Larvicidal action of Nux-vomica (Strychnus nux-vomica L.) against Diamond back moth (Plutella xylostella L.)

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Abstract: The present investigation reports on larvicidal efficacy of plant extracts of Nux-vomica, Strychnus nux-vomica against Diamond back moth (DBM). In this investigation shade dried and powdered nux-vomica plant samples (leaves, root bark, stem bark, seed and fruit rind) were extracted with organic solvents ethanol, methanol, acetone, hexane and chloroform and also formulated as Emulsifiable Concentrates (EC) using surfactant and solvents. This formulated plant extracts were tested against third instar larvae of DBM for larvicidal efficacy using leaf disc bioassay method under laboratory condition. Among the five solvent extracts tested, hexane extracts of root bark 11.11 EC @ 2 % showed highest larval mortality of 76.66 % followed by seed 14.25 EC, leaf 16.66 EC, stem bark 12.50 EC and fruit rind 12.50 EC extracts exhibited maximum mortality @ 2 % concentration recording 66.66, 63.33, 56.66 and 40.00 per cent mortality respectively. Positive and negative control such as respective solvent and water showed 10.00 and 3.33 % larval mortality respectively. The results of these experiment clearly indicate that nux-vomica plant possess promising larvicidal action against diamond back moth.

Keywords: Alkaloids, larvicidal action, Nux-vomica, Solvent extracts, Plutella xylostella

INTRODUCTION

Cauliflower is important cruciferous vegetable grown in India with an area of 4,33,870 hectares (Anonymous, 2016). Diamond back moth (DBM) is notorious pest of cauliflower (NIPHM, 2014). An estimate of the total cost associated with damage and management of DBM worldwide was 4-5 billion USD per annum (Zalucki et al., 2012). In India Krishnamoorthy (2004) reported 52% yield loss in crucifers due to Diamond Back Moth. Management of this pest has become a remarkable task and farmers apply chemical pesticides once in a week for the effective management of this pest. However indiscriminate use of chemicals has resulted in problems like resurgence, resistance, replacement, impact on non-target organisms, including humans, environmental pollution. Sole reliance on insecticides has facilitated rapid build-up of resistance in the multivoltine DBM, which undergoes 20 generations a year in the tropics (Talekar and Shelton, 1993). To overcome resistance in DBM to insecticides, farmers often increase the doses of insecticides when insecticides alone account for between 30 and 50 per cent of the total cost of production and health problems with farmers were also common in states where these crops are grown (Weinberger and Srinivasan, 2009). Increasing awareness about the deleterious effects of insecticides. Now farmers and researchers are switching over to botanical pesticides, which overcome many problems associated with chemical insecticides especially in the vegetables. In nature more than 1800 plant species are reported to have biopesticidal properties (Grainge et al., 1984). Our present studies in Nux-vomica (Strychnus nux-vomica) belongs to the family Loganiaceae commonly known as poison nut, snake wood, strychnine tree, quaker buttons andyetti. It has alkaloids such as strychnine, brucine, vomicine etc. The alkaloids content also varies according to plant parts. Seeds of nux-vomica contain 0.4 and 0.6 % strychnine and brucine, respectively. Other parts of the tree have varying percentage of these two alkaloids viz., 1.7 and 2.8 % in root bark, 0.3 and 0.4 % in rootwood, 0.9 and 2.1 % in stem bark, 0.5 and 0.01 % in stem wood and 0.2 and 0.5 % in leaves, respectively (Bisset et al. 1976) By keeping above aspects in mind, experiments were conducted to test the larvicidal efficacy of organic solvent extracts of different plant samples of nux-vomica against Diamond back moth Plutella xylostella L..

MATERIALS AND METHODS

Collection and processing of plant samples: Details on availability of Strychnus nux-vomica L. were collected from Botanical Survey of India (BSI), Coimbatore in Tamil Nadu. Different plant parts viz., leaves, seeds, stem bark, root bark and fruit rind of S. nux-vomica were collected from drought prone area of Krishnagiri district of Tamil Nadu. Fresh leaves, stem bark, root bark, fruits...
and seeds each weighing almost 3 kg were collected from the trees and brought to the laboratory (Plate 1). The plant samples were shade dried in the Entomology laboratory, TNAU, Coimbatore up to two weeks and grind into fine powder and packed in 3 kg plastic containers separately for further usage.

**Extraction of active principles from plant samples:**
Dry powders of plant samples were packed in filter paper made 20 cm × 4.5 cm size cylindrical thimbles. The samples filled thimbles were kept in the cylindrical sample holder present in the Soxhlet apparatus and filled with organic solvents such as ethanol, methanol, acetone, hexane and chloroform individually. Plant samples were extracted with organic solvents. When organic solvents mixed with plant samples it produced coloured solution, extraction was done upto this coloured solution became transparent. During extraction process temperature maintenance was an essential task. Over temperature leads to explosion. Temperature ranges vary according to the solvents used for extraction process, temperature maintained during extraction process were viz., ethanol (79°C), methanol (65°C), acetone (56°C), hexane (69°C), chloroform (61°C). This extraction process has taken approximately 12-18 h for each samples. The extracts were collected in 50 ml screw capped vials and excess solvents evaporated in hot water bath (65°C) and concentrated extracts stored at 4°C for further usage by following Yadav et al. (2014) with slight modification.

**Preparation of EC formulation:** Two fifty milliliter capacity beaker was kept in electronic balance, tared the weight of plastic container and 1 g of crude extract was transferred to plastic containers from screw cap vials. Suggested EC formulation solvent cyclohexane added drop by drop to the crude extract using micropipette, till crude extract completely soluble in the solvent. Then 1 ml of surfactant such as tween 20 or triton X added to the solution. EC formulation must be stable upto 15 min and give milky appearance when dissolved in water. This test was carried out by transferring 1 ml of EC solution to 50ml test tube filled with water. Observation was done after 15 min for whether particles float or settle downside rather it completely miscible. If sometimes particles does not miscible, instead floated on surfaces, in this case experiment was carried out again. Finally EC formulations were brought to insectary, dissolved to needed concentration with water and progressed the bioassay.

**Mass culturing of diamond back moth in laboratory:**
The culture was started from field collected larvae and maintained on cauliflower leaves, in the laboratory at 27 ± 2°C. The plastic cups were kept inversely, on those cups fresh cauliflower leaves were placed. Entire larval period, larvae were fed with enough amount of cauliflower leaves by frequently changing the leaves day by day. When the larvae pupate in the leaf, the pupae was collected using brush in a petriplate and placed in moth emergence cage, into which the cabbage leaves or mustard seedlings grown in disposable cups and 10 per cent honey solution was provided. The emerging adults were started to laying eggs in large numbers in the mustard seedlings or cabbage leaves. Fresh mustard seedlings/leaves were provided for egg laying. The neonate larvae was transferred into the cabbage leaves by gentle tapping and also by placing the cabbage leaves nearer to the mustard seedlings (with touching) upon which the eggs were laid. The larvae were provided with fresh leaves daily and pupae were collected and placed in moth emergence cage to continue the cycle.

**Larvicidal bioassay:** Leaf-dip bioassay as per Tabashnik et al. (1991) was employed for larvicidal bioassay. Cauliflower leaves were first washed with distilled water and air-dried. Leaf disc of 9 cm diameter were cut and dipped in different concentrations viz., 0.5, 1, 1.5 and 2% of extracts of *S. nux-vomica* EC formulations. Each disc was dipped for 10-20 seconds and allowed to air-dry for a period of one hour. After complete evaporation, the leaves were transferred to clean bioassay containers over a moistened filter paper. The leaf discs were placed slantingly to rest on side of the container so that larvae can move on either side. Ten 3rd instar larvae (~0.8mg) of diamond back moth (*P. xylostella*) were released in each disc and three replicates were maintained per treatment. A treatment water alone served on to negative control and pure solvents at different concentration act as a positive control. Larval mortality was recorded every 24 h, consecutively for 3 days. All the experiments were carried out in a room temperature with a photoperiod of 12:12 (L:D) and experiments with control mortality more than 20% were discarded and repeated.
In the same way larvicidal bioassay were conducted in addition to ethanol, solvents extracts of methanol, acetone, hexane and chloroform also conducted. Per cent larval mortality was calculated by following (Arivoli and Tennyson, 2013).

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\text{Per cent larval mortality} = \frac{\text{Number of dead larvae}}{\text{Total number of treated larvae}} \times 100
\]

In larvicidal bioassay experiments few larvae were died naturally. This natural mortality were corrected using standard formula given by (Abbots, 1925).
RESULTS AND DISCUSSION

The data summarized on table 1,3,5,7 and 9 represents Larvicidal effect of hexane extracts of Strychnus nux-vomica Linn. in laboratory. Larvae mortality was recorded in hexane extracts of nux-vomica root bark, 11.11 EC @ 2 % concentration which is 76.66 % followed by seed 14.25 EC, leaf 12.50 EC and fruit rind 12.50 EC which is 76.66 % followed by seed 14.25 EC, leaf 12.50 EC and fruit rind 12.50 EC respectively. In all plant samples order of efficacy was leaf, stem bark, fruit rind, seed, root bark, water alone, which is followed by seed (1.07 %), leaf (1.34 %), stem (1.75 %) and fruit rind (2.78 %) at 2 % concentration of formulations (Tables 1,3,5,7 and 9) (fig. 1).

Among five plant samples tested for bioefficacy study, hexane extracts of nux-vomica root bark samples was found to be more effective with LC50 value of 0.85 % which is followed by seed (1.07 %), leaf (1.34 %), stem (1.75 %) and fruit rind (2.78 %) at 2 % concentration of formulations (Tables 2,4,6,8 and 10). This larval mortality in control and treatment was determined by Finney’s probit analysis (Finney, 1971). The corrected per cent mortality was worked out using the formula given by Abbots, 1925.

Corrected mortality = \( \frac{(P - P_0)}{(100 - P_0)} \times 100 \)

Where,
- P0 - Larvae mortality in control
- P - Larvae mortality in treatment

Statistical analysis: The data obtained from laboratory experiments were analyzed in completely randomized design (CRD) (Gomez and Gomez, 1984). The mean values were separated using Least square Difference (LSD). The median lethal dose (LD50) and Median lethal concentration (LC50) of insecticides used were determined by Finney’s probit analysis (Finney, 1971). The corrected per cent mortality was separated using Least square Difference (LSD) (0.05); Values in the parenthesis are arc sine transformed values.

Table 1. Larvicidal effect of EC formulation of S. nux-vomica ethanolic extracts against Plutellaxylostella Linn. in laboratory.

| Treatments | 0.5% | 1% | 1.5% | 2% |
|------------|------|----|------|----|
| Leaf       | 06.66 | 06.66 | 30.00 | 43.33 |
| Root bark  | 06.66 | 06.66 | 30.00 | 43.33 |
| Stem bark  | 06.66 | 06.66 | 30.00 | 43.33 |
| Fruit rind | 06.66 | 06.66 | 30.00 | 43.33 |
| Seed       | 06.66 | 06.66 | 30.00 | 43.33 |
| Solvent    | 06.66 | 06.66 | 30.00 | 43.33 |
| Water      | 06.66 | 06.66 | 30.00 | 43.33 |
| SE (01)    | 06.66 | 06.66 | 30.00 | 43.33 |
| SE (02)    | 06.66 | 06.66 | 30.00 | 43.33 |

Table 1. Larvicidal effect of EC formulation of S. nux-vomica ethanolic extracts against Plutellaxylostella Linn. in laboratory.

Larvae mortality in control and treatment was determined by Finney’s probit analysis (Finney, 1971). The corrected per cent mortality was worked out using the formula given by Abbots, 1925. Corrected per cent mortality = P - P0 / 100-Pc x 100

Where,
- P0 - Observed mortality in control
- P - Observed mortality in treatment
- Pc - Observed mortality in untreated check

### References

1. Abbots, 1925.
2. Gomez, L. and Gomez, A. (1984). Statistical procedures for agricultural research. John Wiley and Sons, New York.
3. Finney, D. J. (1971). Probit analysis, 3rd ed. Cambridge University Press, Cambridge.

### Observations

Observations are mean of three replications. In column, means followed by common letters are not significantly different by LSDP (0.05); Values in the parenthesis are arc sine transformed values.
Table 2. Probit regression analysis of mortality data of *P. xylostella* treated with EC formulations of *S. nux-vomica* ethanol extracts.

| Treatments          | No. of larvae used | LC_{50} (%) | Fiducial limits (%) | X^2 (cal) | Regression equation | Order of efficacy |
|---------------------|--------------------|-------------|---------------------|-----------|----------------------|------------------|
|                     |                    | lower      | Upper               |           |                      |                  |
|                     |                    | LC_{95}    | (%)                 |           |                      |                  |
| Leaf (22.22 EC)     | 30                 | 2.21       | 1.27                | 3.84      | 2.86                 | 198.01           | 0.051 | Y=4.45+1.55X | 3     |
| Root bark (12.55 EC)| 30                 | 1.36       | 0.95                | 1.94      | 14.99                | 2.61             | 86.12 | 0.12 | Y=4.78+1.58X | 1     |
| Stem bark (12.55 EC)| 30                 | 3.15       | 1.36                | 7.27      | 38.82                | 2.53             | 594.77 | 0.81 | Y=4.24+1.44X | 4     |
| Seed (12.55 EC)     | 30                 | 2.00       | 1.24                | 3.21      | 19.15                | 2.94             | 123.69 | 0.24 | Y=4.49+1.63X | 2     |
| Fruit rind (10.00 EC)| 30                | 12.74      | 0.64                | 251.45    | 402.90               | 0.28             | 570.186.83 | 0.182 | Y=3.79+1.07X | 5     |
| Water               | 30                 | ***        | ***                 | ***       | ***                  | ***              | ***    | *** | ***          |       |

Table 3. Larvicidal effect of EC formulations of *S. nux-vomica* methanol extracts against *P. xylostella* in laboratory.

| Treatments          | 0.5 %  | 1 %     | 1.5 %    | 2 %     |
|---------------------|-------|--------|---------|--------|
|                     | 24 h  | 48 h   | 72 h    | 24 h   |
|                     | 48 h  | 72 h   | 24 h    | 48 h   |
|                     | 72 h  | 24 h   | 48 h    | 72 h   | 24 h | 48 h |
| Leaf (16.66 EC)     | 06.66 | 10.00  | 16.66   | 06.66  | 16.66| 26.66| 16.66| 26.66| 36.66| 23.33| 33.33| 46.66 |
| Root bark (12.55 EC)| (14.95)^a | (18.43)^b | (24.04)^c | (14.95)^d | (24.04)^e | (31.08)^f | (24.04)^g | (31.04)^h | (37.22)^i | (28.88)^j | (35.24)^k | (43.08)^l |
| Stem bark (14.25 EC)| (10.51)^m | (14.95)^n | (18.43)^o | (14.95)^p | (21.36)^q | (27.73)^r | (21.38)^s | (26.56)^t | (33.21)^u | (26.56)^v | (31.04)^w | (37.26)^x |
| Seed (11.11 EC)     | (14.95)^y | (18.43)^z | (26.56)^{| | (18.43)^} | (28.86)^~ | (33.21)^_ | (28.86)^` | (33.21)^a | (41.15)^b | (33.21)^c | (39.23)^d | (46.89)^e |
| Fruit rind (14.25 EC)| (10.51)^f | (10.51)^g | (14.95)^h | (10.51)^i | (21.41)^j | (10.51)^k | (18.43)^l | (24.04)^m | (14.95)^n | (21.38)^o | (24.09)^p | (24.09)^q |
| Solvent             | 03.33 | 03.33  | 06.66   | 03.33  | 03.33 | 13.33 | 03.33 | 10.00 | 16.66 | 06.66 | 13.33 | 16.66 |
| Water               | 03.33 | 03.33  | 03.33   | 03.33  | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 |
| SE (d)              | 0.08  | 0.96   | 0.68    | 0.94   | 0.01 | 0.63 | 0.02 | 0.8329 | 0.55 | 0.9284 | 0.56 | 0.78 |
| CD (0.05)           | 01.84* | 01.99* | 01.42*  | 01.95* | 02.11* | 01.31* | 02.12* | 1.732* | 0.15* | 0.17* | 0.164* |

Observations are mean of three replicates; In column, means followed by common letters are not significantly different by LSD (P=0.05); Values in the parenthesis are arc sine transformed values.
### Table 4. Probit regression analysis of mortality data of *P. xylostella* treated with EC formulations of *S. nux-vomica* methanol extracts.

| Treatments                  | No. of larvae used | LC₅₀ (%) | Fiducial limits (%) | Fiducial limits (%) | X² (cal) | Regression equation | Order of efficacy |
|-----------------------------|--------------------|----------|--------------------|--------------------|----------|---------------------|-------------------|
|                            |                    | (%)      | lower              | upper              | lower    | upper               |                   |
| Leaf (16.66 EC)             | 30                 | 2.58     | 1.34               | 4.96               | 28.30    | 2.82                | 283.96            | 0.103             | Y = 4.35 + 1.56X   | 3                 |
| Root bark (12.55 EC)        | 30                 | 1.58     | 1.08               | 2.30               | 15.34    | 2.84                | 88.71             | 0.251             | Y = 4.66 + 1.65X   | 1                 |
| Stem bark (14.25 EC)        | 30                 | 3.25     | 1.46               | 7.24               | 31.57    | 2.72                | 368.34            | 0.607             | Y = 4.12 + 1.76X   | 4                 |
| Seed (11.11 EC)             | 30                 | 2.17     | 1.24               | 3.79               | 24.98    | 2.74                | 227.23            | 0.136             | Y = 4.48 + 1.52X   | 2                 |
| Fruit rind (14.25 EC)       | 30                 | 9.08     | 0.98               | 83.70              | 138.31   | 0.74                | 255575.18         | 0.098             | Y = 3.65 + 1.44X   | 5                 |
| Water                       | 30                 | ***      | ***                | ***               | ***      | ***                | ***              | ***               | ***               |                   |

### Table 5. larvicidal effect of EC formulations of *S. nux-vomica* acetone extracts against *P. xylostella* in laboratory.

| Treatments                  | Larval mortality (%) | 0.5% | 1% | 1.5% | 2% | 24 h | 48 h | 72 h | 24 h | 48 h | 72 h | 24 h | 48 h | 72 h |
|-----------------------------|----------------------|------|----|------|----|------|------|------|------|------|------|------|------|------|
| Leaf (20.00)                | 10.00 (28.86)c       | 26.66 | 16.66 | 23.33 | 40.00 | 20.00 | 40.00 | 50.00 | 30.00 | 46.66 | 56.66 |
| Root bark (11.11 EC)        | 20.00 (35.24)c       | 26.66 | 16.66 | 33.33 | 43.33 | 26.66 | 46.66 | 60.00 | 46.66 | 56.66 | 66.66 |
| Stem bark (9.00 EC)         | 60.66 (31.04)c       | 10.00 | 16.66 | 13.33 | 20.00 | 26.66 | 16.66 | 26.66 | 40.00 | 26.66 | 36.66 | 46.66 |
| Seed (14.28 EC)             | 10.00 (31.04)c       | 24.04 | (28.86)c | 26.66 | 23.33 | 43.33 | 53.33 | 43.33 | 50.00 | 60.00 |
| Fruit rind (12.50 EC)       | 0.33 (31.04)c        | 06.66 | 10.00 | 13.33 | 10.00 | 13.33 | 10.00 | 13.33 | 20.00 | 13.33 | 16.66 | 26.66 |
| Solvent (10.51)c            | 0.33 (31.04)c        | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 |
| Water (10.51)c              | 0.33 (31.04)c        | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 | 03.33 |
| CD (0.05)                   | 0.15*               | 0.76* | 0.65* | 0.89* | 0.27* | 0.34* | 0.11* | 0.63* | 0.73* | 0.65* | 0.64* |

Observations are mean of three replicates; In column, means followed by common letters are not significantly different by LSD (P=0.05); Values in the parenthesis are arc sine transformed values.
**Table 6.** Probit regression analysis of mortality data of *P. xylostella* treated with EC formulations of *S. nux-vomica* acetone extract.

| Treatments          | No. of larvae used | LC₅₀ (%) | Fiducial limits (%) | LC₉₅ (%) | Fiducial limits (%) | X² (Cal) | Regression equation | Order of efficacy |
|---------------------|--------------------|----------|---------------------|----------|---------------------|----------|---------------------|-------------------|
| Leaf (20.00)        | 30                 | 1.61     | 1.01                | 2.57     | 24.95               | 2.35     | 264.31              | 0.0076            | Y=4.70+1.38X     |
| Root bark (11.11 EC)| 30                 | 1.14     | 0.81                | 1.61     | 13.39               | 2.46     | 72.83               | 0.404             | Y=4.90+1.52X     |
| Stem bark (9.00 EC) | 30                 | 2.41     | 1.33                | 4.35     | 24.25               | 2.94     | 199.64              | 0.112             | Y=4.37+1.62X     |
| Seed (14.28 EC)     | 30                 | 1.62     | 1.15                | 2.28     | 12.11               | 3.05     | 48.05               | 2.07              | Y=4.60+1.83X     |
| Fruit rind (12.50 EC)| 30             | 7.18     | 1.16                | 44.25    | 118.34              | 1.20     | 11577.28            | 2.08              | Y=3.84+1.28X     |
| Water               | 30                 | ***      | ***                 | ***      | ***                 | ***      | ***                 | ***              | ***              |

**Table 7.** Larvicidal effect of EC formulations of *S. nux-vomica* hexane extracts against *P. xylostella*.

| Treatments          | Larval mortality at 0.5 % | Larval mortality at 1 % | Larval mortality at 1.5 % | Larval mortality at 2 % |
|---------------------|----------------------------|-------------------------|----------------------------|----------------------------|
|                     | 24 h  | 48 h  | 72 h  | 24 h  | 48 h  | 72 h  | 24 h  | 48 h  | 72 h  | 24 h  | 48 h  | 72 h  |
| Leaf (16.66 EC)     | 13.33 | 20.00 | 26.66 | 23.33 | 30.00 | 40.00 | 23.33 | 40.00 | 56.66 | 50.00 | 76.66 | 23.33 |
| Root bark (11.11 EC)| 20.00 | 30.00 | 40.00 | 36.66 | 43.33 | 50.00 | 36.66 | 53.33 | 66.66 | 50.00 | 83.33 | 26.66 |
| Stem bark (9.00 EC) | 10.00 | 16.66 | 20.00 | 16.66 | 20.00 | 33.33 | 13.33 | 33.33 | 46.66 | 33.33 | 66.66 | 13.33 |
| Seed (12.50 EC)     | 18.43 | 24.04 | 26.56 | 24.04 | 26.56 | 35.24 | 21.38 | 35.24 | 43.05 | 35.24 | 41.16 | 24.04 |
| Fruit rind (12.50 EC)| 16.66 | 26.66 | 33.33 | 30.00 | 36.66 | 46.66 | 26.66 | 50.00 | 63.33 | 43.33 | 56.66 | 26.66 |
| Solvent             | 14.95 | 18.43 | 18.43 | 18.43 | 24.04 | 21.38 | 26.56 | 28.86 | 32.21 | 39.23 | 37.22 | 14.95 |
| Water               | 03.33 | 03.33 | 03.33 | 03.33 | 06.66 | 06.66 | 06.66 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| CD (0.05)           | 01.67 | 00.87 | 01.44 | 01.25 | 01.10 | 01.28 | 0.9008 | 01.04 | 01.05 | 02.78 | 01.19 | 01.19 |

Observations are mean of three replicates; In column, means followed by common letters are not significantly different by LSD(P=0.05); Values in the parenthesis are arc sine transformed values; Total number of larvae per replication =10.
### Table 8. Probit regression analysis of mortality data of *P. xylostella* treated with EC formulations of *S. nux-vomica* hexane extracts.

| Treatments | No. of larvae used | LC<sub>50</sub> | Fiducial limits (%) | Fiducial limits (%) | Regression equation | Order of efficacy |
|------------|-------------------|----------------|---------------------|---------------------|---------------------|------------------|
| Leaf       | 30                | 1.34           | 0.97                | 1.85                | 12.08               | 2.77             |
| (16.66 EC) |                   |                |                     |                     |                     | 52.67            | 0.21             | Y=4.78+1.72X     | 3                 |
| Root bark  | 30                | 0.85           | 0.60                | 1.22                | 8.43                | 2.26             |
| (11.11 EC) |                   |                |                     |                     |                     | 31.33            | 0.69             | Y=5.11+1.66X     | 1                 |
| Stem bark  | 30                | 1.75           | 1.19                | 2.58                | 14.33               | 3.014            |
| (12.50 EC) |                   |                |                     |                     |                     | 68.19            | 0.087            | Y=4.56+1.77X     | 4                 |
| Seed       | 30                | 1.07           | 0.76                | 1.49                | 11.83               | 2.44             |
| (14.25 EC) |                   |                |                     |                     |                     | 57.18            | 0.25             | Y=4.95+1.56X     | 2                 |
| Fruit rind | 30                | 2.78           | 1.59                | 4.85                | 16.76               | 3.35             |
| (12.50 EC) |                   |                |                     |                     |                     | 83.86            | 0.412            | Y=4.06+2.03X     | 5                 |
| Water      | 30                | ***            | ***                 | ***                 | ***                 | ***              |

Table 9. Larvicidal effect of EC formulations of *S. nux-vomica* chloroform extracts against *P. xylostella* laboratory.

| Treatments | 0.5% | 1% | 1.5% | 2% |
|------------|------|----|------|----|
| Leaf       |      |    |      |    |
| (20.00 EC) |      |    |      |    |
| (18.43)    | 10.00| 20.00| 26.66| 36.66|
| (26.56)    | (28.86) | 33.33| 43.33| 52.71|
| (31.04)    | (37.22) | (26.56) | (39.23) | (48.79) |
| Root bark  |      |    |      |    |
| (12.55 EC) |      |    |      |    |
| (24.04)    | (31.04) | (35.24) | (41.16) | (49.70) |
| (33.21)    | (37.22) | (26.56) | (43.05) | (50.76) |
| (31.04)    | (37.22) | (26.56) | (43.05) | (50.76) |
| Stem bark  |      |    |      |    |
| (12.55 EC) |      |    |      |    |
| (14.95)    | (26.56) | (18.43) | (24.04) | (31.23) |
| (21.38)    | (28.86) | 33.33| 43.33| 45.00|
| Seed       |      |    |      |    |
| (11.11 EC) |      |    |      |    |
| (21.38)    | (28.86) | (35.24) | (41.16) | (49.70) |
| (26.56)    | (37.22) | (26.56) | (43.05) | (50.76) |
| (31.04)    | (37.22) | (26.56) | (43.05) | (50.76) |
| (26.56)    | (37.22) | (26.56) | (43.05) | (50.76) |
| Fruit rind |      |    |      |    |
| (10.00 EC) |      |    |      |    |
| (10.51)    | (18.43) | (21.38) | (24.04) | (31.23) |
| (14.95)    | (28.86) | 33.33| 43.33| 45.00|
| Solvent    |      |    |      |    |
| (10.51)    | (18.43) | (21.38) | (24.04) | (31.23) |
| (10.51)    | (14.95) | (14.95) | (18.43) | (21.38) |
| (10.51)    | (14.95) | (14.95) | (18.43) | (21.38) |
| Water      |      |    |      |    |
| (10.51)    | (10.51) | (10.51) | (10.51) | (10.51) |
| (10.51)    | (10.51) | (10.51) | (10.51) | (10.51) |
| (10.51)    | (10.51) | (10.51) | (10.51) | (10.51) |
| SE (d)     |      |    |      |    |
| 0.04       | 0.06 | 0.29| 0.58| 0.65|
| CD (0.05)  | 0.0087 | 0.0137 | 0.0060 | 0.0201 |

Observations are mean of three replicates; In column, means followed by a common letter(s) are not significantly different by LSD(P=0.05); Values in the parenthesis are arcsine transformed values.
mortality variations are due alkaloids content variation from plant samples to plant samples and types of solvent used for extraction purposes. Literature on bio efficacy of nux-vomica against DBM is scanty or nil. So I am comparing my studies with available literature on botanicals against DBM. Morallo-Rejesus (1982) reported that ethanol extracts of *Piper nigrum* L. Against *P. Xylostella* Linn. revealed a LC$_{50}$ value 1.819 per cent. Sood and Sharma (2010) found that ethanol extracts of *Adiantum capillus-Veneris* against *P. xylostella* L. recorded maximum mortality 75 per cent at 20,000 ppm in 72 HAT and LC$_{50}$ value of 6777.66 ppm. The extracts of *Vitex negundo*, *Clerodendrum inerme*, *Lantana camera*, and *Eupatorium odoratum* caused highest mortality against *A. janata*, *P. xylostella* and *S. litura* larvae in the laboratory assay (Kulkarni, 2002; Yankanchi, 2003). Methanol extracts of *Adiantum capillus-Veneris* showed 70 per cent mortality at 20,000 ppm in 72 HAT and LC$_{50}$ value was 7,683.89 ppm (Sood and Sharma, 2010). Methanol extracts of *S. nux-vomica* showed 86.00 per cent mortality at 1,000 ppm concentration against *Teak defoliator*, *Hybleapurea C.* (Senthil kumar et al., 2012). According to Senthil kumar et al. (2012) acetone extracts of *S. nux-vomica* L. showed 86.67 per cent larval mortality to *Teak defoliator*, *H. purea* at 1000 ppm concentration. Hexane extracts of *S. nux-vomica* L. exhibited 100 per cent larval mortality against *C. quinquefasciatus* Say. 48 HAT at 1000 ppm concentration and recording LC$_{50}$ Value 261.91 ppm (Arivoli and Tennyson, 2012). Chloroform extracts of *S. nux-vomica* exhibited 100 per cent larval mortality against *C. quinquefasciatus* Say. at 1000 ppm in 48 HAT treatments and the LC$_{50}$ values was 1291.2 (Arivoli and Tennyson, 2012). Obviously literatures of Arivoli and Tennyson. (2012) on larvicidal efficacy of *S. nux-vomica* against *C. quinquefasciatus* Say and Senthilkumar et al. (2012) on insecticidal properties of *S. nux-vomica* against *Teak defoliator*, *H. purea* supports to my research work.

**Conclusion**

Totally five plant samples of nux-vomica with five different solvents combination were tested. Among them nux-vomica root samples extracted with hexane showed highest mortality of 76.66 % against third instar larvae of Diamond back moth at root bark 11.11 EC formulation@ 2 % concentration. This result indicates the larvicidal action of nux-vomica against diamond back moth. Though root samples had maximum mortality, collecting root samples is tedious process. Instead of that we can utilize seeds for industrial purposes which also showed 66.66 % mortality against third instar larvae of the moth.
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