jalgoan, Jalna and Yavatmal), Andhra Pradesh (Adilabad, Warangal and Guntur), Karnataka (Davanagere and Ranebennur) and Tamil Nadu (Coimbatore and Dindigul), to the insecticidal protein Cry1Ac from *Bacillus thuringiensis* was determined through bioassays using probit analysis. All the populations were susceptible to Cry 1Ac protein. The lethal concentration (related to mortality), LC_{50}, ranged from 0.114 to 0.594, LC_{90} from 1.016 to 6.700 and LC_{95} ranged from 2.004 to 19.462 µg of Cry1Ac / ml of diet. Molt inhibitory concentration (related to developmental stage, not allowing larvae to go beyond 1st instar), MIC_{50} ranged from 0.051 to 0.140, MIC_{90} ranged from 0.246 to 0.910 and MIC_{95} ranged from 0.424 to 1.826 µg of Cry1Ac / ml of diet. The inhibitory concentration (not allowing larvae to reach 3rd instar), IC_{50}, ranged from 0.015 to 0.052, IC_{90} ranged from 0.080 to 0.246 and IC_{95} ranged from 0.140 to 0.472 µg of Cry1Ac / ml of diet. The effective concentration (weight related), EC_{50} ranged from 0.0004 to 0.0036 and EC_{90} values ranged from 0.0094 to 0.0471 µg of Cry1Ac / ml of diet for the various populations. These values form the baseline data for susceptibility of *H. armigera* to Cry1Ac and can be used as benchmark for monitoring resistance to Cry1Ac.

Table 1. Summary of collection, rearing and bioassay of various *Helicoverpa armigera* population screened against Cry1Ac protein of *Bacillus thuringiensis*

S. No.	Locations	Date of collection of larvae	No. of larvae collected	Assayed on	Date of Rating
1.	Barwah (MP)	10&11/10/2001	264	30&31/10/2001	6&7/11/2001
2.	Khandwa (MP)	10, 12&13/10/2001	285	1,2&3/11/2001	8,9&10/11/2001
3.	Rajkot (Guj.)	20/10/2201	250	10&12/11/2001	17&19/11/2001
4.	Vadodra (Guj.)	21&22/10/2001	312	13,14&15/11/2001	20,21&22/11/2001
5.	Jalgoan (Mah.)	15&16/10/2001	250	7,8&9/11/2001	14,15&16/11/2001
6.	Yavatmal (Mah.)	22&23/09/2001	300	12&13/10/2001	19&20/10/2001
7.	Jalna (Mah.)	12&13/09/2001	250	2,5,6&8/10/2001	9,12,13&15/10/2001
8.	Adilabad (AP)	24&25/09/2001	325	16&17/10/2001	23&24/10/2001
9.	Warangal (AP)	07&08/09/2001	340	28&29/9/2001&2/10/2001	5,6&9/10/2001
10.	Guntur (AP)	04&05/09/2001	432	29/9/2001 & 2/10/2001	6&9/10/2001
11.	Ranebennur (Kar.)	05/09/2001	132	25,26 & 27/9/2001	2,3&4/10/2001
12.	Davanagere (Kar.)	28/10/2001	120	23,24 & 26/11/2001	30/11, 01/12, 03/12/2001
13.	Coimbatore (TN)	01&02/11/2001	216	23,24 & 26/11/2001	30/11, 01/12, 03/12/2001
14.	Dindigul (TN)	03&04/11/2001	184	27, 28 & 29/11/2001	04/12, 05/12 & 06/12/2001

Table 2. Summary of bioassay results of various *Helicoverpa armigera* population screened against Cry1Ac protein of *Bacillus thuringiensis*

Location	LC_{50}	LC_{90}	LC_{95}	MIC_{50}	MIC_{90}	MIC_{95}	IC_{50}	IC_{90}	IC_{95}	EC_{50}	EC_{90}
Barwah	0.186	1.466	3.076	0.094	0.616	1.210	0.036	0.192	0.346	0.0017	0.0160
Khandwa	0.256	2.038	4.264	0.102	0.648	1.228	0.028	0.170	0.322	0.0034	0.0471
Rajkot	0.594	5.554	12.252	0.128	0.690	1.230	0.038	0.206	0.364	0.0012	0.0284
Vadodra	0.198	1.438	2.828	0.054	0.280	0.492	0.018	0.080	0.140	0.0021	0.016
Jalgoan	0.404	6.700	19.462	0.132	0.910	1.826	0.046	0.246	0.472	0.0036	0.0284
Yavatmal	0.220	1.572	3.180	0.082	0.462	0.718	0.026	0.122	0.210	0.0007	0.0209
Jalna	0.308	1.916	3.578	0.140	0.558	0.902	0.052	0.204	0.326	0.0016	0.0303
Adilabad	0.150	1.472	3.272	0.072	0.414	0.758	0.020	0.110	0.200	0.0006	0.0194
Warangal	0.202	1.952	4.344	0.092	0.482	0.848	0.018	0.102	0.182	0.0017	0.0312
Guntur	0.206	1.444	2.836	0.120	0.526	0.868	0.034	0.198	0.366	0.0031	0.0539
Ranebennur	0.142	1.016	2.004	0.066	0.356	0.628	0.02	0.108	0.194	0.0028	0.0427
Davanagere	0.114	1.086	2.748	0.052	0.256	0.458	0.017	0.084	0.154	0.0004	0.0127
Coimbatore	0.165	1.175	2.297	0.051	0.246	0.424	0.015	0.082	0.141	0.0009	0.0094
Dindigul	0.195	2.610	6.460	0.070	0.640	1.370	0.020	0.140	0.270	0.0012	0.0144
Mean	0.238	2.245	5.186	0.089	0.472	0.926	0.028	0.146	0.263	0.0018	0.0265
SD	0.125	1.712	4.860	0.031	0.189	0.402	0.011	0.055	0.103	0.0011	0.0136

LC: Lethal concentration (related to mortality). LC_{50} - Dose of Cry1Ac in µg needed to kill 50% of the population. Similarly LC_{90} and LC_{95} are doses needed to kill 90 and 95% of the population, respectively

MIC: Moult inhibitory concentration (growth stage related). MIC_{50} – Dose of Cry 1Ac in µg that will inhibit molting of neonates into II instar, of 50% of population in the assay period of 7 days. MIC_{90} and MIC_{95} are doses of Cry1Ac that will inhibit molting into 2nd instar of 90 and 95% of population, respectively.

IC (also known as IC not 3rd): Inhibitory concentration (growth stage related). IC_{50}, IC_{90}, IC_{95} doses of Cry1Ac in µg that will inhibit molting of 2nd instar larvae into 3rd instar in 50, 90 and 95% of population, respectively.

EC: Effective concentration (related to stunting – weight related). EC_{50} and EC_{90} – doses of Cry1Ac in µg that would stunt the larvae as to weigh 50% and 10% of the weight of untreated control larvae.

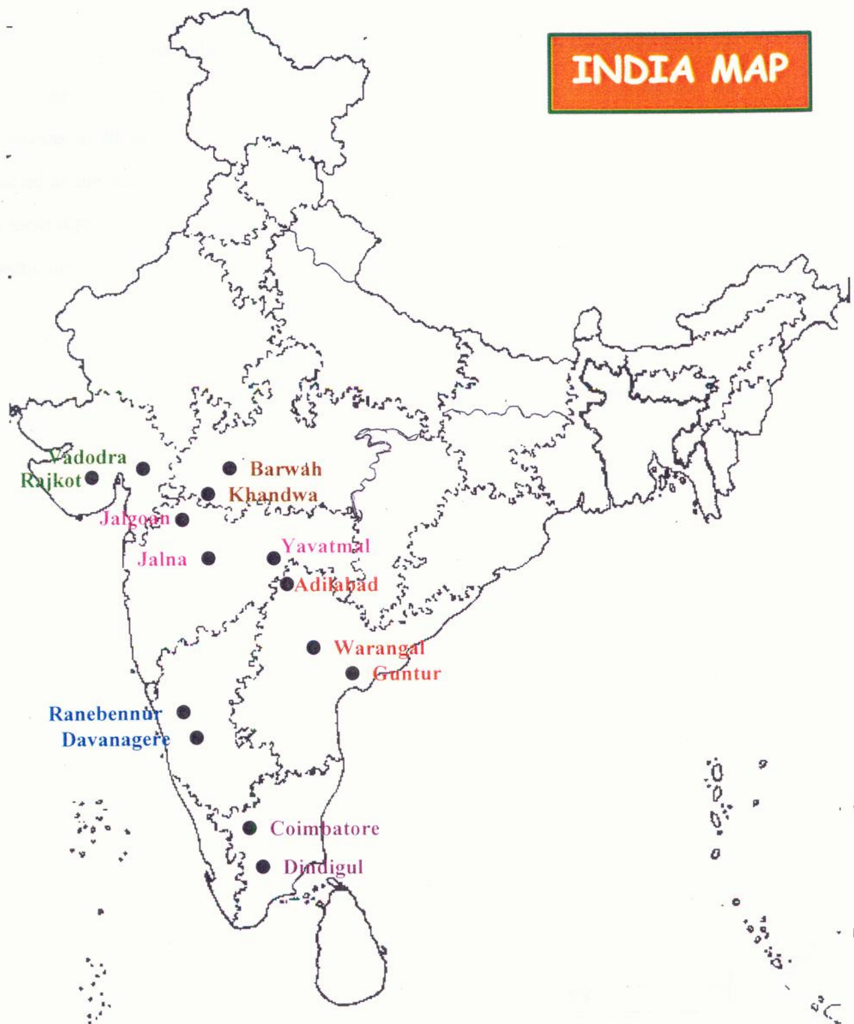

Fig. 1. Collection localities of cotton bollworms from different geographical locations of India covering six states and fourteen places

Among the methods advocated for managing resistance to *Bt* toxins produced in crops, periodic monitoring of susceptibility across geographical populations of bollworms to *Bt* toxin forms the first and foremost step. *Helicoverpa armigera* was selected as the subject of study because among the bollworms in India, *H. armigera* is the most difficult to control and also has developed resistance to many currently used insecticides.

As a benchmark study, *H. armigera* populations from ten geographical locations, covering the entire cotton belt of India, were screened for susceptibility to Cry1Ac during *kharif* of 2000. The same study has been extended during *kharif* of 2001 but covering fourteen locations in Central and South India cotton growing states.

MATERIALS AND METHODS

1. Locations for the collection of *H. armigera*

Grown-up larvae (III instar and above) of *H. armigera* were collected from the *Bt* cotton experimental trial plots of Mahyco. The field locations from which the populations were collected are as follows (Table 3):

Table 3. Collection of *Helicoverpa armigera* from different locations

Sl. No.	Collection locality	State	Initial nos. of larvae collected
1.	Barwah	Madhya Pradesh	264
2.	Khandwa	Madhya Pradesh	285
3.	Rajkot	Gujarat	250
4.	Vadodra	Gujarat	312
5.	Jalgoan	Maharashtra	250
6.	Jalna	Maharashtra	300
7.	Yavatmal	Maharashtra	250
8.	Adilabad	Andhra Pradesh	325
9.	Warangal	Andhra Pradesh	340
10.	Guntur	Andhra Pradesh	432
11.	Ranebennur	Karnataka	132
12.	Davanagere	Karnataka	120
13.	Coimbatore	Tamil Nadu	216
14.	Dindigul	Tamil Nadu	184

2. *Helicoverpa armigera* culture

The larvae were collected individually in glass vials containing semi-synthetic diet developed by Nagarkatti and Satyaprakash (1974) and transported to the laboratory of Project Directorate of Biological Control (ICAR), Bangalore. The larvae were transferred in the laboratory on freshly prepared diet. Moths on emergence were transferred to egg laying cages and eggs were collected as described by Kumar and Ballal (1990). The neonate larvae were used for bioassay against Cry1Ac protein.

The eggs collected from the egg laying cages were surface sterilised in 0.05% sodium hypochlorite solution, transferred to cloth and kept for hatching. A portion of neonate culture was used for maintaining the culture and the rest was used for bioassay. The neonate larvae, meant for culture maintenance, were reared on semi-synthetic. The diet for *H. armigera* consisted of - *Kabuligram* flour (105 g), Ascorbic acid (3.25 g), Methyl parahydroxy benzoate (2 g), Sorbic acid (1 g), Streptomycin sulphate (0.25 g), Yeast (10g), Multivitaplex® (2 Capsules), Vitamin E (2 Capsules), 10% formalin (2 ml) and water 800 ml - for one set of diet. The pupae of *H. armigera* collected from artificial diet were surface sterilised in 0.1% sodium hypochlorite solution before transferring in egg-laying cage.

3. Cry1Ac standard

The source of Cry1Ac was the freeze-dried formulation of MVP® II (cell - cap® encapsulation system of Mycogen USA). The formulation contains 19.7% (by weight) of Cry1Ac. An appropriate amount of MVP powder was weighed and diluted in 0.2% agar solution for bioassay. The *Bt* protein was assayed by the diet incorporation method. *Helicoverpa armigera* diet was prepared using above-mentioned ingredients

Table 4. Stock Dilution Worksheet for Dose-Response Bioassay (Diet-Incorporation)

Project/bioassay for which test materials was used:		Geographical isolates of *H. armigera*	
Test Material (s):	**Specifications:**		**Primary Dilution :**
1. MVP (Cry 1 Ac) 19.7% by wt of Cry 1Ac	Date of Dilution:		Primary stock volume (μL): 277
	Primary stock (μg/mL):	1000	Water volume (μL): 6,656
	Final 1st dilution (μg/mL):	8.00	Total volume (μL): 6,933
	Total # dilutions:	7	**Diet incorporation :**
	Serial dilution ratio:	¼	Sample/dilution (mL): 5.2
	Sample dilution in diet:	±	Diet/dilution (mL): 20.8
	Diet / Well (μL/ mL):	750	Total volume/dilution (mL): 26.0
	# Wells/dilution:	32	Diet/test material (mL): 145.6
	# Trials:	1	Diet/test – incl. UTC (mL): 332.8

Dilution	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**	**#7**
Initial volume (μL)	6,933	6,933	6,933	6,933	6,933	6,933	6,933
Volume removed for next dilution (μL)	1,733	1,733	1,733	1,733	1,733	1,733	1,733
Volume remaining for this dilution (μL)	5,200	5,200	5,200	5,200	5,200	5,200	5,200
Volume to discard (μL)	0	0	0	0	0	0	0
Stock sample conc. (μg/mL)	40.0	10.0	2.5	0.625	0.156	0.039	0.01
Diet sample conc. (μg/mL)	**8.0**	**2.0**	**0.5**	**0.125**	**0.031**	**0.008**	**0.002**

Dilution Procedure:

1. 277 μL primary stock + 6.656 mL water

⇩

8.0 ppm in diet

2. 1.733 mL #1 + 5.2 mL water

⇩

2.0 ppm in diet

3. 1.733 mL #2 + 5.2 mL water

⇩

0.5 ppm in diet

4. 1.733 mL #3 + 5.2 mL water

⇩

0.125 ppm in diet

5. 1.733 mL #4 + 5.2 mL water

⇩

0.031 ppm in diet

6. 1.733 mL #5 + 5.2 mL water

⇩

0.008 ppm in diet

7. 1.733 mL #6 + 5.2 mL water

⇩

0.002 ppm in diet ⇨ **Discard 1.733 mL** (except formalin) and was poured into sterile glass bottles and kept warm in hot water bath maintained at 60°C. The primary stock solution for Cry1Ac was prepared by mixing the 25.38 mg MVP II powder in 5 ml of 0.2 % agar solution. Sterile centrifuge tubes (40 ml) were used for preparing the primary stock solution and the serial dilutions. The primary stock solution was mixed thoroughly using vortex™ Cyclo-mixer and serial dilutions were prepared sequentially in 0.2% agar solution as mentioned in dilution sheets (Table 4). The 5.2 ml of the sample was mixed in the 20.8 ml of the diet and poured in insect bioassay trays (CD International trays™). Seven serial dilutions were made and compared with control. Newly hatched larvae were transferred on to the diet in the bioassay trays @ 1 larva / well with the help of fine hair brush. After larval transfer, bioassay trays were covered with pull-n-peel tabs (CD International pull-n-peel tabs™). The entire experiment was done under laminar flow clean bench. The trays were kept in BOD incubator maintained at 27±0.5°C. Thirty-two larvae were used for each toxin concentration and the entire assay was repeated 8 times with each population of *H. armigera*. Thus for each population a total of 1792 larvae were used in the assay.

The bioassays was rated after seven days and observations on mortality, instars of surviving larvae and group weight of all the surviving larvae was recorded. Probit analysis of the data was carried out using JMP package version 3.1 (SAS Institute Inc., Cary, NC, USA) to compute LC_{50}, LC_{90}, LC_{95}, MIC_{50}, MIC_{90}, MIC_{95}, IC_{50}, IC_{90}, IC_{95}, EC_{50} and EC_{90}.

RESULTS AND DISCUSSION

The geographical populations of *H. armigera* were maintained for 1 to 2 months in the laboratory. Table 3 gives an account of initial numbers collected from the field.

Fourteen different geographical populations of *H. armigera* exhibited differential mortality response to *Bt* Cry1Ac toxin. LC_{50} values of neonates ranged 0.114 to 0.594 μg/ml, with Davanagere (Karnataka) population having lowest LC_{50}

value of 0.114 and Rajkot (Gujarat) with highest LC_{50} value of 0.594 μg/ml (Table 5) (Fig. 2). LC_{90} values ranged from 1.016 - 6.700 μg /ml for 14 different *H. armigera* populations (Fig. 3). LC_{95} values ranged from 2.004 – 19.462 μg /ml for 14 different *H. armigera* populations (Fig. 4). The mortality response showed that all the populations were highly susceptible to *Bt* Cry1Ac toxin. Cry1Ac has been reported to be most potent toxin out of eleven different toxin tested against *H. armigera* (Chakrabarti *et al.*, 1998). Variation in susceptibility of Cry1Ac toxin among 12 different populations of European corn borer has been reported but on the whole all populations were found to be highly susceptible (Marcon *et al.*, 1999). Gujar *et al.* (2000) reported variations in susceptibility of *H. armigera* populations collected from various places in India. They had studied the susceptibility of *H. armigera* collected from crops like pigeon pea, cotton, *Chenopodium*, okra, tomato and reported that populations collected from Delhi and Raichur were least susceptible with 8.72 and 39.5; 15.33 and 43.8 per cent mortality, respectively, and that of Hyderabad and Madurai were most susceptible with 80.8 and 93.3; 70.3 and 93.7 per cent mortality, respectively at dosages of 10 and 100 ppm of *Btk* HD-1 strain. However, for HD-73 strain Mehna and Nagpur populations were least susceptible, whereas all populations collected from Andhra Pradesh and Tamil Nadu were highly susceptible.

Moult inhibitory concentration (MIC) is a dose that inhibits neonate larvae to grow beyond 1st instar. MIC_{50} values ranged from 0.051 to 0.140 (Fig. 5), MIC_{90} values from 0.246 to 0.910 μg/ml diet (Fig. 6) and MIC_{95} values from 0.424 to 1.826 μg/ml diet for 14 different populations (Fig. 7) (Table 6).

Growth inhibitory effect of Cry1Ac toxin revealed that IC_{50} values of neonate larvae that could not reach 3rd instar stage ranged from 0.015 to 0.052 (Fig. 8), IC_{90} 0.080 to 0.246 (Fig. 9) and IC_{95} 0.140 to 0.472 μg/ml diet (Fig. 10) for 14 different populations (Table 7). Wu *et al.* (1999) had earlier reported differential susceptibility of

H. armigera to Cry1Ac in China and found wide range of susceptibility (100- fold) and narrow range of growth inhibition (5- fold) in 23 geographic populations. Gujar *et al.* (2000) reported variable growth reduction (90.0 - 95.8 per cent) in different populations of *H. armigera* to HD-1 and HD-73 strains of *B. thuringiensis*.

Effective concentration (EC) of Cry1Ac that was required to stunt the weight of the larvae to various extents was also studied. EC_{50} ranged from 0.00036 to 0.00364 μg/ml diet (Fig. 11) and Ec_{90} 0.0094 to 0.05394 μg/ml diet for 14 different populations (Fig. 12) (Table 8). The relative suitability of larval mortality and growth inhibition assays for monitoring the sensitivity of *H. virescens* and *H. zea* to Cry1Ac has been reported (Sims *et al.*, 1997).

Table 5. Log dosage probit response of neonates of *Helicoverpa armigera* (Hübner) to Cry1Ac toxin, lethal concentrations

Geographical locations	Replications	LC_{50}	Fiducial limit		LC_{90}	Fiducial limit		LC_{95}	Fiducial limit		Slope±SE	Larvae per dose
			Lower	Upper		Lower	Upper		Lower	Upper		
Barwah	1	0.07	0.05	0.11	0.55	0.32	1.26	1.12	0.58	3.11	2.46±0.31	32
	2	0.14	0.08	0.22	2.22	1.11	6.28	5.70	2.45	21.16	1.82±0.22	32
	3	0.07	0.05	0.10	0.43	0.26	0.93	0.80	0.44	2.06	2.80±0.37	32
	4	0.34	0.23	0.50	1.91	1.16	4.11	3.44	1.90	8.89	2.93±0.40	32
	5	0.31	0.21	0.47	2.22	1.29	5.06	4.32	2.26	12.05	2.59±0.34	32
	6	0.08	0.06	0.11	0.47	0.27	1.16	0.92	0.53	2.61	2.51±0.314	32
	7	0.34	0.22	0.50	1.81	1.12	3.81	3.04	1.80	7.19	3.03±0.42	32
	8	0.14	0.09	0.23	2.12	1.10	5.58	5.27	2.25	18.56	2.02±0.25	32
	Mean	**0.186**	**0.124**	**0.28**	**1.466**	**0.828**	**3.528**	**3.076**	**1.526**	**9.454**	**2.52±0.328**	
Khandwa	1	0.14	0.09	0.22	2.11	1.07	5.90	5.36	2.33	19.48	1.85±0.23	32
	2	0.14	0.09	0.21	1.21	0.68	2.85	2.54	1.27	7.40	2.32±0.29	32
	3	0.37	0.26	0.53	1.69	1.07	3.47	2.84	1.65	6.92	3.33±0.47	32
	4	0.43	0.28	0.66	3.53	1.97	8.58	7.22	3.59	21.85	2.40±0.31	32
	5	0.20	0.13	0.31	1.65	0.94	3.83	3.36	1.71	9.62	2.42±0.31	32
	6	0.43	0.29	0.64	3.50	1.96	8.55	7.22	3.59	21.85	2.40±0.33	32
	7	0.14	0.09	0.21	1.21	0.69	2.85	2.54	1.27	7.40	2.32±0.27	32
	8	0.20	0.14	0.33	1.68	0.94	3.86	3.36	1.71	9.62	2.42±0.31	32
	Mean	**0.256**	**0.17**	**0.386**	**2.038**	**1.146**	**4.926**	**4.264**	**2.11**	**13.054**	**2.464±0.322**	
Rajkot	1	0.70	0.53	1.19	5.06	2.94	11.96	9.51	4.95	27.79	2.72±0.38	32
	2	0.87	0.58	1.32	6.05	3.43	14.91	11.72	5.91	36.05	2.60±0.36	32
	3	0.17	0.10	0.29	3.58	1.68	11.31	10.05	3.98	42.75	1.67±0.21	32
	4	0.91	0.58	1.49	10.55	5.22	32.33	24.28	10.37	98.01	2.06±0.28	32
	5	0.32	0.21	0.48	2.73	1.53	6.62	5.70	2.82	17.15	2.34±0.30	32
	6	0.73	0.52	1.26	5.73	3.17	14.06	10.51	4.288	33.79	2.104±0.348	32
	7	0.17	0.10	0.26	3.88	1.88	12.31	12.05	5.62	55.75	1.27±0.21	32
	8	0.89	0.58	1.34	7.05	3.83	19.91	13.196	6.91	43.51	1.90±0.36	32
	Mean	**0.594**	**0.40**	**0.954**	**5.554**	**2.96**	**15.426**	**12.252**	**5.606**	**44.35**	**1.758±0.306**	

Table 5. Continued ...

Vadodra	1	0.17	0.12	0.24	0.82	0.51	1.67	1.39	0.80	3.39	3.22±0.45	32
	2	0.09	0.06	0.14	0.55	0.34	1.18	1.02	0.56	2.61	2.83±0.37	32
	3	0.08	0.05	0.13	0.89	0.49	2.18	1.98	0.96	6.10	2.15±0.27	32
	4	0.26	0.17	0.40	2.09	1.19	4.88	4.23	2.15	12.16	2.44±0.31	32
	5	0.39	0.26	0.59	2.84	1.64	6.59	5.57	2.87	15.91	2.55±0.33	32
	6	0.26	0.17	0.42	2.39	1.39	6.26	5.23	2.604	15.72	2.14±0.23	32
	7	0.17	0.12	0.24	0.92	0.93	2.34	1.644	0.92	4.22	2.89±0.40	32
	8	0.17	0.11	0.24	0.92	0.91	2.30	1.61	0.88	4.13	2.88±0.408	32
	Mean	**0.198**	**0.132**	**0.30**	**1.438**	**0.834**	**3.30**	**2.828**	**1.468**	**8.034**	**2.638±0.346**	
Jalgoan	1	0.24	0.14	0.44	8.21	3.36	33.22	27.12	9.01	158.71	1.44±0.18	32
	2	0.29	0.16	0.52	11.11	4.31	49.59	38.60	12.01	255.66	1.38±0.18	32
	3	0.36	0.24	0.56	3.46	1.88	8.73	7.46	3.58	23.66	2.24±0.29	32
	4	0.44	0.28	0.73	6.65	3.23	20.26	16.69	6.94	67.14	1.87±0.24	32
	5	0.69	0.47	1.02	4.07	2.42	9.24	7.44	3.99	20.67	2.85±0.40	32
	6	0.23	0.144	0.42	4.92	2.39	23.69	21.03	7.33	109.24	1.64±0.18	32
	7	0.69	0.47	1.02	4.07	2.42	9.24	7.44	3.99	20.67	2.75±0.40	32
	8	0.29	0.16	0.52	11.11	4.31	39.59	29.60	10.00	185.59	1.48±0.18	32
	Mean	**0.404**	**0.258**	**0.654**	**6.70**	**3.04**	**24.208**	**19.462**	**7.106**	**105.168**	**1.956±0.258**	
Jalna	1	0.14	0.09	0.20	0.99	0.58	2.23	1.95	1.03	5.34	2.55±0.33	32
	2	0.25	0.17	0.37	1.42	0.87	3.03	2.56	1.42	6.56	2.92±0.39	32
	3	0.53	0.36	0.79	3.42	2.01	7.83	6.44	3.40	18.07	2.71±0.37	32
	4	0.23	0.16	0.35	1.60	0.94	3.59	3.10	1.64	8.46	2.61±0.34	32
	5	0.39	0.27	0.57	2.15	1.31	4.62	3.84	2.13	9.97	2.96±0.40	32
	6	0.53	0.36	0.81	3.38	1.98	7.68	6.33	3.32	17.54	2.78±0.37	32
	7	0.25	0.17	0.35	1.39	0.88	2.95	2.46	1.42	6.31	2.92±0.39	32
	8	0.15	0.10	0.21	0.98	0.57	2.15	1.92	1.03	5.19	2.56±0.33	32
	Mean	**0.308**	**0.21**	**0.456**	**1.916**	**1.142**	**4.26**	**3.578**	**1.924**	**9.68**	**2.75±0.366**	

Table 5. Continued ...

Yavatmal	1	0.28	0.18	0.43	2.87	1.55	7.30	6.36	3.02	20.37	2.17±0.27	32
	2	0.19	0.12	0.28	1.34	0.78	3.01	2.62	1.38	7.19	2.56±0.33	32
	3	0.04	0.02	0.05	0.27	0.16	0.63	0.55	0.29	1.56	2.46±0.32	32
	4	0.29	0.21	0.39	0.95	0.64	1.78	1.42	0.90	3.12	4.23±0.65	32
	5	0.30	0.20	0.46	2.43	1.38	5.75	4.95	2.50	14.44	2.42±0.31	32
	6	0.28	0.19	0.45	2.97	1.64	7.64	6.78	3.22	20.42	2.27±0.29	32
	7	0.29	0.23	0.42	1.03	0.78	1.88	1.67	1.31	5.76	4.33±0.66	32
	8	0.09	0.02	0.10	0.72	0.29	1.56	1.09	0.32	1.83	1.59±0.18	32
	Mean	**0.22**	**0.146**	**0.322**	**1.572**	**0.902**	**3.694**	**3.18**	**1.618**	**9.336**	**2.768±0.376**	
Adilabad	1	0.11	0.07	0.16	0.68	0.41	1.49	1.29	0.70	3.40	2.70±0.35	32
	2	0.13	0.08	0.19	0.91	0.53	2.04	1.79	0.94	4.89	2.55±0.33	32
	3	0.19	0.12	0.29	1.89	1.03	4.67	4.15	2.00	12.85	2.19±0.27	32
	4	0.16	0.10	0.25	2.08	1.08	5.54	4.99	2.26	17.11	1.96±0.24	32
	5	0.16	0.10	0.25	1.80	0.96	4.61	4.14	1.94	13.41	2.07±0.26	32
	6	0.16	0.10	0.25	1.55	0.99	4.78	3.64	1.69	11.41	2.17±0.26	32
	7	0.13	0.08	0.18	0.84	0.58	2.19	1.59	0.84	3.89	2.65±0.35	32
	8	0.16	0.10	0.25	2.03	1.18	6.04	4.57	2.16	15.71	2.06±0.26	32
	Mean	**0.15**	**0.094**	**0.228**	**1.472**	**0.802**	**3.67**	**3.272**	**1.562**	**10.332**	**2.294±0.29**	
Warangal	1	0.11	0.08	0.16	0.52	0.33	1.05	0.87	0.51	2.11	3.37±0.46	32
	2	0.14	0.10	0.21	0.98	0.58	2.17	1.89	1.01	5.09	2.62±0.34	32
	3	0.22	0.14	0.36	3.27	1.65	9.22	8.14	3.54	29.79	1.89±0.23	32
	4	0.33	0.21	0.53	3.75	1.98	9.95	8.55	3.94	28.89	2.09±0.26	32
	5	0.21	0.14	0.31	1.24	0.75	2.66	2.27	1.25	5.85	2.86±0.38	32
	6	0.22	0.15	0.34	3.23	1.68	9.22	8.10	3.51	29.74	1.89±0.23	32
	7	0.21	0.13	0.33	1.28	0.72	2.66	2.41	1.34	6.40	2.86±0.38	32
	8	0.18	0.12	0.27	1.35	0.77	3.15	2.52	1.30	6.90	2.95±0.42	
	Mean	**0.202**	**0.134**	**0.314**	**1.952**	**1.058**	**5.01**	**4.344**	**2.05**	**14.346**	**2.566±0.344**	

Table 5. Continued ...

Guntur	1	0.14	0.10	0.20	0.59	0.38	1.18	0.96	0.57	2.27	3.55±0.51	32
	2	0.11	0.07	0.16	0.83	0.48	1.90	1.69	0.87	4.73	2.44±0.31	32
	3	0.15	0.10	0.23	1.44	0.80	3.48	3.11	1.53	9.37	2.23±0.28	32
	4	0.34	0.23	0.52	2.51	1.45	5.80	4.94	2.55	14.02	2.54±0.33	32
	5	0.29	0.19	0.43	1.85	1.10	4.09	3.48	1.87	9.35	2.72±0.36	32
	6	0.34	0.21	0.52	2.47	1.45	5.91	4.34	2.55	12.78	2.34±0.29	32
	7	0.15	0.12	0.23	1.48	0.80	3.37	3.09	1.34	8.17	2.13±0.25	32
	8	0.13	0.09	0.18	0.38	0.28	0.59	1.08	0.54	2.89	3.34±0.53	32
	Mean	**0.206**	**0.138**	**0.308**	**1.444**	**0.842**	**3.29**	**2.836**	**1.478**	**7.948**	**2.269±0.358**	
Ranebennur	1	0.15	0.10	0.22	0.92	0.55	1.98	1.71	0.93	4.44	2.78±0.37	32
	2	0.14	0.09	0.21	1.27	0.71	3.02	2.70	1.34	7.98	2.27±0.28	32
	3	0.17	0.12	0.25	0.87	0.54	1.79	1.51	0.86	3.72	3.11±0.42	32
	4	0.06	0.04	0.10	0.64	0.35	1.55	1.41	0.69	4.31	2.17±0.27	32
	5	0.19	0.13	0.29	1.38	0.81	3.10	2.69	1.42	7.29	2.58±0.33	32
	6	0.07	0.03	0.08	0.60	0.35	1.45	1.37	0.67	4.67	2.10±0.28	32
	7	0.17	0.10	0.23	0.91	0.54	1.89	1.55	0.88	3.72	3.18±0.41	32
	8	0.19	0.16	0.34	1.54	0.89	3.52	3.10	1.59	8.35	2.47±0.46	32
	Mean	**0.142**	**0.096**	**0.214**	**1.016**	**0.592**	**2.288**	**2.004**	**1.048**	**5.560**	**2.582±0.334**	
Davanagere	1	0.08	0.05	0.11	0.46	0.28	0.98	0.85	0.47	2.17	2.84±0.38	32
	2	0.07	0.05	0.09	0.16	0.12	0.27	0.21	0.15	0.40	6.02±1.03	32
	3	0.23	0.16	0.33	1.09	0.69	2.23	1.85	1.07	4.51	3.25±0.45	32
	4	0.10	0.06	0.15	1.15	0.61	2.93	2.67	1.25	8.64	2.04±0.25	32
	5	0.09	0.05	0.15	2.57	1.14	8.96	8.16	2.98	40.17	1.49±0.19	32
	6	0.08	0.05	0.10	0.49	0.30	0.95	0.92	0.51	2.24	2.81±0.38	32
	7	0.17	0.11	0.24	0.88	0.52	1.92	1.48	0.84	3.65	3.21±0.41	32
	8	0.09	0.01	0.16	1.89	0.88	6.35	5.84	2.20	27.64	3.36±0.59	32
	Mean	**0.114**	**0.074**	**0.166**	**1.086**	**0.568**	**3.074**	**2.748**	**1.184**	**11.178**	**3.128±0.46**	

Table 5. Continued ...

Coimbatore	1	0.15	0.10	0.23	1.24	0.71	2.89	2.55	1.30	7.31	2.39±0.30	32
	2	0.31	0.21	0.47	2.10	1.24	4.71	4.01	2.12	10.96	2.66±0.35	32
	3	0.30	0.20	0.45	1.97	1.16	4.39	3.74	1.99	10.13	2.69±0.35	32
	4	0.11	0.08	0.17	0.79	0.47	1.74	1.52	0.81	4.08	2.62±0.34	32
	5	0.08	0.05	0.13	0.89	0.49	2.19	1.99	0.96	6.13	2.15±0.27	32
	6	0.12	0.08	0.18	0.75	0.45	1.62	1.40	0.76	3.63	2.76±0.36	32
	7	0.12	0.08	0.18	0.83	0.49	1.83	1.60	0.85	4.29	2.62±0.34	32
	8	0.13	0.08	0.19	0.83	0.49	1.80	1.57	0.84	4.15	2.68±0.35	32
	Mean	**0.165**	**0.110**	**0.25**	**1.175**	**0.687**	**2.646**	**2.297**	**1.203**	**6.335**	**2.57±0.33**	
Dindigul	1	0.19	0.12	0.29	1.88	1.03	4.65	4.13	2.00	12.79	2.19±0.27	32
	2	0.34	0.23	0.53	2.94	1.64	7.13	6.10	3.03	18.40	2.36±0.30	32
	3	0.14	0.08	0.23	2.42	1.19	7.09	6.43	2.70	24.89	1.76±0.22	32
	4	0.09	0.05	0.14	1.48	0.74	4.21	3.89	1.67	14.51	1.79±0.22	32
	5	0.21	0.13	0.35	4.30	2.00	13.78	12.06	4.74	52.21	1.67±0.21	32
	6	0.28	0.18	0.46	4.27	2.11	12.42	10.75	4.58	40.97	1.86±0.23	32
	7	0.17	0.11	0.27	1.85	1.00	4.65	4.15	1.97	13.05	2.13±0.26	32
	8	0.14	0.09	0.22	1.76	0.92	4.61	4.18	1.91	14.03	1.98±0.24	32
	Mean	**0.195**	**0.124**	**0.311**	**2.61**	**1.33**	**7.32**	**6.46**	**2.825**	**23.87**	**1.97±0.24**	

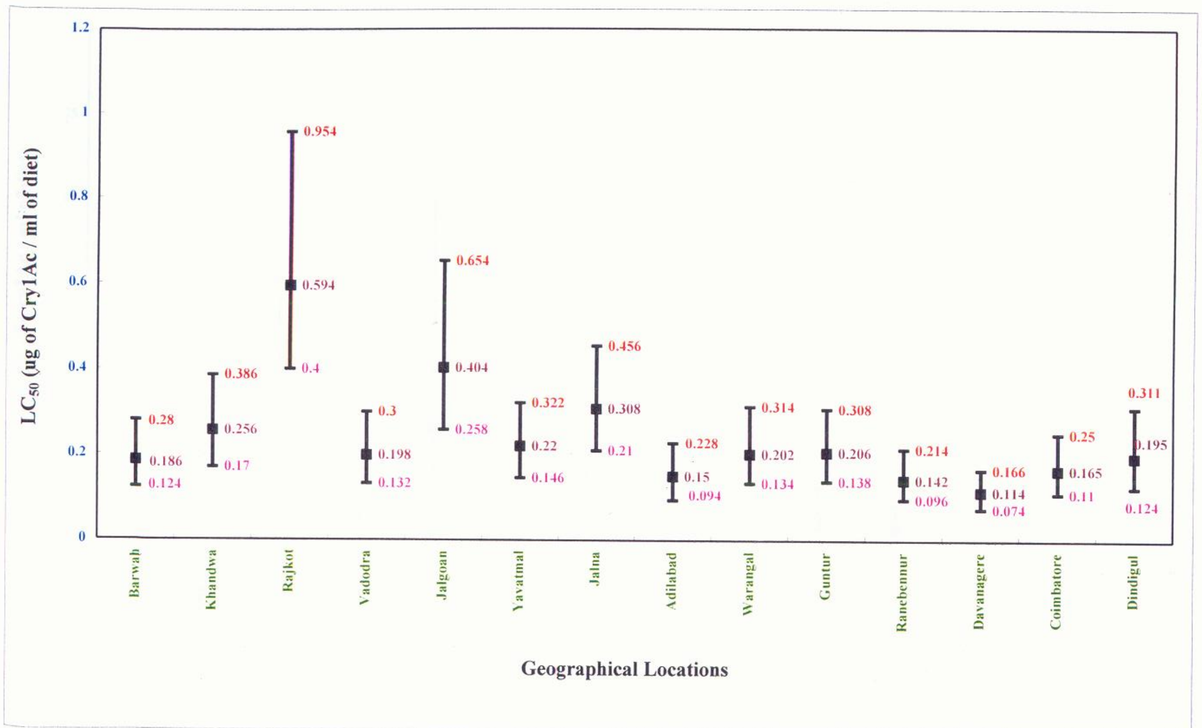

Fig. 2. LC$_{50}$ values for neonates of 14 different populations of *Helicoverpa armigera* to *Bacillus thuringiensis* Cry1Ac protein (box showing mean value and bars showing range values)

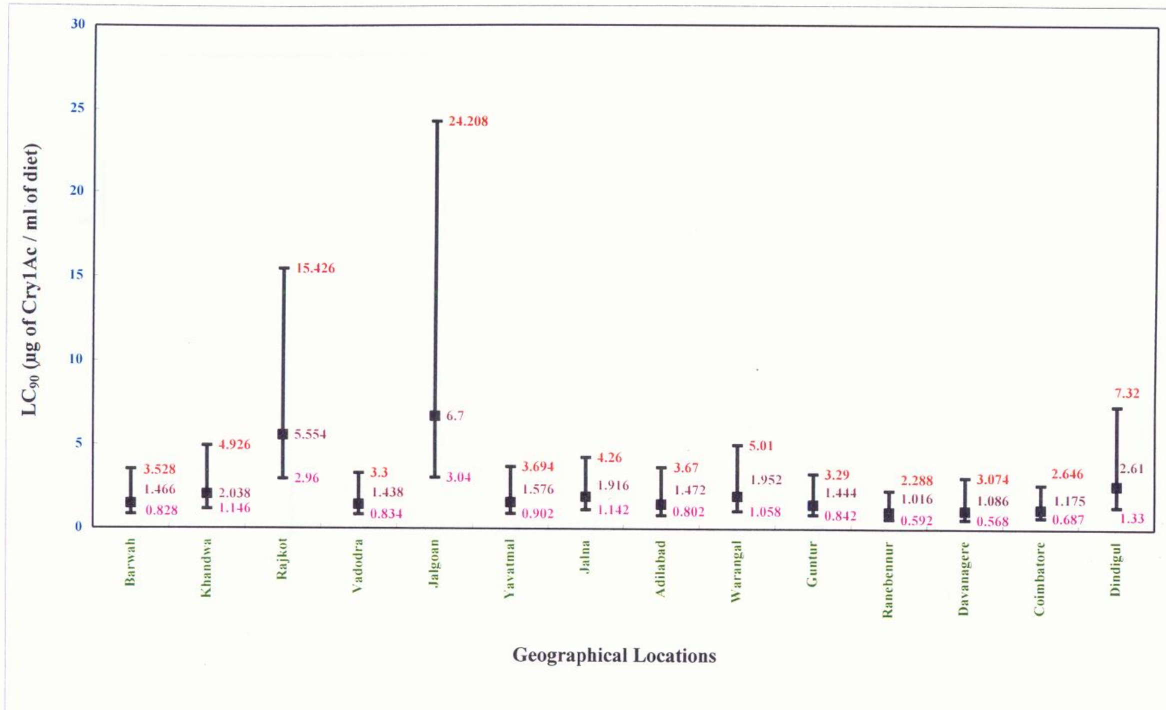

Fig. 3. LC_{90} values for neonates of 14 different populations of *Helicoverpa armigera* to *Bacillus thuringiensis* Cry1Ac protein (box showing mean value and bars showing range values)

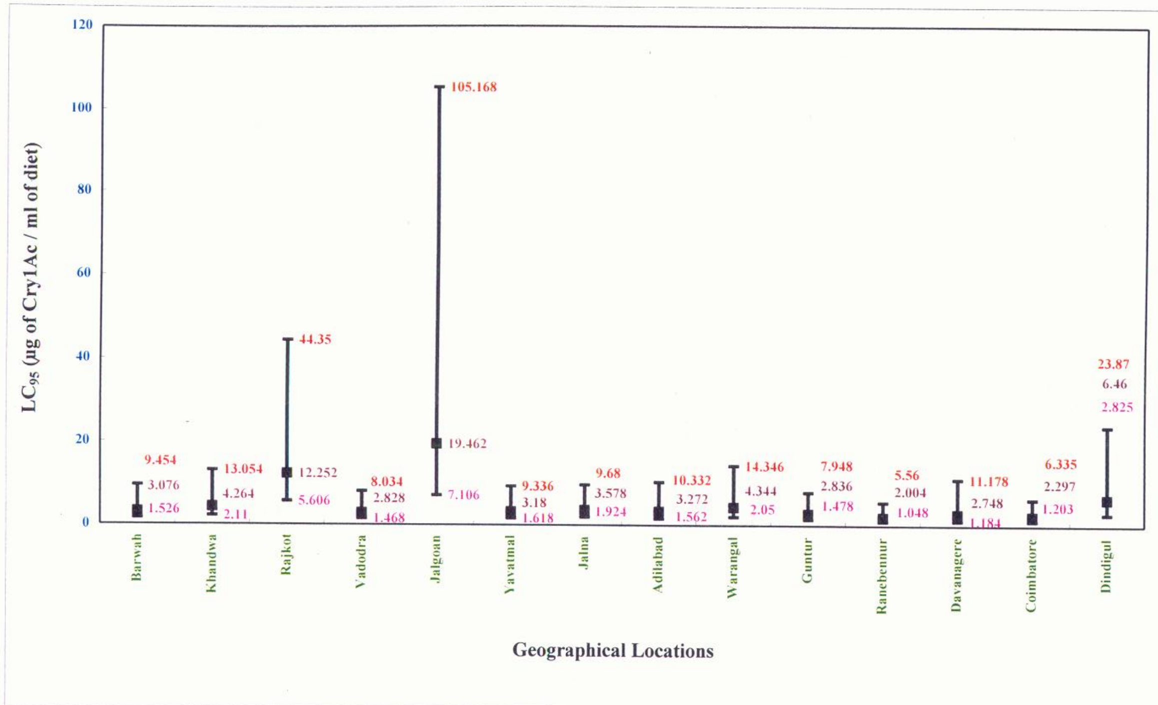

Fig. 4. LC_{95} values for neonates of 14 different populations of *Helicoverpa armigera* to *Bacillus thuringiensis* Cry1Ac protein (box showing mean value and bars showing range values)

Table 6. Log dosage probit response of neonates of *Helicoverpa armigera* (Hübner) to Cry1Ac toxin, molt inhibitory concentrations

Geographical locations	Replications	MIC_{50}	Fiducial limit		MIC_{90}	Fiducial limit		MIC_{95}	Fiducial limit		Slope±SE	Larvae per dose
			Lower	Upper		Lower	Upper		Lower	Upper		
Barwah	1	0.04	0.03	0.07	0.31	0.18	0.69	0.60	0.32	1.63	2.60±0.34	32
	2	0.06	0.04	0.10	0.80	0.42	2.09	1.93	0.89	6.45	1.97±0.24	32
	3	0.05	0.03	0.07	0.21	0.13	0.42	0.34	0.20	0.82	3.45±0.49	32
	4	0.14	0.10	0.20	0.65	0.41	1.32	1.10	0.64	2.66	3.25±0.45	32
	5	0.18	0.12	0.26	1.11	0.67	2.42	2.08	1.13	5.45	2.76±0.36	32
	6	0.05	0.03	0.08	0.33	0.19	0.70	0.60	0.33	1.596	2.20±0.34	32
	7	0.16	0.11	0.23	0.68	0.44	1.34	1.10	0.65	2.46	3.05±0.35	
	8	0.07	0.05	0.11	0.84	0.46	2.12	1.93	0.93	6.15	1.57±0.24	
	Mean	**0.094**	**0.064**	**0.14**	**0.616**	**0.362**	**1.388**	**1.21**	**0.636**	**3.402**	**2.806±0.376**	
Khandwa	1	0.05	0.04	0.08	0.41	0.24	0.92	0.81	0.42	2.23	2.51±0.32	32
	2	0.05	0.04	0.07	0.24	0.15	0.49	0.41	0.24	1.00	3.23±0.45	32
	3	0.11	0.08	0.16	0.48	0.31	0.95	0.78	0.47	1.84	3.53±0.51	32
	4	0.16	0.10	0.24	1.30	0.74	3.01	2.66	1.35	7.61	2.39±0.30	32
	5	0.14	0.09	0.20	0.81	0.49	1.72	1.48	0.81	3.79	2.85±0.38	32
	6	0.16	0.11	0.24	1.15	0.64	3.20	2.36	1.18	6.31	2.49±0.30	32
	7	0.01	0.01	0.03	0.08	0.05	0.16	0.14	0.08	0.35	3.23±0.49	
	8	0.14	0.09	0.18	0.72	0.47	1.89	1.18	0.71	3.22	2.98±0.38	
	Mean	**0.102**	**0.07**	**0.15**	**0.648**	**0.386**	**1.418**	**1.228**	**0.658**	**3.294**	**2.902±0.392**	
Rajkot	1	0.19	0.14	0.28	0.89	0.57	1.81	1.50	0.87	3.61	3.31±0.46	32
	2	0.25	0.18	0.36	1.13	0.72	2.28	1.88	1.10	4.51	3.36±0.47	32
	3	0.05	0.04	0.08	0.41	0.24	0.92	0.81	0.42	2.23	2.51±0.32	32
	4	0.07	0.05	0.11	0.50	0.30	1.12	0.98	0.52	2.65	2.58±0.33	32
	5	0.08	0.05	0.12	0.52	0.31	1.12	0.98	0.53	2.56	2.72±0.36	32
	6	0.13	0.11	0.23	0.68	0.47	1.59	1.40	0.74	3.28	3.09±0.41	
	7	0.05	0.04	0.08	0.41	0.24	0.70	0.71	0.32	1.90	2.29±0.32	
	8	0.20	0.15	0.26	0.98	0.57	2.06	1.58	1.00	4.18	3.14±0.44	
	Mean	**0.128**	**0.092**	**0.19**	**0.69**	**0.428**	**1.45**	**1.23**	**0.688**	**3.112**	**2.896±0.388**	

Table 6. Continued ...

Vadodra	1	0.05	0.04	0.08	0.25	0.16	0.51	0.42	0.25	1.01	3.33±0.47	32
	2	0.03	0.02	0.04	0.15	0.09	0.31	0.25	0.15	0.62	3.24±0.46	32
	3	0.03	0.02	0.04	0.18	0.11	0.41	0.35	0.19	0.95	2.66±0.36	32
	4	0.07	0.05	0.10	0.45	0.27	0.98	0.85	0.46	2.25	2.68±0.35	32
	5	0.09	0.07	0.13	0.37	0.24	0.73	0.59	0.36	1.37	3.65±0.53	32
	6	0.07	0.05	0.09	0.45	0.23	0.98	0.75	0.43	2.05	2.68±0.35	32
	7	0.05	0.04	0.07	0.24	0.10	0.41	0.32	0.22	0.86	3.33±0.47	32
	8	0.04	0.03	0.06	0.15	0.09	0.38	0.30	0.20	0.81	3.32±0.47	32
	Mean	**0.054**	**0.04**	**0.078**	**0.28**	**0.174**	**0.588**	**0.492**	**0.282**	**1.24**	**3.112±0.434**	
Jalgoan	1	0.08	0.05	0.13	1.07	0.56	2.76	2.53	1.17	8.36	1.99±0.25	32
	2	0.11	0.07	0.17	1.16	0.63	2.87	2.59	1.25	8.03	2.14±0.27	32
	3	0.11	0.08	0.16	0.65	0.39	1.38	1.18	0.65	3.02	2.86±0.38	32
	4	0.13	0.09	0.18	0.70	0.43	1.48	1.26	0.71	3.20	2.93±0.39	32
	5	0.23	0.16	0.33	0.97	0.62	1.92	1.57	0.94	3.70	3.53±0.51	32
	6	0.11	0.07	0.17	1.06	0.63	2.67	2.49	1.15	7.36	2.27±0.30	32
	7	0.23	0.16	0.29	0.87	0.62	1.71	1.40	0.84	3.43	3.66±0.51	32
	8	0.07	0.04	0.12	0.80	0.33	1.87	1.59	0.84	5.03	2.14±0.27	32
	Mean	**0.132**	**0.09**	**0.194**	**0.91**	**0.526**	**2.082**	**1.826**	**0.944**	**5.262**	**2.69±0.36**	
Jalna	1	0.07	0.05	0.11	0.31	0.20	0.61	0.50	0.30	1.17	3.55±0.51	32
	2	0.10	0.07	0.13	0.32	0.22	0.60	0.48	0.30	1.06	4.24±0.66	32
	3	0.17	0.12	0.23	0.59	0.40	1.15	0.91	0.56	2.06	4.04±0.62	32
	4	0.14	0.09	0.20	0.68	0.43	1.41	1.18	0.68	2.90	3.14±0.43	32
	5	0.22	0.16	0.31	0.89	0.58	1.76	1.44	0.86	3.35	3.61±0.52	32
	6	0.17	0.12	0.23	0.64	0.40	1.35	1.01	0.66	2.49	3.89±0.62	32
	7	0.10	0.07	0.13	0.37	0.22	0.80	0.58	0.30	1.16	4.09±0.61	32
	8	0.15	0.10	0.23	0.56	0.48	1.17	1.12	0.66	2.67	3.17±0.41	32
	Mean	**0.14**	**0.098**	**0.196**	**0.558**	**0.366**	**1.106**	**0.902**	**0.54**	**2.108**	**3.716±0.548**	

Table 6. Continued ...

Yavatmal	1	0.08	0.05	0.12	0.51	0.31	1.12	0.97	0.53	2.58	2.68±0.35	32
	2	0.09	0.06	0.13	0.47	0.29	0.97	0.82	0.47	2.01	3.11±0.42	32
	3	0.01	0.01	0.01	0.06	0.03	0.13	0.11	0.06	0.31	2.79±0.42	32
	4	0.10	0.07	0.14	0.58	0.35	1.25	1.08	0.59	2.78	2.81±0.37	32
	5	0.13	0.09	0.19	0.69	0.43	1.45	1.23	0.69	3.05	3.03±0.41	32
	6	0.08	0.05	0.12	0.51	0.31	1.12	0.97	0.53	2.58	2.68±0.35	32
	7	0.10	0.07	0.14	0.58	0.35	1.25	1.08	0.59	2.78	2.81±0.37	32
	8	0.07	0.04	0.09	0.29	0.18	0.58	0.11	0.38	1.08	3.26±0.46	32
	Mean	**0.082**	**0.054**	**0.118**	**0.462**	**0.282**	**0.984**	**0.718**	**0.468**	**2.146**	**2.884±0.394**	
Adilabad	1	0.06	0.04	0.08	0.34	0.21	0.73	0.62	0.34	1.60	2.84±0.38	32
	2	0.07	0.05	0.11	0.33	0.21	0.66	0.54	0.32	1.28	3.41±0.48	32
	3	0.08	0.06	0.12	0.44	0.27	0.92	0.79	0.44	1.97	2.98±0.40	32
	4	0.08	0.05	0.12	0.54	0.32	1.19	1.05	0.56	2.81	2.61±0.34	32
	5	0.07	0.05	0.10	0.42	0.26	0.91	0.79	0.43	2.06	2.76±0.36	32
	6	0.07	0.05	0.10	0.42	0.26	0.91	0.79	0.43	2.06	2.76±0.36	32
	7	0.07	0.05	0.10	0.33	0.21	0.66	0.54	0.32	1.28	3.41±0.48	32
	8	0.08	0.05	0.12	0.49	0.29	1.08	0.94	0.50	2.49	2.59±0.33	32
	Mean	**0.072**	**0.05**	**0.106**	**0.414**	**0.254**	**0.882**	**0.758**	**0.418**	**1.944**	**2.92±0.392**	
Warangal	1	0.06	0.04	0.08	0.20	0.13	0.37	0.30	0.19	0.66	4.21±0.65	32
	2	0.07	0.05	0.10	0.31	0.20	0.61	0.50	0.30	1.18	3.47±0.49	32
	3	0.07	0.05	0.11	0.44	0.27	0.93	0.79	0.44	2.03	2.86±0.38	32
	4	0.12	0.08	0.18	0.83	0.49	1.84	1.60	0.85	4.31	2.61±0.34	32
	5	0.14	0.10	0.20	0.63	0.40	1.27	1.05	0.62	2.50	3.40±0.48	32
	6	0.07	0.05	0.11	0.44	0.27	0.93	0.79	0.44	2.03	2.86±0.38	32
	7	0.14	0.10	0.20	0.63	0.40	1.27	1.05	0.62	2.50	3.40±0.48	32
	8	0.07	0.04	0.15	0.38	0.22	0.81	0.70	0.38	1.48	2.67±0.54	32
	Mean	**0.092**	**0.064**	**0.152**	**0.482**	**0.298**	**1.004**	**0.848**	**0.48**	**2.004**	**3.31±0.468**	

Table 6. Continued ...

Guntur	1	0.09	0.06	0.12	0.28	0.19	0.53	0.42	0.27	0.92	4.35±0.69	32
	2	0.08	0.06	0.12	0.44	0.27	0.92	0.79	0.44	1.97	2.98±0.40	32
	3	0.08	0.06	0.12	0.40	0.25	0.80	0.67	0.39	1.61	3.28±0.46	32
	4	0.19	0.14	0.28	0.89	0.56	1.80	1.49	0.87	3.59	3.32±0.46	32
	5	0.16	0.12	0.23	0.62	0.41	1.21	0.97	0.59	2.24	3.79±0.56	32
	6	0.19	0.14	0.28	0.89	0.56	1.80	1.49	0.87	3.59	3.32±0.46	32
	7	0.08	0.06	0.12	0.40	0.25	0.80	0.67	0.39	1.61	3.28±0.46	32
	8	0.09	0.06	0.12	0.28	0.19	0.56	0.44	0.28	0.60	3.03±0.61	32
	Mean	**0.12**	**0.088**	**0.174**	**0.526**	**0.336**	**1.052**	**0.868**	**0.512**	**2.066**	**3.544±0.514**	
Ranebennur	1	0.08	0.06	0.12	0.37	0.24	0.74	0.62	0.36	1.46	3.42±0.48	32
	2	0.07	0.05	0.11	0.53	0.31	1.18	1.04	0.55	2.86	2.52±0.32	32
	3	0.08	0.06	0.12	0.33	0.22	0.64	0.52	0.32	1.19	3.73±0.55	32
	4	0.03	0.02	0.05	0.18	0.11	0.38	0.32	0.18	0.81	3.02±0.42	32
	5	0.07	0.05	0.11	0.37	0.23	0.76	0.64	0.37	1.56	3.16±0.43	32
	6	0.05	0.03	0.08	0.37	0.11	0.82	0.57	0.28	1.38	2.81±0.36	32
	7	0.08	0.06	0.12	0.33	0.22	0.64	0.77	0.42	1.49	3.63±0.55	32
	8	0.07	0.05	0.11	0.37	0.23	0.76	0.64	0.37	1.86	3.06±0.43	32
	Mean	**0.066**	**0.048**	**0.102**	**0.356**	**0.222**	**0.740**	**0.628**	**0.356**	**1.576**	**3.17±0.44**	
Davanagere	1	0.07	0.05	0.10	0.38	0.23	0.80	0.68	0.38	1.73	2.94±0.39	32
	2	0.05	0.04	0.07	0.12	0.09	0.21	0.15	0.11	0.30	6.47±1.15	32
	3	0.08	0.05	0.11	0.33	0.21	0.65	0.54	0.32	1.26	3.50±0.50	32
	4	0.04	0.02	0.05	0.21	0.13	0.45	0.39	0.21	1.01	2.84±0.39	32
	5	0.02	0.01	0.03	0.24	0.13	0.59	0.53	0.26	1.71	2.13±0.28	32
	6	0.07	0.03	0.09	0.28	0.19	0.63	0.45	0.30	1.39	3.94±0.49	32
	7	0.07	0.05	0.09	0.29	0.20	0.60	0.40	0.28	1.30	3.73±0.66	32
	8	0.02	0.02	0.04	0.20	0.08	0.39	0.42	0.19	0.92	3.06±0.48	32
	Mean	**0.052**	**0.034**	**0.072**	**0.256**	**0.158**	**0.540**	**0.458**	**0.256**	**1.202**	**3.576±0.542**	

Table 6. Continued ...

Coimbatore	1	0.05	0.04	0.08	0.25	0.16	0.50	0.41	0.24	1.00	3.28±0.46	32
	2	0.07	0.04	0.10	0.49	0.28	1.09	0.97	0.51	2.66	2.51±0.32	32
	3	0.08	0.06	0.12	0.33	0.22	0.64	0.52	0.32	1.19	3.73±0.55	32
	4	0.05	0.04	0.07	0.20	0.13	0.39	0.32	0.19	0.74	3.67±0.54	32
	5	0.03	0.02	0.05	0.16	0.10	0.34	0.29	0.16	0.71	3.13±0.44	32
	6	0.05	0.03	0.07	0.17	0.11	0.33	0.26	0.16	0.59	4.00±0.61	32
	7	0.04	0.03	0.06	0.20	0.13	0.42	0.35	0.20	0.85	3.22±0.45	32
	8	0.04	0.03	0.06	0.17	0.11	0.34	0.27	0.16	0.63	3.65±0.54	32
	Mean	**0.051**	**0.032**	**0.076**	**0.246**	**0.155**	**0.506**	**0.424**	**0.242**	**1.046**	**3.398±0.49**	
Dindigul	1	0.08	0.06	0.13	0.67	0.39	1.53	1.35	0.70	3.79	2.44±0.31	32
	2	0.07	0.05	0.11	0.48	0.28	1.05	0.92	0.49	2.44	2.65±0.34	32
	3	0.05	0.03	0.07	0.58	0.31	1.48	1.36	0.64	4.46	2.01±0.25	32
	4	0.03	0.02	0.05	0.41	0.22	1.05	0.96	0.45	3.18	2.01±0.26	32
	5	0.09	0.06	0.14	0.86	0.48	2.06	1.85	0.91	5.55	2.23±0.28	32
	6	0.11	0.07	0.16	1.01	0.56	2.42	2.18	1.07	6.51	2.24±0.28	32
	7	0.08	0.06	0.13	0.67	0.39	1.53	1.35	0.70	3.79	2.44±0.31	32
	8	0.05	0.03	0.08	0.47	0.26	1.13	1.01	0.50	3.02	2.25±0.29	32
	Mean	**0.07**	**0.05**	**0.11**	**0.64**	**0.36**	**1.53**	**1.37**	**0.68**	**4.09**	**2.28±0.29**	

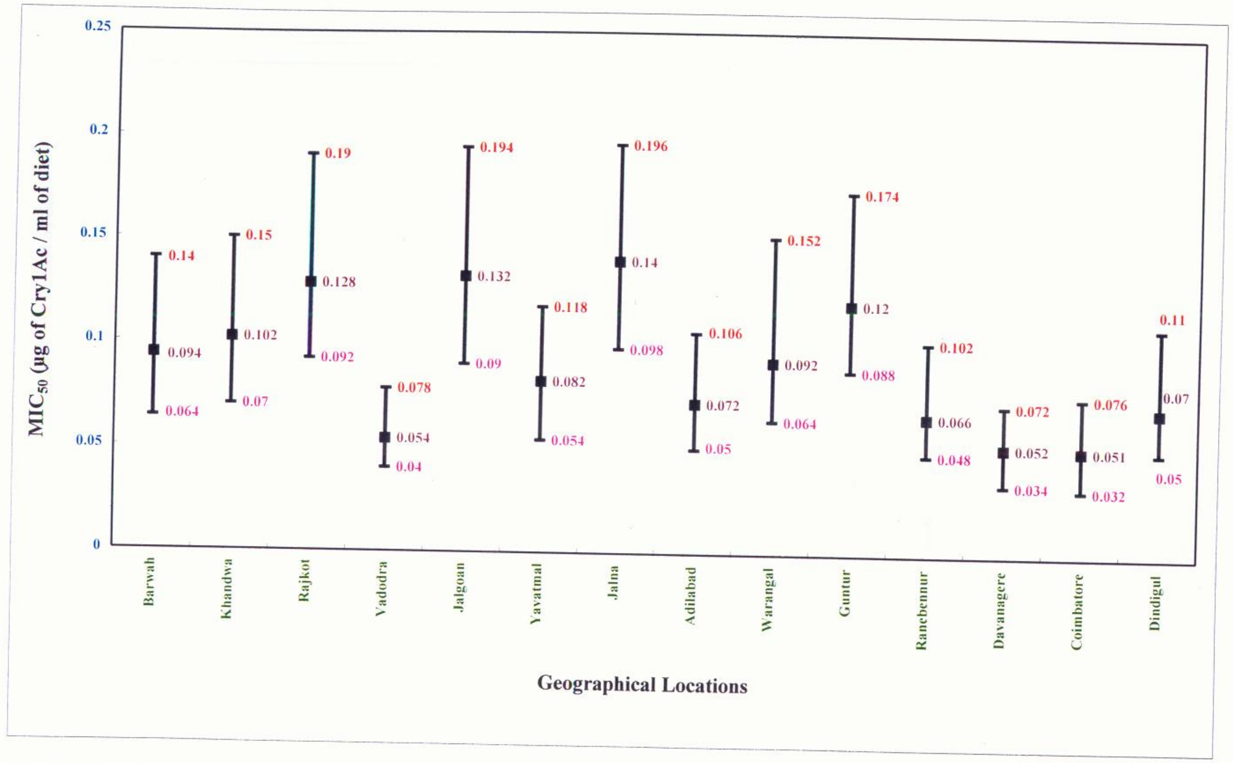

Fig. 5. MIC_{50} values for neonates of 14 different populations of *Helicoverpa armigera* to *Bacillus thuringiensis* Cry1Ac protein (box showing mean value and bars showing range values)

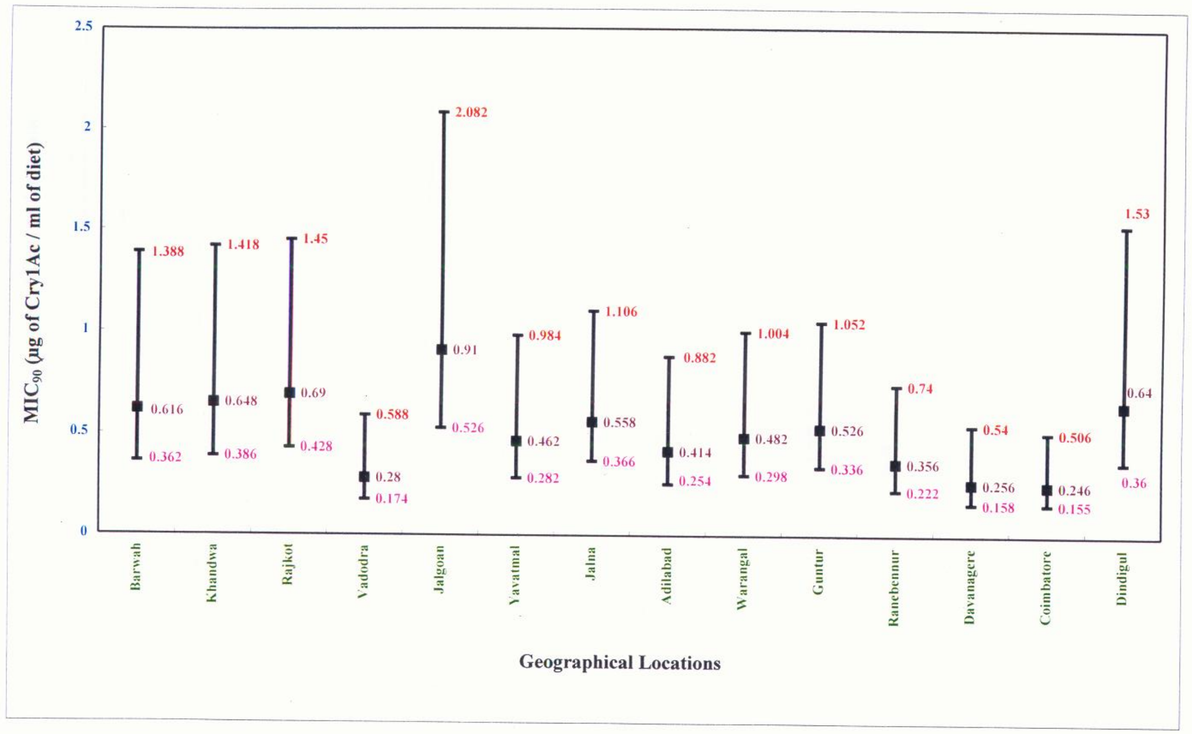

Fig. 6. **MIC$_{90}$ values for neonates of 14 different populations of *Helicoverpa armigera* to *Bacillus thuringiensis* Cry1Ac protein (box showing mean value and bars showing range values)**

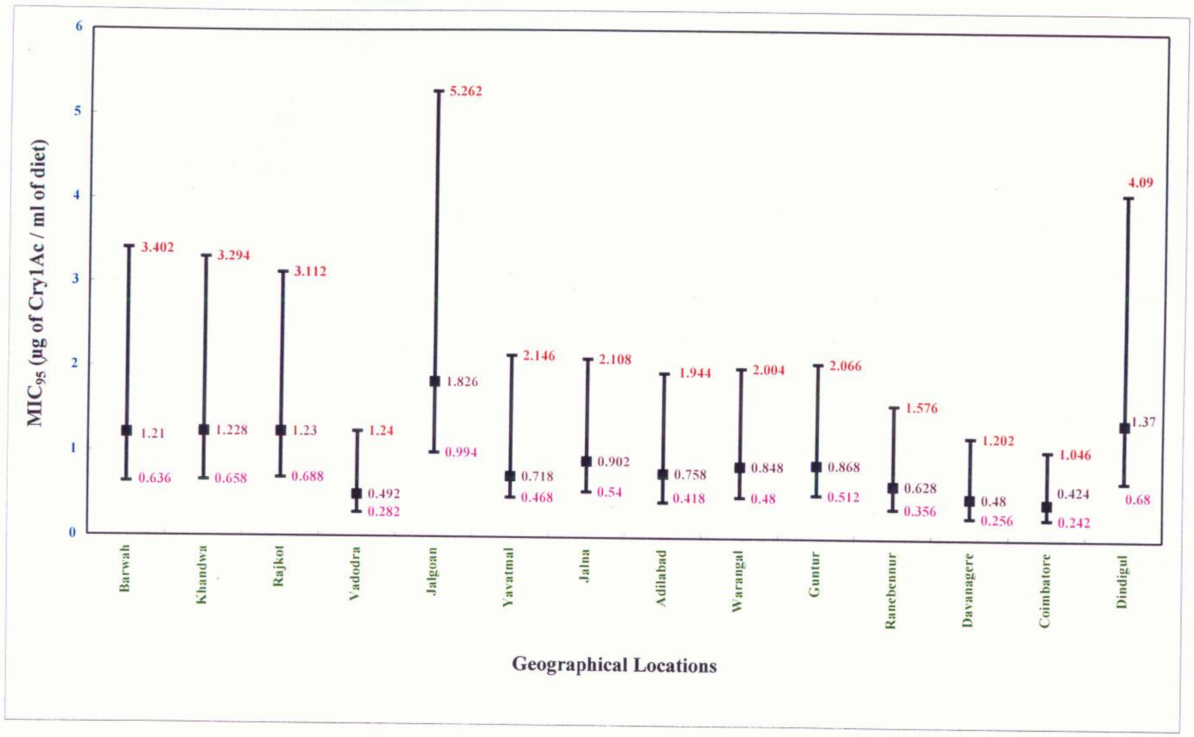

Fig. 7. MIC$_{95}$ values for neonates of 14 different populations of *Helicoverpa armigera* to *Bacillus thuringiensis* Cry1Ac protein (box showing mean value and bars showing range values)

Table 7. Log dosage probit response of neonates of *Helicoverpa armigera* (Hübner) to Cry1Ac toxin, inhibitory concentrations (related to not reaching 3rd instar)

Geographical locations	Replications	IC_{50}	Fiducial limit		IC_{90}	Fiducial limit		IC_{95}	Fiducial limit		Slope±SE	Larvae per dose
			Lower	Upper		Lower	Upper		Lower	Upper		
Barwah	1	0.02	0.01	0.03	0.11	0.07	0.24	0.20	0.11	0.52	3.00±0.43	32
	2	0.02	0.01	0.03	0.15	0.09	0.34	0.30	0.15	0.86	2.50±0.34	32
	3	0.02	0.01	0.03	0.07	0.05	0.14	0.11	0.07	0.26	3.99±0.62	32
	4	0.05	0.03	0.07	0.27	0.17	0.57	0.48	0.27	1.21	3.01±0.41	32
	5	0.07	0.05	0.10	0.36	0.22	0.76	0.64	0.36	1.60	3.03±0.41	32
	6	0.04	0.03	0.06	0.16	0.11	0.32	0.26	0.16	0.60	3.80±0.48	32
	7	0.05	0.03	0.07	0.27	0.17	0.57	0.48	0.27	1.21	3.01±0.41	32
	8	0.02	0.01	0.03	0.15	0.09	0.34	0.30	0.15	0.86	2.50±0.34	32
	Mean	**0.036**	**0.022**	**0.052**	**0.192**	**0.12**	**0.41**	**0.346**	**0.192**	**0.89**	**3.106±0.442**	
Khandwa	1	0.02	0.01	0.03	0.11	0.07	0.22	0.18	0.11	0.47	3.13±0.45	32
	2	0.01	0.01	0.02	0.07	0.04	0.14	0.11	0.06	0.27	3.40±0.51	32
	3	0.04	0.03	0.05	0.13	0.09	0.26	0.21	0.13	0.48	3.95±0.60	32
	4	0.02	0.02	0.04	0.32	0.17	0.83	0.75	0.35	2.55	1.99±0.26	32
	5	0.05	0.03	0.07	0.22	0.14	0.44	0.36	0.21	0.88	3.29±0.46	32
	6	0.02	0.02	0.04	0.22	0.13	0.55	0.50	0.25	1.54	2.77±0.40	32
	7	0.01	0.01	0.02	0.07	0.04	0.14	0.11	0.06	0.27	3.40±0.51	32
	8	0.05	0.03	0.07	0.22	0.14	0.44	0.36	0.21	0.88	3.29±0.46	32
	Mean	**0.028**	**0.02**	**0.042**	**0.17**	**0.102**	**0.378**	**0.322**	**0.172**	**0.93**	**3.152±0.456**	
Rajkot	1	0.06	0.05	0.09	0.22	0.15	0.41	0.33	0.21	0.73	4.08±0.62	32
	2	0.06	0.04	0.08	0.38	0.23	0.83	0.72	0.39	1.90	2.68±0.35	32
	3	0.02	0.01	0.03	0.11	0.07	0.25	0.21	0.11	0.57	2.74±0.39	32
	4	0.02	0.02	0.04	0.16	0.09	0.35	0.29	0.16	0.79	2.75±0.38	32
	5	0.03	0.02	0.05	0.16	0.10	0.33	0.27	0.16	0.67	3.25±0.46	32
	6	0.06	0.05	0.09	0.22	0.15	0.41	0.55	0.29	1.50	2.48±0.31	32
	7	0.02	0.01	0.03	0.11	0.07	0.25	0.21	0.11	0.57	2.74±0.39	32
	8	0.03	0.02	0.05	0.29	0.16	0.64	0.33	0.21	0.73	4.08±0.62	32
	Mean	**0.038**	**0.028**	**0.058**	**0.206**	**0.128**	**0.434**	**0.364**	**0.206**	**0.932**	**3.10±0.44**	

Table 7. Continued ...

Vadodra	1	0.02	0.01	0.03	0.08	0.05	0.17	0.14	0.08	0.33	3.49±0.52	32
	2	0.01	0.01	0.02	0.07	0.05	0.16	0.13	0.07	0.34	3.06±0.45	32
	3	0.01	0.01	0.02	0.06	0.04	0.13	0.11	0.06	0.28	3.05±0.46	32
	4	0.02	0.01	0.02	0.07	0.04	0.14	0.11	0.07	0.26	3.68±0.56	32
	5	0.03	0.02	0.04	0.12	0.08	0.26	0.21	0.12	0.52	3.26±0.47	32
	6	0.02	0.01	0.03	0.09	0.06	0.19	0.16	0.09	0.46	3.38±0.49	32
	7	0.01	0.01	0.02	0.07	0.04	0.14	0.12	0.07	0.26	3.11±0.47	32
	8	0.02	0.01	0.03	0.08	0.05	0.18	0.14	0.08	0.33	3.49±0.52	32
	Mean	**0.018**	**0.012**	**0.026**	**0.08**	**0.052**	**0.172**	**0.14**	**0.08**	**0.346**	**3.308±0.492**	
Jalgoan	1	0.02	0.01	0.03	0.22	0.12	0.57	0.51	0.24	1.66	2.10±0.28	32
	2	0.03	0.02	0.04	0.33	0.18	0.86	0.78	0.36	2.64	2.00±0.26	32
	3	0.04	0.02	0.05	0.17	0.11	0.34	0.28	0.16	0.70	3.26±0.46	32
	4	0.05	0.03	0.06	0.18	0.12	0.35	0.28	0.17	0.65	3.74±0.55	32
	5	0.09	0.06	0.12	0.33	0.22	0.63	0.51	0.31	1.15	3.88±0.58	32
	6	0.03	0.02	0.03	0.24	0.14	0.61	0.47	0.24	1.36	2.79±0.38	32
	7	0.09	0.06	0.12	0.24	0.18	0.38	0.49	0.24	1.26	3.49±0.46	32
	8	0.03	0.02	0.03	0.26	0.13	0.66	0.45	0.26	1.46	2.69±0.43	32
	Mean	**0.046**	**0.028**	**0.06**	**0.246**	**0.15**	**0.55**	**0.472**	**0.248**	**1.36**	**2.996±0.426**	
Jalna	1	0.04	0.03	0.05	0.14	0.09	0.28	0.23	0.14	1.66	3.73±0.56	32
	2	0.05	0.03	0.07	0.17	0.11	0.33	0.26	0.16	2.64	3.99±0.60	32
	3	0.05	0.04	0.07	0.18	0.12	0.34	0.27	0.17	0.70	4.14±0.63	32
	4	0.04	0.03	0.06	0.18	0.11	0.37	0.30	0.18	0.65	3.30±0.47	32
	5	0.08	0.06	0.12	0.35	0.23	0.69	0.57	0.34	1.15	3.56±0.51	32
	6	0.05	0.04	0.07	0.18	0.14	0.44	0.37	0.23	0.70	3.74±0.63	32
	7	0.05	0.04	0.07	0.22	0.12	0.41	0.32	0.19	2.18	3.84±0.47	32
	8	0.05	0.03	0.08	0.21	0.13	0.36	0.29	0.17	1.26	3.64±0.55	32
	Mean	**0.052**	**0.038**	**0.074**	**0.204**	**0.132**	**0.402**	**0.326**	**0.198**	**1.36**	**3.744±0.554**	

Table 7. Continued ...

Yavatmal	1	0.03	0.02	0.04	0.12	0.07	0.24	0.19	0.11	0.47	3.41±0.50	32
	2	0.03	0.02	0.04	0.12	0.08	0.24	0.20	0.12	0.47	3.54±0.52	32
	3	0.00	0.00	0.01	0.02	0.01	0.05	0.04	0.02	0.13	2.81±0.52	32
	4	0.03	0.02	0.04	0.12	0.08	0.26	0.21	0.12	0.54	3.17±0.45	32
	5	0.04	0.03	0.06	0.23	0.14	0.48	0.41	0.23	1.02	3.00±0.41	32
	6	0.03	0.02	0.04	0.12	0.07	0.24	0.19	0.11	0.47	3.41±0.50	32
	7	0.03	0.02	0.04	0.12	0.08	0.26	0.21	0.12	0.54	3.17±0.45	32
	8	0.02	0.014	0.034	0.12	0.08	0.26	0.23	0.13	0.57	3.00±0.49	
	Mean	**0.026**	**0.018**	**0.038**	**0.122**	**0.072**	**0.254**	**0.21**	**0.12**	**0.526**	**3.186±0.48**	
Adilabad	1	0.02	0.01	0.02	0.08	0.05	0.17	0.14	0.08	0.35	3.21±0.47	32
	2	0.02	0.02	0.03	0.10	0.07	0.21	0.17	0.10	0.42	3.46±0.51	32
	3	0.01	0.01	0.03	0.11	0.07	0.24	0.21	0.11	0.55	2.87±0.40	32
	4	0.03	0.02	0.03	0.12	0.07	0.25	0.20	0.12	0.51	3.18±0.46	32
	5	0.02	0.01	0.03	0.14	0.08	0.33	0.28	0.14	0.83	2.43±0.34	32
	6	0.02	0.01	0.03	0.12	0.08	0.26	0.28	0.14	0.63	2.43±0.43	32
	7	0.01	0.01	0.02	0.10	0.05	0.22	0.14	0.08	0.42	3.63±0.47	32
	8	0.03	0.02	0.03	0.11	0.06	0.24	0.20	0.11	0.54	3.03±0.40	32
	Mean	**0.02**	**0.014**	**0.028**	**0.11**	**0.068**	**0.24**	**0.20**	**0.11**	**0.532**	**3.03±0.436**	
Warangal	1	0.00	0.00	0.01	0.03	0.02	0.09	0.07	0.04	0.25	2.44±0.41	32
	2	0.02	0.01	0.03	0.10	0.06	0.21	0.18	0.10	0.47	2.93±0.42	32
	3	0.01	0.01	0.02	0.10	0.06	0.22	0.18	0.10	0.51	2.70±0.39	32
	4	0.02	0.01	0.03	0.11	0.07	0.23	0.19	0.11	0.49	3.04±0.43	32
	5	0.04	0.03	0.06	0.17	0.11	0.35	0.29	0.17	0.69	3.46±0.50	32
	6	0.01	0.01	0.03	0.10	0.04	0.22	0.18	0.10	0.51	2.70±0.39	32
	7	0.04	0.03	0.05	0.17	0.07	0.35	0.29	0.17	0.69	3.46±0.50	32
	8	0.00	0.00	0.01	0.04	0.02	0.09	0.08	0.04	0.25	2.57±0.40	32
	Mean	**0.018**	**0.012**	**0.03**	**0.102**	**0.044**	**0.22**	**0.182**	**0.104**	**0.482**	**2.914±0.43**	

Table 7. Continued ...

Guntur	1	0.02	0.01	0.02	0.11	0.07	0.25	0.21	0.11	0.58	2.68±0.38	32
	2	0.02	0.01	0.03	0.16	0.09	0.37	0.32	0.16	0.98	2.35±0.32	32
	3	0.03	0.02	0.05	0.16	0.10	0.34	0.29	0.16	0.71	3.13±0.44	32
	4	0.05	0.04	0.08	0.32	0.20	0.70	0.60	0.33	1.57	2.78±0.37	32
	5	0.05	0.04	0.07	0.24	0.15	0.49	0.41	0.24	1.00	3.23±0.45	32
	6	0.05	0.04	0.08	0.32	0.20	0.70	0.60	0.33	1.57	2.78±0.37	32
	7	0.03	0.02	0.05	0.16	0.10	0.34	0.29	0.16	0.71	3.10±0.44	32
	8	0.02	0.01	0.02	0.11	0.07	0.25	0.21	0.11	0.60	2.68±0.38	32
	Mean	**0.034**	**0.024**	**0.05**	**0.198**	**0.122**	**0.43**	**0.366**	**0.20**	**0.968**	**2.834±0.392**	
Ranebennur	1	0.02	0.01	0.03	0.11	0.06	0.23	0.19	0.11	0.51	2.89±0.41	32
	2	0.02	0.01	0.03	0.15	0.09	0.34	0.29	0.15	0.80	2.63±0.36	32
	3	0.03	0.02	0.04	0.12	0.07	0.24	0.19	0.11	0.47	3.41±0.50	32
	4	0.01	0.01	0.02	0.08	0.04	0.18	0.15	0.08	0.47	2.48±0.37	32
	5	0.01	0.01	0.02	0.08	0.05	0.19	0.15	0.08	0.42	2.84±0.41	32
	6	0.01	0.01	0.02	0.08	0.04	0.18	0.15	0.08	0.47	2.48±0.37	32
	7	0.03	0.02	0.04	0.16	0.07	0.34	0.28	0.11	0.71	3.23±0.45	32
	8	0.01	0.01	0.02	0.08	0.05	0.19	0.15	0.16	0.42	2.84±0.41	32
	Mean	**0. 02**	**0.012**	**0.028**	**0.108**	**0.054**	**0.236**	**0.194**	**0.106**	**0.534**	**2.85±0.41**	
Davanagere	1	0.02	0.01	0.02	0.12	0.07	0.29	0.24	0.13	0.71	2.52±0.35	32
	2	0.02	0.02	0.03	0.06	0.04	0.10	0.08	0.05	0.16	5.24±0.91	32
	3	0.03	0.02	0.04	0.13	0.08	0.26	0.22	0.12	0.55	3.15±0.45	32
	4	0.01	0.00	0.01	0.08	0.04	0.21	0.18	0.08	0.62	2.15±0.33	32
	5	0.004	0.002	0.01	0.03	0.02	0.06	0.05	0.03	0.16	2.72±0.48	32
	6	0.02	0.01	0.02	0.12	0.07	0.29	0.23	0.13	0.71	2.52±0.35	32
	7	0.02	0.02	0.04	0.12	0.07	0.24	0.19	0.11	0.47	3.41±0.50	32
	8	0.008	0.0012	0.01	0.03	0.01	0.13	0.04	0.01	0.14	3.54±0.65	32
	Mean	**0.016**	**0.0104**	**0.022**	**0.084**	**0.05**	**0.224**	**0.154**	**0.082**	**0.44**	**3.156±0.504**	

Table 7. Continued ...

Coimbatore	1	0.02	0.01	0.03	0.09	0.06	0.18	0.14	0.09	0.34	3.55±0.53	32
	2	0.01	0.01	0.02	0.08	0.05	0.17	0.14	0.08	0.39	2.84±0.41	32
	3	0.03	0.02	0.04	0.14	0.09	0.30	0.25	0.14	0.65	2.94±0.41	32
	4	0.02	0.01	0.02	0.09	0.05	0.19	0.15	0.09	0.39	3.09±0.45	32
	5	0.01	0.01	0.02	0.07	0.05	0.16	0.13	0.07	0.34	3.01±0.44	32
	6	0.01	0.01	0.02	0.07	0.04	0.15	0.12	0.07	0.31	3.13±0.46	32
	7	0.01	0.01	0.02	0.07	0.05	0.16	0.13	0.07	0.34	3.01±0.44	32
	8	0.01	0.01	0.02	0.05	0.03	0.09	0.07	0.04	0.15	4.24±0.68	32
	Mean	**0.015**	**0.011**	**0.023**	**0.082**	**0.052**	**0.173**	**0.141**	**0.081**	**0.363**	**3.226±0.48**	
Dindigul	1	0.02	0.01	0.03	0.18	0.10	0.40	0.35	0.18	1.01	2.47±0.33	32
	2	0.02	0.02	0.03	0.13	0.08	0.29	0.24	0.13	0.62	2.95±0.41	32
	3	0.01	0.01	0.02	0.09	0.05	0.22	0.19	0.09	0.58	2.39±0.35	32
	4	0.01	0.01	0.01	0.04	0.03	0.09	0.07	0.04	0.18	3.56±0.56	32
	5	0.04	0.03	0.06	0.23	0.14	0.48	0.41	0.23	1.07	2.87±0.39	
	6	0.03	0.02	0.05	0.21	0.12	0.46	0.40	0.21	1.09	2.65±0.36	
	7	0.02	0.01	0.03	0.18	0.10	0.41	0.36	0.18	1.05	2.42±0.33	
	8	0.01	0.01	0.02	0.07	0.05	0.16	0.13	0.07	0.35	3.00±0.44	32
	Mean	**0.02**	**0.015**	**0.031**	**0.14**	**0.08**	**0.31**	**0.27**	**0.14**	**0.74**	**2.79±0.40**	

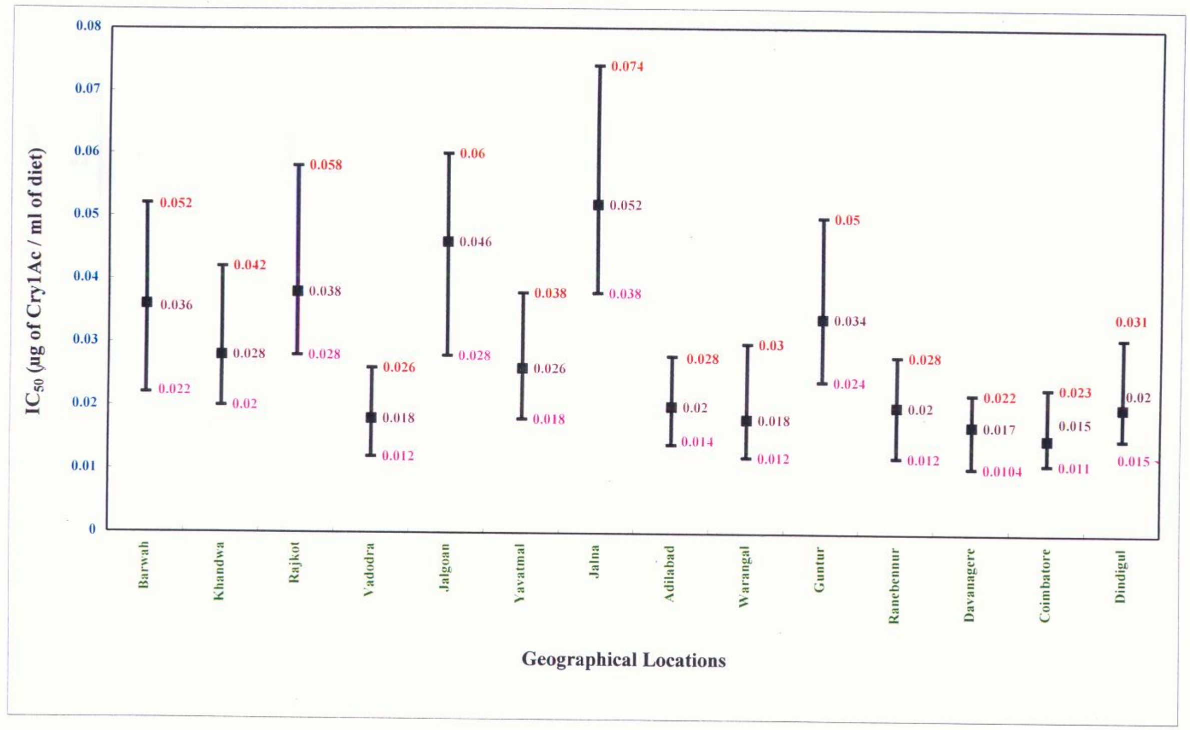

Fig. 8. IC_{50} values for neonates of 14 different populations of *Helicoverpa armigera* to *Bacillus thuringiensis* Cry1Ac protein (box showing mean value and bars showing range values)

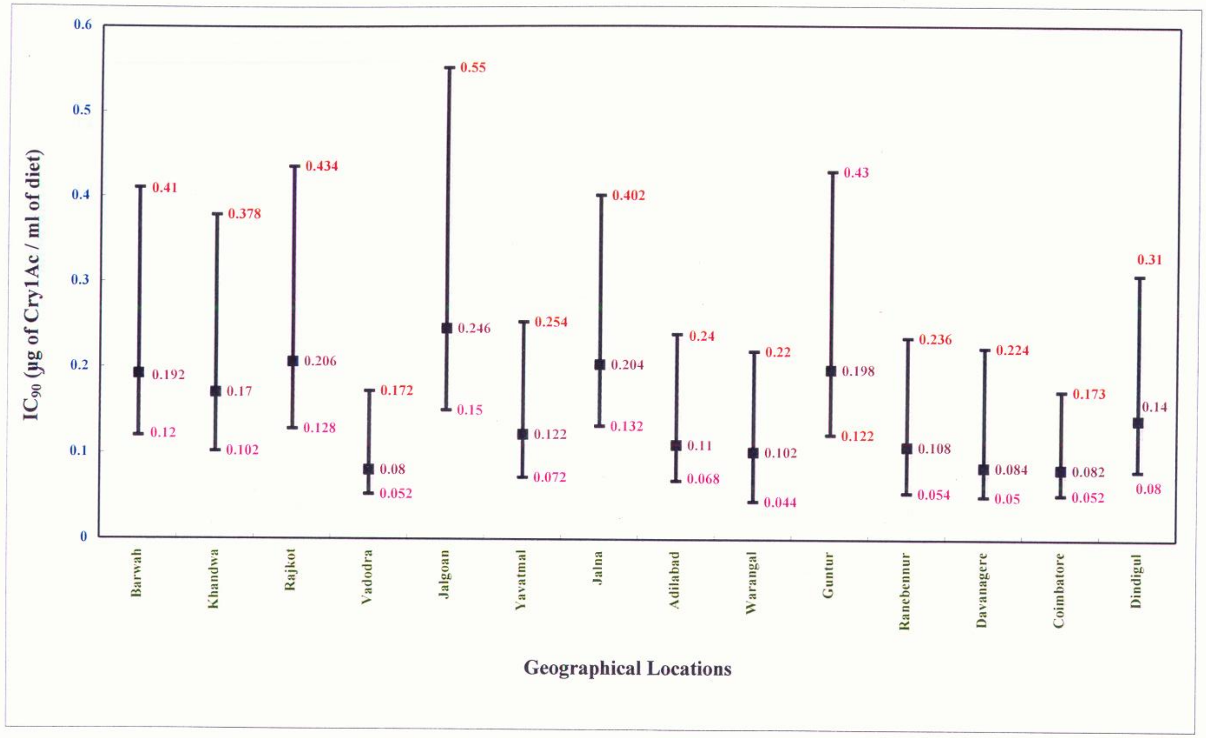

Fig. 9. IC$_{90}$ values for neonates of 14 different populations of *Helicoverpa armigera* to *Bacillus thuringiensis* Cry1Ac protein (box showing mean value and bars showing range values)

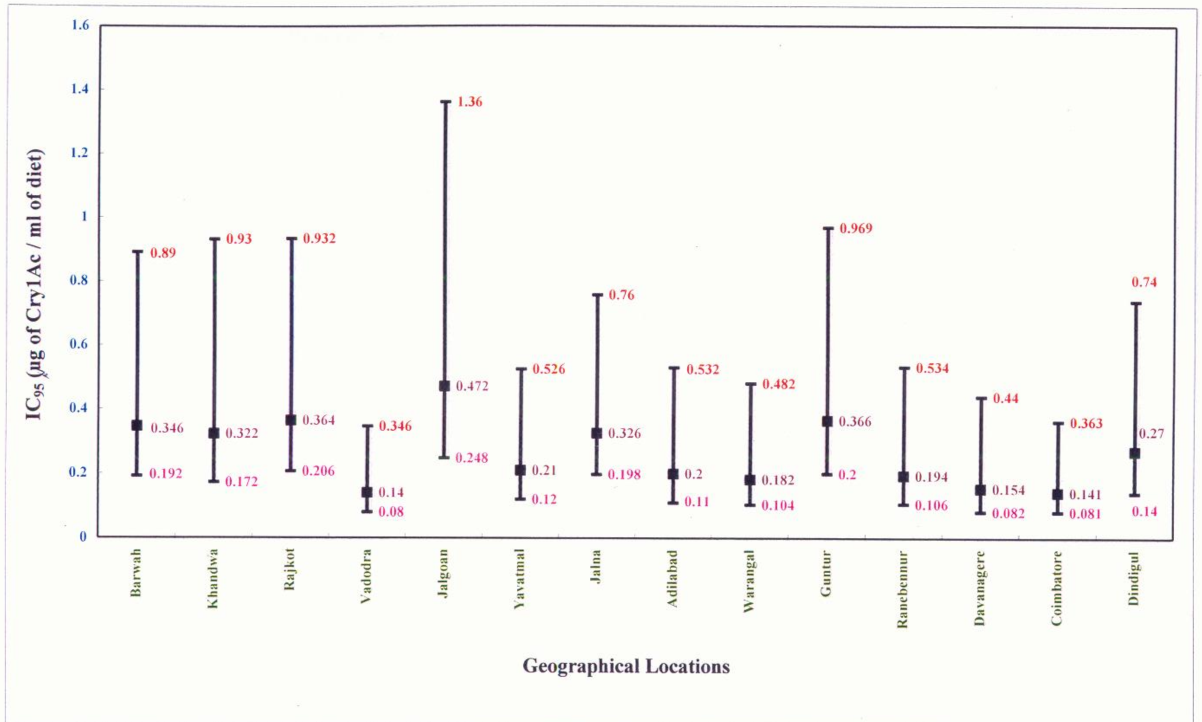

Fig. 10. IC_{95} values for neonates of 14 different populations of ***Helicoverpa armigera*** to ***Bacillus thuringiensis*** Cry1Ac protein (box showing mean value and bars showing range values)

Table 8. Log dosage probit response of neonates of *Helicoverpa armigera* (Hübner) to Cry1Ac toxin, effective concentration (related to weight)

Geographical locations	Replications	EC_{50}	Fiducial limit		EC_{90}	Fiducial limit		Larvae per dose
			Lower	Upper		Lower	Upper	
Barwah	1	0.0024	0.0022	0.0026	0.0127	0.0107	0.0152	32
	2	0.0013	0.0011	0.0016	0.0138	0.0103	0.0191	32
	3	0.0010	0.0009	0.0012	0.0146	0.0123	0.0174	32
	4	0.0024	0.0022	0.0025	0.0179	0.0156	0.0207	32
	5	0.0016	0.0015	0.0017	0.0210	0.0186	0.0238	32
	6	0.0021	0.0018	0.0021	0.0178	0.015	0.01931	32
	7	0.0021	0.0018	0.0021	0.0174	0.015	0.01931	32
	8	0.0011	0.0011	0.0016	0.0138	0.0103	0.0191	32
	Mean	**0.0017**	**0.0016**	**0.0019**	**0.016**	**0.0135**	**0.0192**	
Khandwa	1	0.0018	0.0017	0.0018	0.0089	0.0082	0.0096	32
	2	0.0054	0.0043	0.0068	0.0251	0.0165	0.0423	32
	3	0.0042	0.0036	0.0050	0.0105	0.0085	0.0132	32
	4	0.0036	0.0028	0.0046	0.0344	0.0215	0.0599	32
	5	0.0022	0.0006	0.0048	0.1568	0.0463	1.1848	32
	6	0.0028	0.0022	0.0041	0.0461	0.010	0.2490	32
	7	0.0408	0.0030	0.0051	0.0475	0.024	0.2730	32
	8	0.0035	0.0026	0.0046	0.0476	0.026	0.2620	32
	Mean	**0.0034**	**0.0026**	**0.0046**	**0.0471**	**0.0200**	**0.262**	
Rajkot	1	0.0014	0.0010	0.0019	0.0133	0.0082	0.0232	32
	2	0.0011	0.0003	0.0025	0.0752	0.0255	0.3507	32
	3	0.0010	0.0007	0.0014	0.0231	0.0151	0.0380	32
	4	0.0007	0.0005	0.0008	0.0104	0.0085	0.0128	32
	5	0.0017	0.0014	0.0020	0.0201	0.0154	0.0268	32
	6	0.0009	0.00073	0.0012	0.0234	0.0115	0.0700	32
	7	0.0011	0.00077	0.0015	0.0250	0.0125	0.0850	32
	8	0.0014	0.00083	0.0024	0.0360	0.0206	0.1200	32
	Mean	**0.0012**	**0.0008**	**0.0017**	**0.0284**	**0.0145**	**0.0903**	

Table 8. Continued ...

Geographical locations	Replications	EC_{50}	Fiducial limit		EC_{90}	Fiducial limit		Larvae per dose
			Lower	Upper		Lower	Upper	
Vadodra	1	0.0012	0.0011	0.0013	0.0095	0.0087	0.0104	32
	2	0.0052	0.0042	0.0065	0.0336	0.0236	0.0504	32
	3	0.0009	0.0007	0.0010	0.0114	0.0091	0.0146	32
	4	0.0020	0.0020	0.0021	0.0105	0.0100	0.0109	32
	5	0.0011	0.0009	0.0013	0.0149	0.0116	0.0194	32
	6	0.0029	0.0026	0.0034	0.0115	0.0105	0.0124	
	7	0.0017	0.0014	0.0020	0.0099	0.0090	0.0113	
	8	0.0016	0.0013	0.0019	0.0100	0.0090	0.0111	
	Mean	**0.0021**	**0.0018**	**0.0024**	**0.0160**	**0.0126**	**0.0211**	
Jalgoan	1	0.0028	0.0025	0.0032	0.0109	0.0083	0.0146	32
	2	0.0036	0.0032	0.0041	0.0360	0.0281	0.0472	32
	3	0.0007	0.0004	0.0011	0.0186	0.0116	0.0323	32
	4	0.0009	0.0005	0.0012	0.0195	0.0129	0.0313	32
	5	0.0102	0.0078	0.0134	0.0569	0.0350	0.0968	32
	6	0.0030	0.0018	0.0027	0.0260	0.0181	0.0322	32
	7	0.0043	0.0050	0.0094	0.0331	0.0213	0.0678	32
	8	0.0036	0.0018	0.0027	0.0260	0.0181	0.0332	32
	Mean	**0.0036**	**0.0029**	**0.0046**	**0.0284**	**0.0192**	**0.0444**	
Yavatmal	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	32
	2	0.0004	0.0002	0.0007	0.0116	0.0080	0.0177	32
	3	0.0006	0.0003	0.0010	0.0201	0.0114	0.0433	32
	4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	32
	5	0.0010	0.0010	0.0010	0.0309	0.0292	0.0327	32
	6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	32
	7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	32
	8	0.0007	0.0005	0.0009	0.0209	0.0162	0.0312	32
	Mean	**0.0007**	**0.0005**	**0.0009**	**0.0209**	**0.0162**	**0.0312**	

Table 8. Continued ...

Geographical locations	Replications	EC_{50}	Fiducial limit		EC_{90}	Fiducial limit		Larvae per dose
			Lower	Upper		Lower	Upper	
Jalna	1	0.0027	0.0022	0.0032	0.0256	0.0175	0.0397	32
	2	0.0013	0.0012	0.0013	0.0224	0.0202	0.0249	32
	3	0.0004	0.0002	0.0007	0.0656	0.0392	0.1209	32
	4	0.0024	0.0018	0.0031	0.0247	0.0146	0.0464	32
	5	0.0010	0.0009	0.0011	0.0133	0.0121	0.0147	32
	6	0.0007	0.0004	0.0011	0.0426	0.0244	0.0833	32
	7	0.0013	0.0012	0.0013	0.0224	0.0202	0.0249	32
	8	0.0027	0.0022	0.0032	0.0256	0.0175	0.0397	32
	Mean	**0.0016**	**0.0013**	**0.0019**	**0.0303**	**0.0207**	**0.0493**	
Adilabad	1	0.0003	0.0001	0.00051	0.0033	0.0028	0.0038	32
	2	0.0012	0.0009	0.0015	0.0067	0.0044	0.0103	32
	3	0.0004	0.0003	0.0005	0.0133	0.0110	0.0161	32
	4	0.0006	0.0004	0.0009	0.0677	0.0436	0.1132	32
	5	0.0005	0.0002	0.0009	0.0059	0.0039	0.0094	32
	6	0.0003	0.0001	0.0006	0.0059	0.0039	0.0094	32
	7	0.0012	0.0009	0.0015	0.0067	0.0044	0.0103	32
	8	0.0003	0.0002	0.0006	0.0450	0.0310	0.0721	32
	Mean	**0.0006**	**0.0004**	**0.0009**	**0.0194**	**0.0131**	**0.0306**	
Warangal	1	0.0020	0.0018	0.0021	0.0278	0.0246	0.0317	32
	2	0.0029	0.0025	0.0034	0.0315	0.0232	0.0440	32
	3	0.0012	0.0008	0.0017	0.0440	0.0277	0.0762	32
	4	0.0011	0.0008	0.0014	0.256	0.0177	0.0392	32
	5	0.0012	0.0010	0.0014	0.0271	0.0224	0.0332	32
	6	0.0012	0.0008	0.0017	0.0440	0.0277	0.0762	32
	7	0.0012	0.0010	0.0014	0.0271	0.0224	0.0332	32
	8	0.0027	0.0024	0.0029	0.0255	0.0192	0.0253	32
	Mean	**0.0017**	**0.0014**	**0.0020**	**0.0312**	**0.0231**	**0.0449**	

Table 8. Continued ...

Geographical locations	Replications	EC_{50}	Fiducial limit		EC_{90}	Fiducial limit		Larvae per dose
			Lower	Upper		Lower	Upper	
Guntur	1	0.0035	0.0034	0.0037	0.0309	0.0283	0.0338	32
	2	0.0013	0.0004	0.0027	0.1470	0.0459	0.9757	32
	3	0.0015	0.0012	0.0018	0.0324	0.0233	0.0469	32
	4	0.0014	0.0011	0.0017	0.0154	0.0112	0.0219	32
	5	0.0076	0.0055	0.0107	0.0440	0.0229	0.0935	32
	6	0.0043	0.0023	0.0068	0.0984	0.0273	0.0825	32
	7	0.0015	0.0012	0.0018	0.0324	0.0233	0.0469	32
	8	0.0035	0.0034	0.0037	0.0309	0.0283	0.0338	32
	Mean	**0.0031**	**0.0023**	**0.0041**	**0.0539**	**0.0263**	**0.0544**	
Ranebennur	1	0.0039	0.0034	0.0044	0.0488	0.0379	0.0641	32
	2	0.0030	0.0026	0.0034	0.0257	0.0196	0.0346	32
	3	0.0021	0.0020	0.0023	0.0372	0.0321	0.0435	32
	4	0.0021	0.0016	0.0026	0.0329	0.0222	0.0521	32
	5	0.0030	0.0012	0.0060	0.0688	0.0237	0.3628	32
	6	0.0021	0.0016	0.0026	0.0329	0.0222	0.0521	32
	7	0.0021	0.0020	0.0023	0.0372	0.0321	0.0435	32
	8	0.0042	0.0030	0.0062	0.0580	0.0270	0.2386	32
	Mean	**0.0028**	**0.0022**	**0.0037**	**0.0427**	**0.0271**	**0.1114**	
Davanagere	1	0.0003	0.00005	0.0006	0.0097	0.0056	0.0203	32
	2	0.0003	0.0001	0.0006	0.0177	0.0170	0.0343	32
	3	0.0004	0.0002	0.0006	0.0236	0.0160	0.0368	32
	4	0.0006	0.00057	0.0007	0.0094	0.0086	0.0103	32
	5	0.0002	0.00015	0.00023	0.0033	0.0031	0.0035	32
	6	0.0003	0.00005	0.0006	0.0097	0.0056	0.0203	32
	7	0.0007	0.00045	0.0007	0.0251	0.0216	0.0392	32
	8	0.0002	0.0001	0.0002	0.0033	0.0031	0.0035	32
	Mean	**0.0004**	**0.0002**	**0.0005**	**0.0127**	**0.0101**	**0.0210**	

Table 8. Continued ...

Coimbatore	1	0.0009	0.0008	0.0009	0.0074	0.0072	0.0077	32
	2	0.0006	0.0006	0.0006	0.0061	0.0060	0.0063	32
	3	0.0007	0.0006	0.0008	0.0062	0.0059	0.0066	32
	4	0.0007	0.0007	0.0008	0.0084	0.0078	0.0090	32
	5	0.0011	0.0009	0.0012	0.0104	0.0091	0.0120	32
	6	0.0011	0.00106	0.0011	0.0113	0.0110	0.0118	32
	7	0.0008	0.00070	0.0009	0.0103	0.0096	0.0111	32
	8	0.0014	0.00130	0.0015	0.0150	0.0137	0.0165	32
	Mean	**0.0009**	**0.0004**	**0.001**	**0.0094**	**0.0087**	**0.0101**	
Dindigul	1	0.0022	0.0020	0.0023	0.0179	0.0158	0.0203	32
	2	0.0012	0.0011	0.0013	0.0207	0.0178	0.0241	32
	3	0.0012	0.0008	0.0015	0.0166	0.0111	0.0266	32
	4	0.0005	0.0003	0.0007	0.0108	0.0080	0.0150	32
	5	0.0006	0.0005	0.0007	0.0105	0.0091	0.0121	
	6	0.0009	0.0008	0.0009	0.0090	0.0086	0.0094	
	7	0.0019	0.0018	0.0020	0.0155	0.0137	0.0177	
	8	0.0010	0.0008	0.0011	0.0139	0.0116	0.0169	32
	Mean	**0.0012**	**0.0010**	**0.0013**	**0.0144**	**0.0120**	**0.0178**	

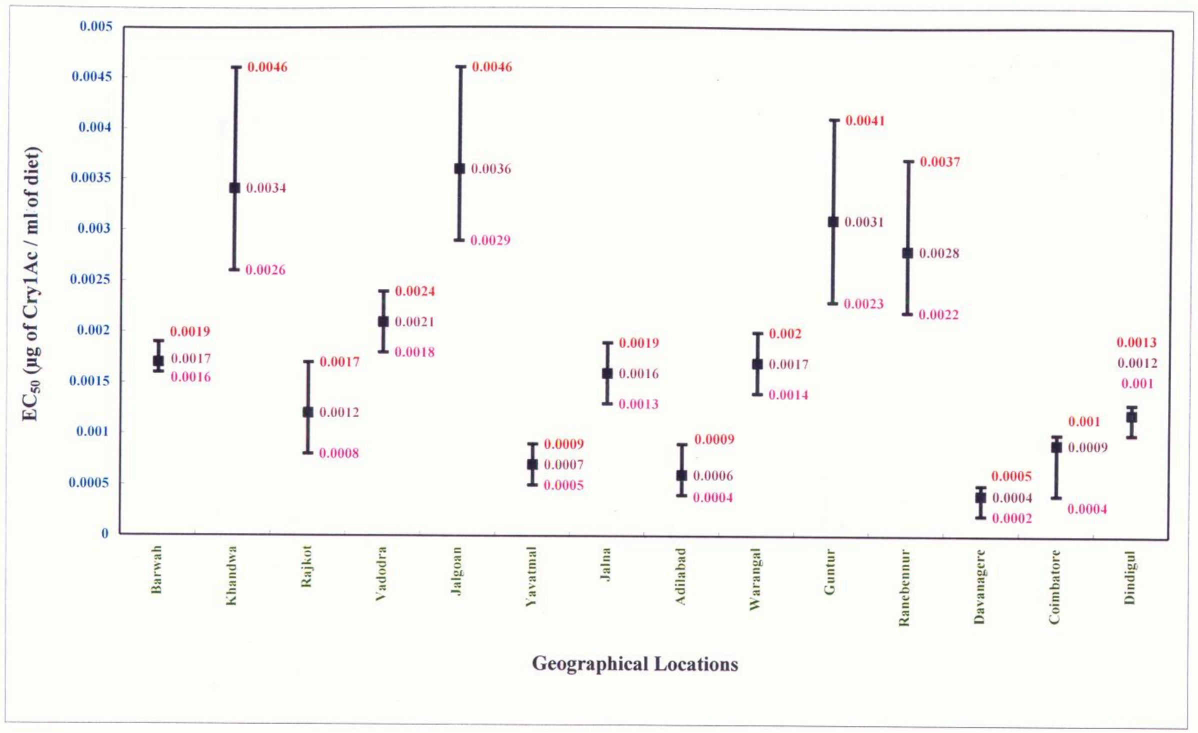

Fig. 11. EC_{50} values for neonates of 14 different populations of *Helicoverpa armigera* to *Bacillus thuringiensis* Cry1Ac protein (box showing mean value and bars showing range values)

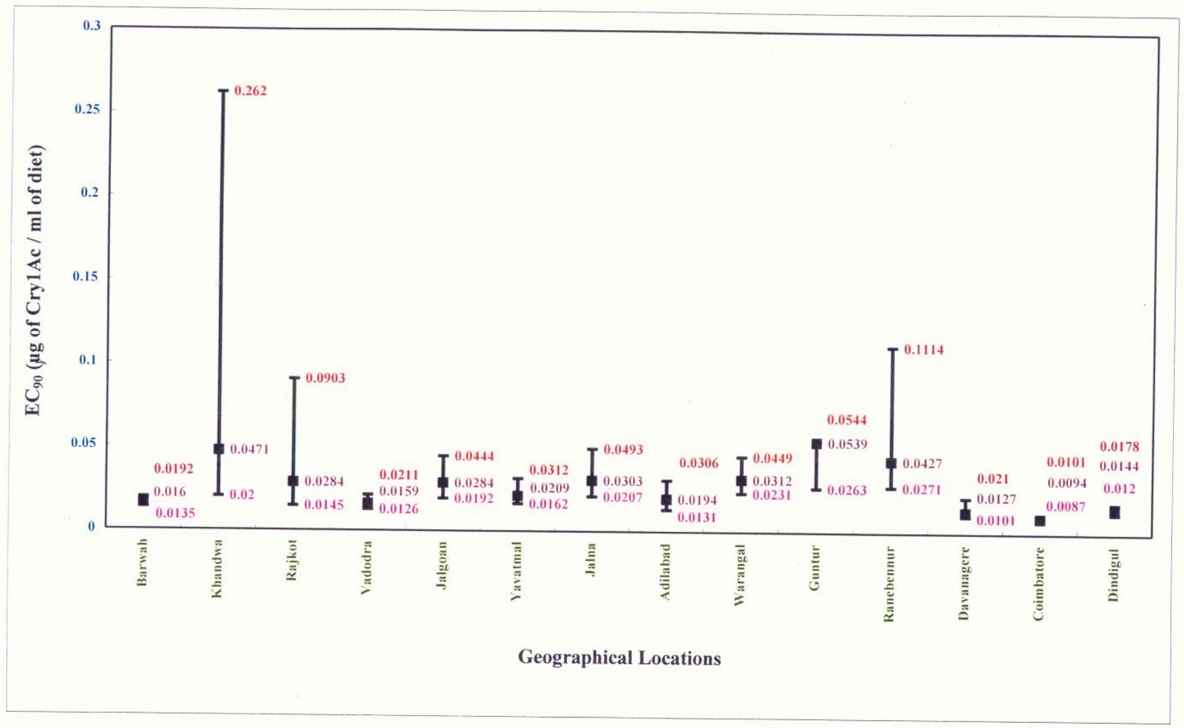

Fig. 12. EC$_{90}$ values for neonates of 14 different populations of *Helicoverpa armigera* to *Bacillus thuringiensis* Cry1Ac protein (box showing mean value and bars showing range values)

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The break up of Rs. 4.00 lakhs received from Mahyco, Mumbai for screening of *Bt* Cry1Ac protein against 14 locations of *Helicoverpa armigera* as consultancy service

Sl. No.	Item	Amount (Rs.)
1.	Recurring charges (including diet ingredients, repair / servicing of equipment (s), if any, etc.	58,000/=
1.1	Collection charges @ Rs. 500/= in one location x 14 locations	7,000/=
1.2	Vehicle hiring charges @ Rs. 1,000/= in one location x 14 locations	14,000/=
1.3	Printing of report (including cartridge, xerox paper, report binding, etc.)	6,000/=
2.	Salary	30,000/=
3.	Travelling allowance	25,000/=
4.	Institutional charges for consultancy service	50,000/=
5.	Consultancy charges	1,50,000/=
6.	Equipments including bioassay trays, pull'N peel tabs (Covers Bio CV – 16)	60,000/=
	Total =	**4,00,000/=**