LARVICIDAL EFFECTS OF SOME PLANT SEED EXTRACTS ON *Anopheles annularis* Vander Wulp AND *Culex quinquefasciatus* Say (DIPTERA: CULICIDAE)

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Abstract

Larvicidal effects of distilled water, 50% ethyl alcohol, acetone and methanol extracts on seed of four plants viz. *Sinapis alba* (Linn.), *Carica papaya* (Linn.), *Momordica charantia* (Linn.) and *Capsicum annuum* (Linn.) were studied upon the mosquito larvae of *Anopheles annularis* Vander Wulp and *Culex quinquefasciatus* Say under normal laboratory conditions with average temperature and relative humidity of 31.1°C and 57.6%, respectively. Percentage mortality, probit mortality, chi-square and ANOVA values for the larvae, extracts and concentrations were calculated for 24 hours exposure period. Mortality was dose dependent. The values of LC_{50} of the seeds of *S. alba* on *An. annularis* at the application doses for the distilled water, 50% ethyl alcohol, acetone and methanol extracts were 3431.791, 1038.363, 1254.810 and 2269.975 ppm, respectively; for *C. papaya* were 804.008, 403.294, 597.165 and 573.241 ppm, respectively; for *M. charantia* were 10593.241, 5017.710, 5650.191 and 6075.204 ppm, respectively; and for *C. annuum* were 1274.968, 4637.201, 1604.852 and 1905.692 ppm, respectively. The values of LC_{50} of *S. alba* seeds on *Cx. quinquefasciatus* at the application doses for the distilled water, 50% ethyl alcohol, acetone and methanol extracts were 1415.311, 432.996, 569.701 and 770.250 ppm, respectively; for *C. papaya* were 705.599, 385.688, 341.003 and 481.067 ppm, respectively; for *M. charantia* were 7764.154, 4496.464, 5353.759 and 5825.031 ppm, respectively; and for *C. annuum* were 2173.631, 1311.538, 78.748 and 182.869 ppm, respectively. Of the four plant seed extracts, *C. papaya* seed extracts were the most toxic for both the mosquito species.

***Key words*:** Larvicide; Seed extracts; LC_{50}; *Anopheles annularis*; *Culex quinquefasciatus*.

INTRODUCTION

Mosquitoes are the most prominent group of insects belonging to the order Diptera. They are small, midge-like flies which comprise the family Culicidae. In Bangladesh, altogether 113 species including 34 Anophelins and 79 Culicins have so far been recorded by different workers (Ahmed 1987). The females of many species of mosquitoes are blood sucking and vectors of some dangerous diseases, such as malaria, dengue fever, filariasis, schistosomiasis and Japanese encephalitis. Mosquito-borne diseases have an economic impact, including loss in commercial and labor particularly in countries with tropical and sub-tropical climates.

Mosquito control is a difficult task and is becoming even more so due to a variety of factors including the development of insecticidal resistance and concern over environmental pollution and many of them are immune suppressants. Historically, the most effective mosquito control is larvicides, applied directly to water source.

The control of mosquito larvae worldwide depends primarily on continued applications of synthetic chemicals including organophophates. Plants are the promising alternative source for the control of insect pests to replace conventional synthetic insecticides because they bio-synthesize a diverse array of low molecular weight PSMs (Plant Secondary Metabolites) or specialized metabolites. Certain plant species have proved efficacy as larvicides against different species of mosquitoes (Mansour *et al.* 1998).

Studies have been reported on the toxicological effects of plant extracts on mosquito larvae around the world (Aina *et al*. 2009, Chanbunjong *et al*. 2010, El-Sheikh *et al*. 2011, Kamaraj *et al*. 2011, Shaktivadivel *et al*. 2012, Sasanti *et al*. 2014, Thangaraj *et al*. 2014). In Bangladesh, study on botanical control of mosquito larvae is limited. The available works on this aspect are those of Ameen *et al*.

(1983a, b), Ameen *et al*. (1985), Hossain *et al*. (1998), Zannat *et al.* (2007), Nikkon *et al*. (2009), Bhuiyan (2013), Nika (2015), Khan *et al*. (2016, 2017) and Nasiruddin *et al.* (2018).

The present paper is directed particularly at determining the use of seed extracts of four plants, namely *Sinapis alba* (Linn.), *Carica papaya* (Linn.), *Momordica charantia* (Linn.) and *Capsicum annuum* (Linn.) in controlling mosquito larvae of *Anopheles annularis* Vander Wulp and *Culex quinquefasciatus* Say.

MATERIAL AND METHODS

The study was carried out in the Entomology Research Laboratory (Average temperature 31.1^{o}C and average relative humidity 57.6%) of Zoology Department, Chittagong University with a view to find out the larvicidal effects of seed extracts of four plants against the larvae of two mosquito species, *Anopheles annularis* and *Culex quinquefasciatus*.

Preparation of seeds

The seeds of the four plants, viz. *Sinapis alba* (English name: White mustard, Family: Brassicaceae), *Carica papaya* (English name: papaya, Family: Caricaceae), *Momordica charantia* (English name: bitter melon, Family: Cucurbitaceae), and *Capsicum annuum* (English name: chili pepper, Family: Solanaceae) were collected from local seed markets except *C. papaya*. For the experimental purpose, the experimental seeds were ground in an electric grinder, and the seed powder was sieved through a sieve of mesh size 0.0025 cm^2.

Maintenance of the experimental mosquito larvae

Anopheles annularis and *Culex quinquefasciatus* larvae were collected from nearby small temporary rain pools and drains, respectively. The larvae were collected in a plastic bowl with a hand sieve and brought to the laboratory and then reared in a glass jar. Third or fourth instar mosquito larvae were obtained from the rearing jar. After being acclimatized in the laboratory condition, the healthy and fresh mosquito larvae were taken for experiments.

Extraction of dry seeds and preparation of doses

Ten grams of dry seed powder were extracted with 100 ml of the distilled water, 50% ethyl alcohol, acetone and methanol solvents separately. For each solution required amount of dry seed powder was taken in a 500 ml conical flask and required amount of solvent was poured into the flask and closed with a cork stopper. The flask was shaken vigorously for 3-4 hours on a magnetic stirrer to ensure maximum extraction of toxic components of the seed powder. After mixing, the resultant liquid was filtered through Whatman filter paper No. 1. The filtrate solution obtained was designated as 'Stock solution'. For each set of experiment a certain (calculated) volume of the stock solution was added to the certain volume of tap water so that final volume in the experimental beakers was always 250 ml in each of the doses and replicates as suggested by APHA (2005).

Bioassay

The bioassays were run in 18 glass beakers, each containing 250 ml of tap water and extract and run for a period of 24 hours. Five concentrations of each extract after preliminary screenings were taken in the final experiments. A set of ten mosquito larvae was released in each dose concentration; three replications were used for each dose concentration. The test mosquito larvae were exposed to the extracts for the stipulated exposure period. The beakers were netted on top. Larval mortality counts were taken after 24 hours.

Data analysis

The data were analyzed statistically by probit analysis following Finney (1971) where LC_{50} values were calculated using a computer based probit analysis program. The values of chi-square (χ^2) were determined as suggested by Fisher and Yates (1963) using experimental data of expected and observed numbers killed and then compared with the tables of statistics for (n-1) degrees of freedom at 1% level of significance. One-way ANOVA was done and compared with the tables of statistics for (n-1) degrees of freedom at 1% level of significance.

RESULTS

The mosquito larvae were exposed to different concentrations of the experimental seed extracts and the achieved mortality range, the slope line equation, chi-square values, the ANOVA values of the different extracts are shown in Table 1 for *An. annularis* and Table 2 for *Cx. quinquefasciatus* larvae.

Table 1. Toxicities of the extracts of *Sinapis alba, Carica papaya, Momordica charantia* and *Capsicum annuum* seeds on *Anopheles annularis* larvae exposed for 24 hours.

Seeds	Solvent	Dose Range (ppm)	Mortality Range (%)	Estimated slope line value	Chi-square value	ANOVA value (Treatment)	ANOVA value (Replication)
Sinapis alba	Distilled water	2000-6000	16.67-96.67	5.466x-14.31	22.100 P<0.01	46.138 P<0.01	1.116 P>0.01
	50% ethyl alcohol	500-1700	10.00-96.67	5.489x-11.53	19.079 P<0.01	95.830 P<0.01	1.217 P>0.01
	Acetone	800-2000	13.33-93.33	6.323x-14.61	4.119 P>0.01	200.599 P<0.01	13.772 P<0.01
	Methanol	2000-3000	23.33-96.67	10.13x-28.72	8.372 P>0.01	52.420 P<0.01	1.383 P>0.01
Carica papaya	Distilled water	350-1550	13.33-93.33	2.200x-1.471	17.120 P<0.01	92.272 P<0.01	2.363 P>0.01
	50% ethyl alcohol	150-950	13.33-93.33	3.374x-3.793	13.066 P>0.01	275.706 P<0.01	7.428 P>0.01
	Acetone	200-1000	6.67-83.33	3.529x-4.806	9.030 P>0.01	70.249 P<0.01	0.167 P>0.01
	Methanol	250-1050	13.33-86.67	1.591x-0.651	31.670 P<0.01	78.670 P<0.01	1.550 P>0.01
Momordica charantia	Distilled water	9000-13000	13.33-96.67	13.15x-48.16	26.928 P<0.01	87.446 P<0.01	0.545 P>0.01
	50% ethyl alcohol	4500-5700	13.33-90.00	8.908x-27.76	28.544 P<0.01	70.160 P<0.01	1.385 P>0.01
	Acetone	5000-6200	13.33-80.00	25.39x-90.30	8.709 P>0.01	107.670 P<0.01	2.153 P>0.01
	Methanol	5500-6700	13.33-90.00	18.21x-63.92	11.431 P>0.01	39.183 P<0.01	0.090 P>0.01
Capsicum annuum	Distilled water	1900-2500	13.33-90.00	19.9x-61.44	4.321 P>0.01	49.105 P<0.01	1.263 P>0.01
	50% ethyl alcohol	1100-1500	6.67-93.33	19.08x-54.47	3.419 P>0.01	242.214 P<0.0.01	7.108 P>0.01
	Acetone	1400-1800	6.67-96.67	8x-20.62	57.935 P<0.01	137.858 P<0.01	2.250 P>0.01
	Methanol	1800-2000	10.00-93.33	75x-240.97	13.040 P>0.01	105.988 P<0.01	0.210 p>0.01

Effects of the extracts of *S. alba, C. papaya, M. charantia* and *C. annuum* seeds on *An. annularis*:

The mortality range of *An. annularis* larvae for *S. alba, C. papaya, M. charantia* and *C. annuum* seed extracts varied from 10.00-96.67%, 6.67-96.67%, 13.33-96.67% and 6.67-96.67%, respectively. Chi square values at 0.01 level of significance showed that most of the extracts had insignificant values except the distilled water and 50% ethanol extracts of *S. alba* and *M. charantia*, distilled water and methanol extracts of *C. papaya* and acetone extract of *C. annuum* seeds. ANOVA test showed that all the treatment values were significant and the replicate values were insignificant with all the seed extracts at 0.01 level excepting acetone extract of *S. alba* seeds for *An. annularis.*

Table 2. Toxicities of the extracts of *Sinapis alba, Carica papaya, Momordica charantia* and *Capsicum annuum* seeds on *Culex quinquefasciatus* larvae exposed for 24 hours.

Seeds	Solvent	Dose Range (ppm)	Mortality Range (%)	Estimated slope line value	Chi-square value	ANOVA value (Treatment)	ANOVA value (Replication)
Sinapis alba	Distilled water	500-4000	6.67-93.33	2.922x-4.198	2.840 P>0.01	2.495 P>0.01	0.428 P>0.01
	50% ethyl alcohol	250-650	13.33-96.67	6.361x-11.76	16.500 P<0.01	67.870 P<0.01	0.516 P>0.01
	Acetone	350-950	23.33-96.67	4.776x-8.193	13.093 P>0.01	72.727 P<0.01	2.363 P>0.01
	Methanol	500-1500	16.67-96.67	2.626x-2.393	32.017 P<0.01	73.817 P<0.01	2.363 P>0.01
Carica papaya	Distilled water	250-1250	6.67-86.67	3.595x-5.239	4.118 P>0.01	82.540 P<0.01	0.540 P>0.01
	50% ethyl alcohol	100-800	6.67-90,.00	3.135x-3.119	8.574 P>0.01	479.240 P<0.01	1.380 P>0.01
	Acetone	150-900	10.00-96.67	3.653x-4.242	12.302 P>0.01	90.565 P<0.01	0.999 P>0.01
	Methanol	200-1000	13.33-93.33	3.359x-3.975	8.060 P>0.01	78.670 P<0.01	7.110 P>0.01
Momordica charantia	Distilled water	6000-10000	6.67-96.67	14.32x-50.88	13.017 P>0.01	124.110 P<0.01	1.550 P>0.01
	50% ethyl alcohol	4000-5200	13.33-96.67	20.41x-69.57	4.805 P>0.01	516.630 P<0.01	9.250 P<0.01
	Acetone	4950-5950	10.00-96.67	40.76x-146.91	5.250 P>0.01	61.630 P<0.01	0.545 P>0.01
	Methanol	5200-6400	13.33-83.33	17.7x-61.49	9.040 P>0.01	61.630 P<0.01	0.545 P>0.01
Capsicum annuum	Distilled water	400-2200	6.67-96.67	4.353x-8.356	12.410 P>0.01	68.320 P<0.01	0.375 P>0.01
	50% ethyl alcohol	150-950	10.00-96.67	4.052x-5.633	10.960 P>0.01	93.110 P<0.0.01	0.444 P0>0.01
	Acetone	200-1000	10.00-96.67	4.100x-6.030	11.250 P>0.01	137.428 P<0.01	10.120 P<0.01
	Methanol	300-1300	3.33-90.00	4.949x-9.203	2.540 P>0.01	67.726 P<0.01	0.324 p>0.01

Effects of the extracts of *S. alba, C. papaya, M. charantia* and *C. annuum* seeds on *Cx. quinquefasciatus*

The mortality range of *Cx. quinquefasciatus* larvae varied from 6.67-96.67%, 6.67-96.67%, 6.67-96.67% and 3.33-96.67% after treating with *S. alba, C. papaya, M. charantia* and *C. annuum* seed extracts, respectively. Chi square values indicated that all the seed extracts showed insignificant values

except 50% ethyl alcohol and methyl extracts of *S. alba* seeds at 0.01 significance level. ANOVA test showed that all the treatment values were significant excepting the distilled water extract of *S. alba* and all the replicate values were insignificant with all the seed extracts excepting 50% ethyl alcohol extract of *M. charantia* and acetone extract of *C. annuum* seeds at 0.01 level for *Cx. quinquefasciatus* larvae.

In terms of LC_{50} values, the relative potency values of the distilled water, 50% ethyl alcohol, acetone and methanol extracts for *An. annularis* and *Cx. quinquefasciatus* were calculated. The relative potency values in terms of LC_{50} values are given in Table 3 for both the mosquito larvae.

Table 3. The LC_{50} and Relative potency values of the distilled water, 50% ethyl alcohol, acetone and methanol extracts of *S. alba, C. papaya, M. charantia* and *C. annuum* seeds on *An. annularis* and *Cx. quinquefasciatus* larvae.

Seeds	Extracts	*An. annularis*		*Cx. quinquefasciatus*	
		LC_{50} (ppm)	Relative potency	LC_{50} (ppm)	Relative potency
Sinapis alba	Distilled water	3431.791	3.087	1415.311	5.486
	50% ethyl alcohol	1038.363	10.202	432.996	17.931
	Acetone	1254.810	8.442	569.701	13.628
	Methanol	2269.975	4.667	770.250	10.080
Carica papaya	Distilled water	804.008	13.175	705.599	11.004
	50% ethyl alcohol	403.294	26.267	385.688	20.131
	Acetone	573.241	18.479	341.003	22.768
	Methanol	597.165	17.739	481.067	16.139
Momordica charantia	Distilled water	10593.241	1.000	7764.154	1.000
	50% ethyl alcohol	5017.710	2.111	4496.464	1.727
	Acetone	5650.204	1.878	5353.759	1.450
	Methanol	6075.204	1.744	5825.031	1.333
Capsicum annuum	Distilled water	2173.632	4.873	1213.240	6.399
	50% ethyl alcohol	1311.538	8.077	420.967	18.444
	Acetone	1604.852	6.601	490.454	15.830
	Methanol	1905.692	5.559	770.601	10.075

Relative potency values of the extracts on *Anopheles annularis*:

In case of *An. annularis*, it was observed in Table 3 that 50% ethyl alcohol extract of *C. papaya* seeds was the most toxic having lowest LC_{50} value of 403.294 ppm and relative potency value of 26.267 whilst the least toxic was the distilled water extract of *M. charantia* seeds with LC_{50} value 10593.241 ppm and relative potency value 1.00. The relative position of the four extracts of four seeds on the basis of their LC_{50} and relative potency values were in the order: 50% ethyl alcohol extrtact of *C. papaya* > acetone extract of *C. papaya* > methanol extract of *C. papaya* > distilled water extract of *C. papaya* > 50% ethyl alcohol extract of *S. alba* > acetone extract of *S. alba* > 50% ethyl alcohol extract of *C. annuum* > acetone extract of *C. annuum* > methanol extract of *C. annuum* > distilled water extract of *C. annuum* > distilled water extract of *S. alba* > methanol extract of *S. alba* > 50% ethyl alcohol extract of *M. charantia* > acetone extract of *M. charantia* > methanol extract of *M. charantia* > distilled water extract of *M. charantia* . Of the seed extracts, the toxicity of the four plants was in the order: *C. papaya* > *C. annuum* > *S. alba* > *M. charantia*. The toxicity of the solvents of the four seeds was in the order: 50% ethyl alcohol > acetone > methanol > distilled water.

Relative potency values of the extracts on *Culex quinquefasciatus*:

In *Cx. quinquefasciatus*, the most and least toxic extracts were acetone extract of *C. papaya* and distilled water extract of *M. charantia* with LC_{50} values of 341.003 ppm and 7764.154 ppm, respectively and relative potency values 22.768 and 1.0, respectively. The relative position of the four extracts of four seeds, in terms of their LC_{50} and relative potency values, was in the order: acetone extrtact of *C.*

papaya > 50% ethyl alcohol extract of *C. papaya* > 50% ethyl alcohol extract of C. *annuum* > 50% ethyl alcohol extract of *S. alba* > methanol extract of *C. papaya* > acetone extract of *C. annuum* > acetone extract of *S. alba* > distilled water extract of *C. papaya* > methanol extract of *S. alba* > methanol extract of *C. annuum* > distilled water extract of *C. annuum* > distilled water extract of *S. alba* > 50% ethyl alcohol extract of *M. charantia* > acetone extract of *M. charantia* > methanol extract of *M. charantia* > distilled water extract of *M. charantia* (Table 3).

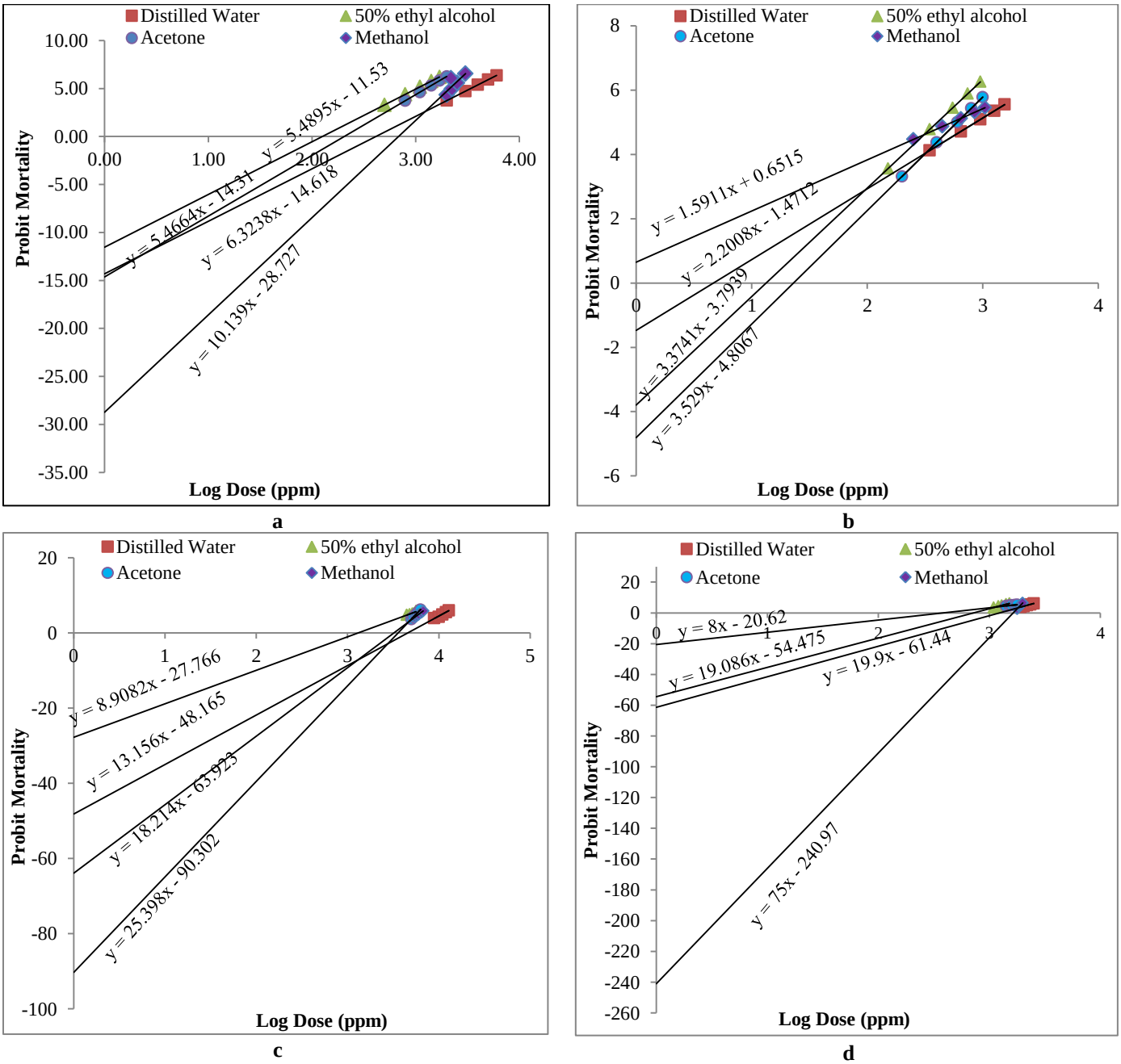

Fig. 1. Regression lines for determining the LC_{50} of distilled water, 50% ethyl alcohol, acetone and methanol extracts of *Sinapis alba* (A), *Carica papaya* (B), *Momordica charantia* (C), and *Capsicum annuum* (D) seeds on *Anopheles annularis* larvae after 24 hours of exposure.

The trend of toxicity of seed extracts of the four experimental plants was in the order: *C. papaya* > *C. annuun* > *S. alba* > *M. charantia*. The trend of toxicity of the four solvents for the four seeds was in the order: 50% ethyl alcohol > acetone > methanol > distilled water excepting *C. papaya* seeds, where, acetone seed extract was more toxic than 50% ethyl alcohol seed extract (Table 3).

During the present study the larvicidal activities of different solvents, such as distilled water, 50% ethyl alcohol, acetone, and methanol extracts of the dry seeds of *S. Alba, C. Papaya, M. Charantia* and *C. annuum* were bioassayed against the third and fourth instar larvae of *An. annularis and Cx. quinquefasciatus*. Their toxicities varied with the dosages and also with experimental plants.

The LC_{50} value of the distilled water extract of *S. alba* seeds on *An. annuularis* was 3431.791 ppm, which was more or less similar to the findings of Bhuiyan (2013) with acetone and methanol extracts of *Polygonum hydropiper* seeds (LC_{50} =3265.356 ppm and LC_{50} =3355.353 ppm, respectively) against *Cx. quinquefasciatus* larvae. The LC_{50} of 50% ethyl alcohol extract of *S. alba* seeds was 1038.363 ppm, somewhat close to the findings of Shaktivadivel *et al.* (2012) with petroleum ether extract of *Cipadessa baccifera* leaf (LC_{50} = 973.32 ppm) against *Cx. pipiens* larvae. The LC_{50} of acetone extract of *S. alba* seeds was 1254.810 ppm, which is quite similar to the findings of Nika (2015) with methanol extract of *Brassica nigra* seeds (LC_{50} = 1396.927 ppm) against *Cx. quinquefasciatus* larvae and the LC_{50} of methanol extract of *S. alba* seeds was 2269.975 ppm, more or less similar to Akter (2009) with 100% ethyl alcohol extract of *Lagestroemia speciosa* seeds (LC_{50} = 2107.05 ppm) against *Cx. quinquefasciatus* larvae.

The LC_{50} value of the distilled water extract of *C. papaya* seeds on *An. annularis* was 804.008 ppm, which was more or less similar to the findings of Shaktivadivel *et al.* (2012) with petroleum ether extract of *Cipadessa baccifera* leaf (LC_{50} = 973.32 ppm) against *Cx. quinquefasciatus* larvae. The LC_{50} of 50% ethyl alcohol extract of *C. papaya* seeds was 403.294 ppm, which is quite similar to the findings of the Bansal *et al.* (2014) with petroleum ether extract of *Cleome viscose* seeds (LC_{50} = 301.9 ppm) against *Cx. quinquefasciatus* larvae. The LC_{50} of acetone extract of *C. papaya* seeds was 597.165 ppm, somewhat close to the findings of Nika (2015) with 50% ethyl alcohol extract of *Cuminum cyminum* seeds (LC_{50} = 543.523 ppm) against *Cx. quinquefasciatus* larvae. The LC_{50} of methanol extract of *C. papaya* seeds was 573.241 ppm, which is more or less similar to the findings of Nika (2015) with 50% ethyl alcohol extract of *Cuminum cyminum* seeds (LC_{50} = 543.523 ppm) against *Cx. quinquefasciatus* larvae.

The LC_{50} value of the distilled water extract of *M. charantia* seeds on *An. annularis* was 10593.241 ppm, which was somewhat close to the finding of Aina *et al.* (2009) with distilled water extract of *Jatropha curcas* seeds (LC_{50} = 12.00 mg/ml= 12000 ppm) against *An. gambiae* larvae. The LC_{50} of 50% ethyl alcohol extract of *M. charantia* seeds was 5017.710 ppm, which was more or less similar to Bhuiya (2013) with the distilled water and 50% ethyl alcohol extract of *Albizzia procera* and *Polygonum hydropiper* seeds (LC_{50} = 4689.829 ppm and LC_{50} = 5030.598 ppm) against *Cx. quinquefasciatus* larvae. The LC_{50} of acetone extract of *M. charantia* seeds was 5650.191 ppm, which was somewhat close to the findings of Akter (2009) with 50% ethyl alcohol extract of *Lagestroemia speciosa* seeds (LC_{50} = 5286.27 ppm) against *Cx. quinquefasciatus* larvae. The LC_{50} of methanol extract of *M. charantia* seeds was 6075.204 ppm, which was nearer to the findings of Nika (2015) with the distilled water extract of *Albizzia lebbeck* seeds (LC_{50} = 6355.342 ppm) against *Cx. quinquefasciatus* larvae.

The LC_{50} value of the distilled water extract of *C. annuum* seeds on *An. annularis* was 2173.632 ppm, which was nearer to the findings of Hossain *et al.* (1998) with ethanol extract of *Azadirachta indica* seeds (LC_{50} = 2100 ppm) against *Cx. quinquefasciatus* larvae. The LC_{50} of 50% ethyl alcohol extract of *C. annuum* seeds was 1311.538 ppm, more or less similar to the findings of Skaktivadivel *et al.* (2012) with ether extract of *Clausena dentate* leaf (LC_{50} = 1435.40 ppm) against *Cx. quinquefasciatus* larvae. The LC_{50} of acetone extract of *C. annuum* seeds was 1604.852 ppm, which was quite similar to the findings of Bhuiyan (2013) with methanol extract of *Albizzia procera* seeds (LC_{50} = 1575.808 ppm) against *Cx. quinquefasciatus* larvae. The

LC_{50} of methanol extract of *C. annuum* seeds was 1905.692 ppm showing similarity with the findings of Nika (2015) with methanol extract of *Trigonella foenum-graecum* seeds (LC_{50} = 1883.852ppm) against *Cx. quinquefasciatus* larvae.

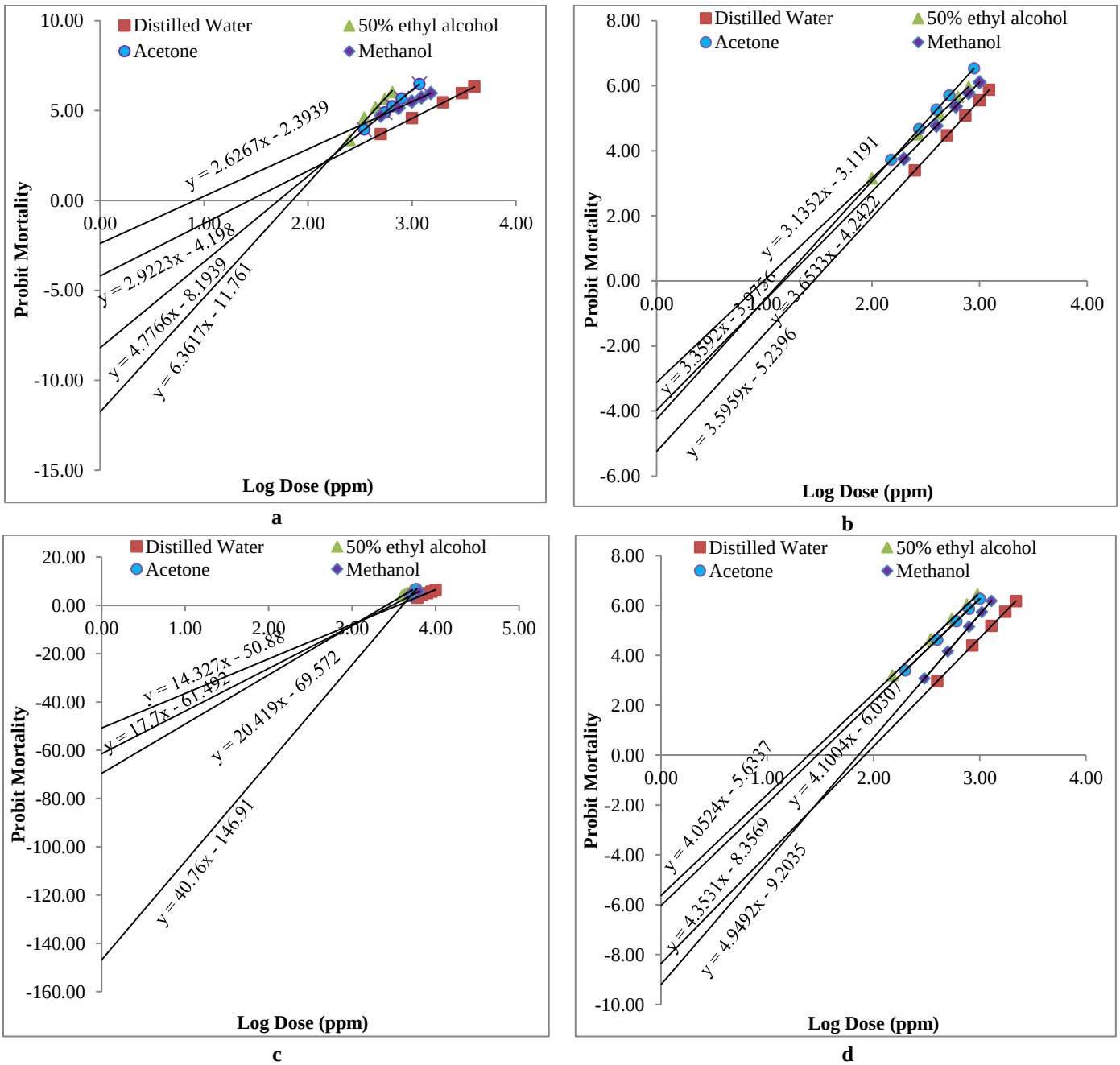

Fig. 2. Regression lines for determining the LC_{50} of distilled water, 50% ethyl alcohol, acetone and methanol extracts of *Sinapis alba* (A), *Carica papaya* (B), *Momordica charantia* (C), and *Capsicum annuum* (D) seeds on *Culex quinquefasciatus* larvae after 24 hours of exposure.

The LC_{50} value of the distilled water extract of *S. alba* seeds on *Cx. quinquefasciatus* larvae was 1415.311 ppm, which was more or less similar to the findings of Skaktivadivel *et al.* (2012) with ether extract of *Clausena dentate* leaf (LC_{50} = 1435.40 ppm) against *Cx. quinquefasciatus* larvae. The LC_{50} of 50% ethyl

alcohol extract of *S. alba* seeds was 432.996 ppm, somewhat close to the findings of Patil *et al*. (2014) with hexane extract of *Gossypium hirsutum* leaf (LC_{50} = 401.03 mg/L =401.03 ppm) against *Ae. aegypti* larvae. The LC_{50} of acetone extract of *S. alba* seeds was 569.701 ppm, quite similar to the findings of Nika (2015) with 50% ethyl alcohol *extract* of *Cuminum cyminum* seeds (LC_{50} = 543.523 ppm) against *Cx. quinquefasciatus* larvae. The LC_{50} of methanol extract of *S. alba* seeds was 770.250 ppm, more or less similar to the findings of Nika (2015) with methanol extracts of *Nigella sativa* seeds (LC_{50} =793.250 ppm) against *Cx. quinquefasciatus* larvae.

The LC_{50} value of the distilled water extract of *C. papaya* seeds on *Cx. quinquefasciatus* was 705.599 ppm, which was more or less similar to Nika (2015) with methanol extract of *Nigella sativa* seeds (LC_{50}=793.981 ppm) against *Cx. quinquefasciatus* larvae. The LC_{50} of 50% ethyl alcohol extract of *C. papaya* seeds was 385.688 ppm, which is quite similar to the findings of Marmimuthu and Mohan (2014) with benzene and hexane extracts of *Pithecellobium dulce* seeds (LC_{50} = 303.22 mg/L = 303.22 ppm and LC_{50} = 322.80 mg/L= 322.80 ppm, respectively) against *Cx. quinquefasciatus* larvae. The LC_{50} of acetone extract of *C. papaya* seeds was 341.003 ppm, somewhat close to the findings of Remia and Logaswamy (2010) with acetone extract of *Lantana camara* leaf (LC_{50} = 356.70 ppm) against *Ae. aegypti* larvae. The LC_{50} of methanol extract of *C. papaya* seeds (481.067 ppm) was more or less similar to the findings of Patil *et al.* (2014) with ethyl acetate extract of *Gossypium hirsutum* leaf (LC_{50} = 401.03 mg/L = 404.03 ppm) against *Ae. aegypti* larvae.

The LC_{50} value of the distilled water extract of *M. charantia* seeds on *Cx. quinquefasciatus* larvae was 7764.154 ppm which was somewhat close to the findings of Akter (2009) with the distilled water extract of *Swietenia mahogoni* seeds (LC_{50} = 6209.98 ppm) against *Cx. quinquefasciatus* larvae. The LC_{50} of 50% ethyl alcohol extract of *M. charantia* seeds was 4496.464 ppm, which was more or less similar to the findings Bhuiya (2013) with the distilled water extract of *Albizzia procera* seeds (LC_{50} = 4689.829 ppm) against *Cx. quinquefasciatus* larvae. The LC_{50} of acetone extract of *M. charantia* seeds was 5353.759 ppm, which was nearer to the findings of Akter (2009) with 50% ethyl alcohol extract of *Lagestroemia speciosa* seeds (LC_{50} =5286.27 ppm) against *Cx. quinquefasciatus* larvae. The LC_{50} of methanol extract of *M. charantia* seeds was 5825.031 ppm, which was nearer to the findings of Nika (2015) with distilled water extract of *Albizzia lebbeck* seeds (LC_{50} = 6355.342 ppm) against *Cx. quinquefasciatus* larvae.

The LC_{50} value of the distilled water extract of *C. annuum* seeds on *Cx. quinquefasciatus* larvae was 1213.240 ppm, which was quite similar to the findings of Nika (2015) with methanol extract of *Brassica nigra*, seeds (LC_{50} = 1396.927 ppm) against *Cx. quinquefasciatus* larvae. The LC_{50} of 50% ethyl alcohol extract of *C. annuum* seeds was 420.967 ppm, more or less similar to the findings of Remia and Logaswamy (2010) with acetone extract of *Lantana camara* leaf (LC_{50} = 356.70 ppm) against *Ae. aegypti* larvae. The LC_{50} of acetone extract of *C. annuum* seeds was 490.967 ppm, quite similar to the findings of Patil *et al.* (2014) with hexane extract of *Gossypium hirsutum* leaf (LC_{50} = 401.03 mg/L = 401.03 ppm) against *Ae. aegypti* larvae. The LC_{50} of methanol extract of *C. annuum* seeds was 770.601 ppm, showing similarity with of the findings of Nika (2015) with methanol extract of *Nigella sativa* (LC_{50} = 793.981ppm) against *Cx. quinquefasciatus* larvae.

The present finding has important implications on the practical control of mosquito larvae in polluted aquatic ecosystems. In view of residue problem in the environment and the development of insect resistance to synthetic insecticides, the recent trend is to explore plants to obtain the extracts that do not pose any residue problem, but are able to suppress unwanted populations. Further research will lead to improve formulations with enhanced activity which may become environmentally acceptable and replace objectionable conventional insecticides for mosquito control.

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