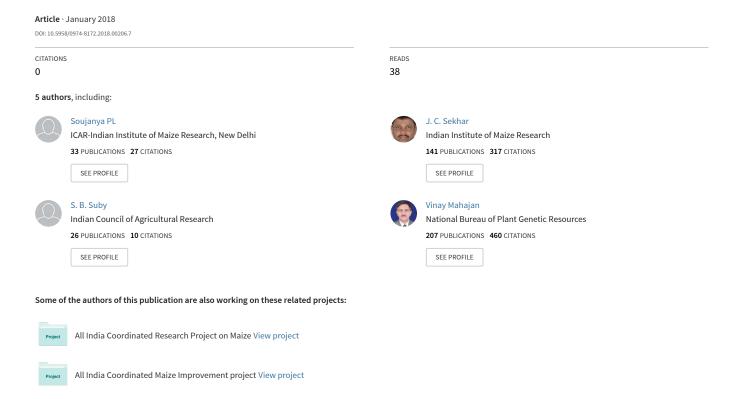
### Repellent and reproductive inhibitory effects of Strychnos nuxvomica L. and Lepidium sativum L. against Sitophilus oryzae (L.) (Coleoptera: Curculionidae)





## REPELLENT AND REPRODUCTIVE INHIBITORY EFFECTS OF *STRYCHNOS NUXVOMICA* L. AND *LEPIDIUM SATIVUM* L. AGAINST *SITOPHILUS ORYZAE* (L.) (COLEOPTERA: CURCULIONIDAE)

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#### ABSTRACT

In order to use eco friendly alternatives to chemical insecticides for the management of rice weevil Sitophilus oryzae L., hexane, ethyl acetate and methanol plant extracts from the leaves of Strychnos nuxvomica L., Lepidium sativum L. and Azadirachta indica A. Juss. were evaluated for repellent (area preference method) and reproductive inhibitory activities. Results showed that all the plant extracts were repellent at doses between 78.4 and 235.8  $\mu$ g/cm² after 1, 6, 24, 48 and 72 h exposure. In repellency tests, hexane and ethyl acetate extracts of A. indica (>90.0%) followed by L. sativum (87.3%) were found to be the most effective compared to the extracts of S. nuxvomica at 235.8  $\mu$ g/cm². In majority of the plant extracts, the per cent repellency increases from 6 to 24 h and then decreases gradually whereas in neem extracts the repellent activity exists even after 72 h. All the plant extracts significantly reduced F<sub>1</sub> progeny emergence compared to untreated control. At 7.5% w/w, ethyl acetate extract of S. nuxvomica (96.3%), and hexane extract of L. sativum (95.3%) effectively suppressed the F<sub>1</sub> progeny production followed by hexane and methanol extracts of A. indica (94.2%, 90.5%), respectively. The present work indicated that the plant extracts from Indian origin were potential grain protectants against S. oryzae.

Farmers store maize from short term to long term duration for food purpose, higher prices and to supply for industrial purposes. During this storage period, maize suffers with post harvest losses mainly due to insect pests. Sitophilus oryzae (L.) is the most destructive internal feeder of stored maize causing quantitative and qualitative losses. It feeds on grain kernels voraciously and was reported that grub consumes more grain (14 mg) than adult (0.4 mg)/ day (Giolebiowska, 1969). The infestation causes 53.30% damage resulting in 14% loss in weight over four months storage period (Lakshmi Soujanya et al., 2013). In India, chemical insecticides are commonly used to manage storage pests. However, due to ban of effective fumigant methyl bromide (Butler and Rodriguez, 1996); and development of resistance to phosphine, (Daglish et al., 2014; Lee et al., 2001) alternate control measures are essential. Plant derived products serve as best option and can be used as stored grain protectants for small scale storage (Utono and Gibson, 2015; Santos et al., 2015; Hossain et al., 2014). India has rich source of flora of indigenous medicinal plants which are traditionally being used for health purposes. Strychnos nux-vomica L. (Loganiaceae) contains caffeic acid-cinnamic acid derivative active against snake bite (Mors et al., 2000) and leaves possess antioxidative properties particularly used for treatment of diabetes and tumour diseases in humans. Phytochemical analysis of S. nux-vomica indicated the presence of flavonoids, phenols, terpenoids, tannins and saponins (Mathivanan et al., 2014). In south Asia, Lepidium sativum L. (Cruciferae) is used to treat asthama, bronchitis and cough (Duke et al., 2002). The chief phytochemical constitutents mainly contains alkaloids, saponins, anthracene glycosides, flavonoids and sterols. Five new dimeric imidazole alkaloids lepidine B, C, D, E and F were found in seeds of L. sativum. (Raval, 2016). Azadirachta indica A. Juss. (Meliaceae) is an ever green tree cultivated in various parts of India possessing antifeedant, antimicrobial, antibacterial and antifungal properties and contains phytochemical constitutents such as diterpenoids, triterpenoids, flavonoids, glycosides, tannins etc. The test plants were chosen based on medicinal importance and their ease of availability to the farmers. Although extensive work has been done on neem, but no research has been done so far on the insecticidal efficacy of plant extracts of L. sativum, S. nux vomica against S .oryzae.. Hence, in this study, hexane, ethyl acetate and methanol plant extracts from the leaves of L.

sativum, S. nux vomica were tested and A. indica in comparison for repellent and reproductive inhibitory activities against S. oryzae.

#### MATERIALS AND METHODS

Adults of *S. oryzae* were reared on whole maize at 26 ±1°C and 60± 5% relative humidity (RH). Leaves of *S. nux vomica*, *L. sativum* were collected in June 2015 from Herbal garden, Sri Konda Laxman Horticultural University, Hyderabad and leaves of *A. indica* were collected from Winter Nursery Centre fields, Hyderabad, Telangana. The leaf material was air dried at room temperature (25-28°C) for one week and then powdered. Leaf powder was extracted with three different solvents of analytical grade based on their increasing polarity- hexane, ethyl acetate and methanol by using Soxhlet apparatus for 10-14 hr. The extracts were concentrated and stored at 4°C for further use.

The repellent tests were carried out according to the method described by Jilani and Saxena (1990). Whatman # No 1 filter paper of 9 cm dia was divided into two equal parts. Each solution was applied to half a filter paper disc with micropipette. The other half of filter paper was applied with acetone as control. After drying of solvent, treated and untreated halves were attached with adhesive tape and placed in petri plates. Thirty adults (5-10 days old) of mixed sex were released at the centre of filter papers. The dishes were then covered and sealed with parafilm. Three replications were used for each concentration. Observations on the number of insects present in treated and untreated portion were recorded after 1, 6, 24, 48 and 72 h.Per centage repellency was calculated according to Nerio et al. (2009): PR = [(NC-NT) /(NC+NT)] × 100.

Three concentrations of 2.5, 5.0 and 7.5% of plant extracts were prepared and mixed with 25g of maize grain. After drying of grain, twenty adults of five day old were released into each plant extracts treated maize jar which was covered with perforated lid. Five replications were made for each concenteration. A control was set up with the same volume of acetone treated grain. After seven days of oviposition, weevils were removed from jars and the entire setup was left for 45 days for  $F_1$  progeny emergence. The % reduction in adult emergence was calculated according to Talukder and Howse (1994) as follows: % reduction =  $[C_N - T_N/C_N] \times 100$ , where  $C_N = N$ umber of newly emerged adult weevils in the untreated control; and

 $T_N$  = Number of newly emerged adults in the treated dish.

#### RESULTS AND DISCUSSION

The % repellency of *S. oryzae* with the plant extracts are given in Table 1, which reveal that the plant extracts exhibited significant repellency. The repellent action was directly proportional to the concenteration; repellency was observed even at low concenterations and differed significantly (F = 7.27; df = 44; p< 0.0001). At 78.4  $\mu$ g/cm², hexane and ethyl acetate extracts of *A. indica* and *L. sativum* repelled 76.6, 77.9 and 74.6, 66.6% respectively. The methanolic extract of neem gave 55.9% repellency while the remaining extracts exhibited <50% repellency. At 125.8, 157.2 and 188.6  $\mu$ g/cm², all the extracts exhibited moderate repellent effect. ANOVA revealed that all the plant extracts differed significantly at highest concentration (F= 3.74; d.f = 44; p< 0.0001).

Hexane and ethyl acetate extracts of Azadirachta indica at 235.8 µg/cm<sup>2</sup> showed the highest mean repellent activity (>90.0%) followed by hexane and ethyl acetate extracts of L. sativum (87.3%). The % repellent action was 64.4%, 81.9% from hexane and ethyl acetate extracts of S. nuxvomica, respectively. The methanolic extracts of S. nuxvomica and A. indica exhibited 76.4% and 80.0% repellency, but it was only 65.3% with L. sativum. Extracts of A. indica and L. sativum exhibited highest repellent activity followed by S. nuxvomica. Plants of Meliaceae and Cruciferae are known for producing large quantities of terpenoids which might be responsible for repellent action. In majority of the plant extracts, the repellency increases from 6 to 24 hr and then decreases gradually whereas in neem extracts the repellent activity exists even after 72 hr.

Several workers had reported repellent activity of plant extracts towards *Sitophilus* sp (Akhtar et al., 2013; Khani et al., 2011; Tavares et al., 2014), but none available on the efficacy of *S. nux vomica* and *L. sativum* against *S. oryzae*. Wei et al. (2014) reported that ethyl acetate extract of dried fruits of *Illicium verum* Hook.f.exhibited maximum repellency of 76.9% with *S. zeamais* followed by petroleum ether and methyl alcohol extract. Pretheep Kumar et al. (2004) found that an extract of protein enriched bean flour had a high level of repellency on *S. oryzae*; 76.3% and 91.2% of repellency with a concentration of 0.1% and 1% of the extract, respectively, was observed after 48 hr of the assay was initiated. Nattu Durai et al. (2015)

Table 1. Repellency due to plant extracts in adults of S. oryzae

| 78.4 125.8 157.2 188 40.0±0.0 42.2±4.4 48.8±2.2 75.5±4 40.0±0.0 42.2±4.4 48.8±2.2 75.5±4 40.0±0.0 42.2±8.0 51.1±2.2 68.8±4 22.2±8.0 51.1±2.2 68.8±4 42.2 40.2±13.3 42.2±11.1 48.8±4 42.2 65.2±5.8 66.6±6.6 71.1±2.2 79.9±4 45.5±2.2 64.4±2.2 68.8±9.6 75.5±4 44.5±2.2 73.3±3.8 75.5±8.0 777±4 45.5±2.2 64.4±2.2 68.8±9.6 75.5±4 40.0±10.1 57.7±4.4 60.0±4.4 80.0 77.7±4 55.5 60.0±3.8 64.4±5.8 70.0±4 40.0±10.1 57.7±4.4 60.0±4.4 80.0±7.7 80.0±3.8 80.0±5.7 83.3±3.3 80.0±5.7 83.3±3.3 80.0±5.7 83.3±3.3 80.0±5.7 83.3±3.3 86.6±6.6 90.0±3.3 80.0±5.7 83.3±3.3 86.6±6.6 77.3±8.8 76.6±3.3 80.0±5.7 83.3±3.3 86.6±6.6 77.3±8.8 66.6±6.6 77.3±8.8 66.6±6.6 77.3±8.8 66.6±6.6 77.3±8.8 66.6±6.6 77.3±8.8 66.6±6.6 77.3±8.8 66.6±6.6 77.3±8.8 66.6±6.6 77.3±8.8 66.6±6.6 77.3±8.8 66.6±6.6 77.9 80.0±5.7 83.3±3.3 86.6±3.3 80.0±5.7 80.  | Fiant extract       | Exposure |                 |                 | Dose (µg/cm <sup>2</sup> ) |                 |                 | Concentration | Progeny               | $\mathbf{F}_1$   |
|---|---------------------|----------|-----------------|-----------------|----------------------------|-----------------|-----------------|---------------|-----------------------|------------------|
| 167.4       125.8       157.2       188.6         1       400±0.0       422±4.4       488±2.2       75.5±2.2         6       298±8.9       34.7±8.7       46.8±13.7       59.3±14.5         24       400±0.0       422±4.8       51.1±2.2       68.8±2.2         48       22.2±5.8       17.7±8.0       51.1±2.2       68.8±2.2         72       33.3±13.3       42.2±13.5       42.2±11.1       48.8±4.4         Mean       66.6±6.6       71.1±2.2       79.9±3.8         6       66.6±3.8       71.1±2.2       73.3±3.8       75.5±2.2         24       71.0±2.2       73.3±3.8       75.5±8.0       77.7±4.4         48       44.5±2.2       64.4±2.8       66.4±6.6       77.7±4.4         48       51.1±2.2       57.5±8.0       75.5±11.7       70.0±15.2         48       51.1±2.2       55.5±8.0       44.4±8.0       77.7±4.4         48       51.1±2.2       55.5±8.0       44.4±8.0       77.7±4.4         48       51.1±2.2       55.5±8.0       44.4±8.0       77.7±4.4         48       51.1±2.2       55.5±8.0       44.4±8.0       77.7±4.4         48       51.1±2.2       55.5±8.0       44.4±8.0  |                     | time (h) |                 |                 |                            |                 |                 |               | emergence<br>(Number) | reduction<br>(%) |
| 1 40.0±0.0 42.2±4.4 48.8±2.2 75.5±2.2 48 40.0±0.0 42.2±8.7 46.8±137 59.3±14.5 42.2±6.8 17.7±8.0 51.1±2.2 68.8±2.2 48 42.2±5.8 17.7±8.0 51.1±2.2 68.8±2.2 42.2±5.8 17.7±8.0 51.1±2.2 68.8±4.4 42.2±5.8 71.1±2.2 79.9±3.8 6 66.6±3.8 71.1±2.2 73.3±3.8 75.5±2.2 24 71.0±2.2 73.3±3.8 75.5±8.0 77.7±4.4 48 44.5±2.2 64.4±2.2 68.8±9.6 75.5±11.7 72 44.5±2.2 64.4±2.2 68.8±9.6 75.5±11.7 72 44.5±2.2 64.4±2.2 68.8±9.6 75.5±11.7 72 44.5±2.2 64.4±2.2 68.8±9.6 75.5±11.7 72 40.0±10.1 60.0±3.8 64.4±5.8 70.0±15.2 44.0±10.1 57.7±4.4 60.0±4.4 80.0±3.8 55.5±8.0 77.7±4.4 72 40.0±10.1 57.7±4.4 60.0±4.4 80.0±5.7 6 773±3.3 80.0±5.7 80.0±5.7 72 80.0±5.7 80.0±5.7 80.0±5.7 72 80.0±5.7 80.0±5.7 80.0±5.7 90.0±5.7 72 80.0±5.7 83.3±3.3 80.0±5.7 80.0±5.7 13.3±8.8 66.5±6.6 72 80.0±5.7 83.3±3.3 80.0±5.7 86.5±6.6 72 80.0±5.7 83.3±3.3 80.0±5.7 86.5±6.6 72 80.0±5.7 83.3±3.3 80.0±5.7 86.5±6.6 72 80.0±5.7 83.3±3.3 80.0±5.7 86.5±6.6 72 80.0±5.7 83.3±3.3 80.0±5.7 86.5±6.6 72 80.0±5.7 83.3±3.3 80.0±5.7 86.5±3.3 60.0±0.0 72 80.0±5.7 83.3±3.3 80.0±5.7 40.0±15.2 66.5±3.3 60.0±5.7 70.  | Strychnos nuxvomica |          | 78.4            | 125.8           | 157.2                      | 188.6           | 235.8           | 2.5%          | $13 \pm 0.3$          | 65.8             |
| 6 29.8 ± 8.9 34.7 ± 8.7 46.8 ± 13.7 59.3 ± 14.5 4 40.0 ± 0.0 42.2 ± 8.0 51.1 ± 2.2 68.8 ± 2.2 4 40.0 ± 0.0 42.2 ± 13.5 42.2 ± 13.1 ± 2.2 68.8 ± 2.2 4 22.2 ± 5.8 17.1 ± 2.2 73.2 ± 3.8 42.2 ± 13.3 42.2 ± 13.5 42.2 ± 11.1 ± 2.2 79.9 ± 3.8 6 66.6 ± 3.8 71.1 ± 2.2 73.2 ± 3.8 75.5 ± 2.2 71.0 ± 2.2 73.3 ± 3.8 75.5 ± 8.0 77.7 ± 4.4 48. 44.5 ± 2.2 64.4 ± 2.2 68.8 ± 9.6 75.5 ± 11.7 72 33.4 ± 7.8 65.5 ± 9.1 57.6 ± 2.3 69.0 ± 5.8 6 40.0 ± 10.1 60.0 ± 3.8 64.4 ± 8.0 77.7 ± 4.4 72 40.0 ± 10.1 57.7 ± 4.4 60.0 ± 4.4 8 51.1 ± 2.2 55.5 ± 8.0 64.4 ± 8.0 77.7 ± 4.4 72 42.2 ± 11.1 51.1 ± 5.8 66.5 ± 6.6 ± 6.6 6 40.0 ± 10.1 57.7 ± 4.4 60.0 ± 4.4 8 51.1 ± 2.2 55.5 ± 8.0 64.4 ± 8.0 77.7 ± 4.4 72 42.2 ± 11.1 51.1 ± 5.8 66.5 ± 6.6 72 80.0 ± 5.7 80.0 ± 5.7 90.0 ± 5.7 83.3 ± 3.3 80.0 ± 5.7 90.0 ± 5.7 83.3 ± 3.3 80.0 ± 5.7 80.0 ± 5.7 83.3 ± 3.3 80.0 ± 5.7 80.0 ± 5.7 80.0 ± 5.7 83.3 ± 3.3 80.0 ± 5.7 80.0 ± 5.7 80.0 ± 5.7 83.3 ± 3.3 80.0 ± 5.7 83.3 ± 3.3 80.0 ± 5.7 83.3 ± 3.3 80.0 ± 5.7 83.3 ± 3.3 80.0 ± 5.7 83.3 ± 3.3 80.0 ± 5.7 83.3 ± 3.3 80.0 ± 5.7 80.0 ± 5.7 80.0 ± 5.7 83.3 ± 3.3 80.0 ± 5.7 80.0 ± 5.7 80.0 ± 5.7 80.0 ± 5.7 80.0 ± 5.7 80.0 ± 5.7 80.0 ± 5.7 80.0 ± 5.7 80.0 ± 5.7 83.3 ± 3.3 80.0 ± 5.7 80.0 ± 5.  | Hexane              |          | $40.0 \pm 0.0$  | $42.2 \pm 4.4$  | $48.8 \pm 2.2$             | $75.5 \pm 2.2$  | $80.0 \pm 3.8$  | 2%            | $14.4 \pm 1.0$        | 62.1             |
| 24 40.0 ± 0.0 42.2 ± 8.0 51.1 ± 2.2 68.8 ± 2.2 48.8 17.7 ± 8.0 51.1 ± 5.8 60.0 ± 3.8 73 ± 13.3 42.2 42.2 42.2 42.8 42.2 42.2 42.2 42.8 66.6 ± 6.6 71.1 ± 2.2 79.9 ± 3.8 66.6 ± 6.6 71.1 ± 2.2 79.9 ± 3.8 71.0 ± 2.2 73.3 ± 3.8 75.5 ± 2.2 73.3 ± 3.8 75.5 ± 2.2 73.3 ± 3.8 75.5 ± 2.2 73.3 ± 3.8 75.5 ± 2.2 73.3 ± 3.8 75.5 ± 2.2 73.3 ± 3.8 75.5 ± 2.2 73.3 ± 3.8 75.5 ± 2.2 73.3 ± 3.8 75.5 ± 2.2 73.3 ± 3.8 75.5 ± 2.2 73.3 ± 3.8 75.5 ± 2.2 73.3 ± 3.8 75.5 ± 2.2 73.3 ± 3.8 60.0 ± 3.8 64.4 ± 5.8 70.0 ± 5.2 40.0 ± 10.1 60.0 ± 3.8 64.4 ± 5.8 70.0 ± 5.2 40.0 ± 10.1 60.0 ± 3.8 64.4 ± 5.8 70.0 ± 5.2 40.0 ± 10.1 60.0 ± 3.8 64.4 ± 5.8 70.0 ± 5.7 44.4 ± 8.0 77.7 ± 4.4 ± 2.2 ± 4.0 ± 11.2 55.5 ± 8.0 ± 5.7 ± 4.4 ± 8.0 77.7 ± 8.3 ± 8.3 ± 3.3  |                     | 9        | $29.8 \pm 8.9$  | $34.7 \pm 8.7$  | $46.8 \pm 13.7$            | $59.3 \pm 14.5$ | $62.1 \pm 14.6$ | 7.5%          | $8.8 \pm 0.73$        | 8.92             |
| ## 222±5.8   17.7±8.0   51.1±5.8   60.0±3.8    ## 33.3   42.2±13.5   42.2±11.1   48.8±4.4    ## 42.2   42.2   42.2   42.2   48.8    ## 42.2   42.2   42.2   48.8    ## 44.5±2.2   73.3±3.8   75.5±2.2    ## 44.5±2.2   73.3±3.8   75.5±2.2    ## 44.5±2.2   74.4±2.2   68.8±9.6   75.5±11.7    ## 44.5±2.2   64.4±2.2   68.8±9.6   75.5±11.7    ## 44.5±3.3   60.0±3.8   64.4±5.8   60.0±5.8    ## 40.0±10.1   60.0±3.8   64.4±5.8   60.0±5.8    ## 51.1±2.2   55.5±8.0   64.4±5.8   70.0±15.2    ## 51.1±2.2   55.5±8.0   64.4±8.0   77.7±4.4    ## 51.1±2.2   55.5±8.0   77.7±4.4    ## 51.1±2.2   55.5±8.0   77.7±4.4    ## 51.1±2.2   55.5±8.0   77.7±4.4    ## 51.1±2.2   55.5±8.0   77.7±4.4    ## 51.1±2.2   55.5±8.0   77.3±4.8    ## 51.1±2.2   55.5±8.0   77.3±4.8    ## 73.3±3.3   80.0±5.7   83.3±3.3   83.3±3.3    ## 73.3±6.6   80.0±5.7   83.3±3.3   80.0±5.7    ## 60.0±11.5   66.6±1.2   70.0±5.7   73.3±8.8    ## 63.3±3.3   80.0±5.7   83.3±3.3   86.6±6.6    ## 63.3±3.3   80.0±5.7   83.3±3.3   86.6±3.3    ## 66.5±6.6   77.9±7.1   80.0±5.7    ## 80.0±5.7   83.3±3.3   80.0±5.7    ## 80.0±5.7   83.3±3.3   80.0±5.7    ## 80.0±5.7   83.3±3.3   80.0±5.7    ## 80.0±5.7   83.3±3.3   80.0±5.7    ## 80.0±5.7   83.3±3.3   80.0±5.7    ## 80.0±5.7   83.3±3.3   80.0±5.7    ## 80.0±5.7   83.3±3.3   80.0±5.7    ## 80.0±5.7   83.3±3.3   80.0±5.7    ## 80.0±5.7   83.3±3.3   80.0±5.7    ## 80.0±5.7   83.3±3.3   80.0±5.7    ## 80.0±5.7   83.3±3.3   80.0±5.7    ## 80.0±5.7   83.3±3.3   80.0±5.7    ## 80.0±5.7   83.3±3.3   80.0±5.7    ## 80.0±5.7   83.3±3.3    ## 80.0±5.7   83.3±3.3    ## 80.0±5.7   83.3±3.3    ## 80.0±5.7   83.3±3.3    ## 80.0±5.7   83.3±3.3    ## 80.0±5.7   83.3±3.3    ## 80.0±5.7   83.0±5.3    ## 80.0±5.7   83.0±5.3    ## 80.0±5.7   83.0±5.3    ## 80.0±5.7   83.0±5.3    ## 80.0±5.7   80.0±5.7    ## 80.0±5.7   83.3±3.3    ## 80.0±5.7   83.3±3.3    ## 80.0±5.7   83.3±3.3    ## 80.0±5.7   83.0±5.3    ## 80.0±5.7   83.0±5.3    ## 80.0±5.7   83.0±5.3    ## 80.0±5.7   83.0±5.3    ## 80.0±5.7   83.0±5.3    ## 80.0±5.7    ## 80.0±5.7    ## 80.0±5.7  |                     | 24       | $40.0 \pm 0.0$  | $42.2 \pm 8.0$  | $51.1 \pm 2.2$             | $68.8 \pm 2.2$  | $75.5 \pm 2.2$  |               |                       |                  |
| T2 33.3 ± 13.3 4.22±13.5 42.2±11.1 48.8±4,4 Mean 33.3 42.2 42.2 42.2 48.8 48.8 44.2 44.2 48.8 44.2 44.2   |                     | 48       | $22.2 \pm 5.8$  | $17.7 \pm 8.0$  | $51.1 \pm 5.8$             | $60.0 \pm 3.8$  | $71.1 \pm 2.2$  |               |                       |                  |
| Mean       33.3       42.2       42.2       48.8         1       66.643.8       71.142.2       73.43.8       75.542.2         24       71.042.2       73.34.38       75.542.2         24       71.042.2       73.34.38       75.542.1         72       34.45.42.2       64.44.22       68.84.96       75.5411.7         72       33.44.7.8       66.04.65.6       6       66.64.66       75.52.1         Mean       55.5       60.04.3.8       64.44.5.8       66.64.66       6       66.64.66         4       40.04.10.1       60.04.3.8       64.44.5.8       66.64.66       6       66.64.66       6       66.64.66       77.74.44         72       42.24.11.1       51.14.5.8       64.44.5.8       60.04.5.7       80.04.5.7       80.04.5.7         Mean       1       70.04.11.5       77.44.4       60.04.3.3       80.04.5.7       80.04.5.7         Activum       1       70.04.11.5       73.34.6       80.04.5.7       80.04.5.7       80.04.5.7         Activum       1       70.04.11.5       73.34.6       80.04.5.7       80.04.5.7       70.04.5.7         Activum       1       70.04.11.5       70.34.8       70.44.8       <  |                     | 72       | $33.3 \pm 13.3$ | $42.2 \pm 13.5$ | $42.2 \pm 11.1$            | $48.8 \pm 4.4$  | $64.4 \pm 4.4$  |               |                       |                  |
| 66.6 ± 3.8   71.1 ± 2.2   73.3 ± 3.8   75.5 ± 2.2     24  |                     | Mean     | 33.3            | 42.2            | 42.2                       | 48.8            | 64.4            |               |                       |                  |
| 6 66.6 ± 3.8 71.1 ± 2.2 73.3 ± 3.8 75.5 ± 2.2 73.4 ± 3.8 71.0 ± 2.2 73.3 ± 3.8 75.5 ± 8.0 77.7 ± 4.4 48 44.5 ± 2.2 64.4 ± 2.2 68.8 ± 9.6 75.5 ± 11.7 72 33.4 ± 7.8 60.0 ± 3.8 64.4 ± 5.8 66.6 ± 6.6 6 6.0 0.0 ± 3.8 64.4 ± 5.8 70.0 ± 15.2 77.2 ± 4.4 60.0 ± 4.4 ± 8.0 77.7 ± 4.4 60.0 ± 10.1 60.0 ± 3.8 64.4 ± 8.8 70.0 ± 15.2 40.0 ± 10.1 57.7 ± 4.4 60.0 ± 4.4 ± 8.0 77.7 ± 4.4 51.1 ± 2.2 55.5 ± 8.0 44.4 ± 8.0 77.7 ± 4.4 51.1 ± 2.2 55.5 ± 8.0 44.4 ± 8.0 77.7 ± 4.4 60.0 ± 3.8 60.0 ± 3.8 60.0 ± 3.8 60.0 ± 5.7 60.  | Ethyl acetate       | _        | $62.2 \pm 5.8$  | $9.9 \pm 9.99$  | $71.1 \pm 2.2$             | $79.9 \pm 3.8$  | $82.2 \pm 2.2$  | 2.5%          | $8.2 \pm 0.8$         | 78.4             |
| 24 71.0±2.2 73.±3.8 75.5±8.0 77.7±4.4 48 44.5±2.2 64.4±2.2 68.8±9.6 75.5±11.7 72 33.4±7.8 68.8 60.0±3.8 64.4±5.8 66.6±6.6 6 40.0±10.1 60.0±3.8 64.4±5.8 70.0±15.2 24 40.0±10.1 57.7±4.4 60.0±4.4 80.0±3.8 48 51.1±2.2 55.5±8.0 44.4±8.0 77.7±4.4 72 42.2±11.1 51.1±5.8 46.6±3.8 53.3±6.6  Mean 45.3 ±3.3 80.0±5.7 83.3±3.3 83.3±3.3 24 73.3±8.8 76.6±8.8 76.6±3.3 80.0±5.7 76.5±6.6 48 73.3±3.3 80.0±5.7 80.0±5.7 90.0±5.7 73.3±8.8 76.6±8.8 76.6±3.3 80.0±5.7 73.3±8.8 76.6±8.8 76.6±3.3 80.0±5.7 73.3±8.8 76.6±8.8 76.6±3.3 80.0±5.7 73.3±8.8 76.6±8.8 76.6±3.3 80.0±5.7 73.3±8.8 76.6±8.8 76.6±3.3 80.0±5.7 73.3±8.8 76.6±8.8 76.6±3.3 80.0±5.7 73.3±8.8 86.6±6.6 73.3±9.3 86.6±6.6 73.3±9.3 86.6±6.6 73.3±9.3 86.6±6.6 73.3±8.8 86.6±6.6 73.3±9.3 86.6±6  |                     | 9        | $66.6 \pm 3.8$  | $71.1 \pm 2.2$  | $73.3 \pm 3.8$             | $75.5 \pm 2.2$  | $83.4 \pm 2.0$  | 2%            | $2.2 \pm 0.6$         | 94.2             |
| 48  |                     | 24       | $71.0 \pm 2.2$  | $73.3 \pm 3.8$  | $75.5 \pm 8.0$             | $77.7 \pm 4.4$  | $84.4 \pm 2.2$  | 7.5%          | $1.4 \pm 0.2$         | 96.3             |
| 72       33.4 ± 7.8       45.5 ± 9.1       57.6 ± 2.3       69.0 ± 5.8         Mean       55.5       68.8       69.26       75.52         1       53.3 ± 3.3       60.0 ± 3.8       64.4 ± 5.8       70.0 ± 15.2         24       40.0 ± 10.1       57.7 ± 4.4       60.0 ± 4.4       80.0 ± 3.8         48       51.1 ± 2.2       55.5 ± 8.0       44.4 ± 8.0       77.7 ± 4.4         72       42.2 ± 11.1       57.3 ± 8.0       46.6 ± 3.8       53.3 ± 6.6       69.52         Mean       45.3       56.8       55.96       69.52       53.3 ± 6.6       69.52         73 ± 4.3       80.0 ± 5.7       80.0 ± 5.7       80.0 ± 5.7       80.0 ± 5.7       80.0 ± 5.7         48       73.3 ± 8.8       76.6 ± 8.8       76.6 ± 6.6       90.0 ± 5.7       73.3 ± 8.8         Amean       74.6       79.3       81.3       83.9 ± 3.3       83.9 ± 3.3         Amean       60.0 ± 11.5       66.6 ± 12       70.0 ± 5.7       73.3 ± 8.8         Amean       60.0 ± 5.7       83.3 ± 6.6       83.0 ± 3.3       86.5 ± 6.6         Amean       60.0 ± 5.7       83.3 ± 3.3       86.6 ± 6.6       70.0 ± 5.7       73.3 ± 8.8         Amean       66.0 ± 11.5   |                     | 48       | $44.5 \pm 2.2$  | $64.4 \pm 2.2$  | $9.6 \pm 8.89$             | $75.5 \pm 11.7$ | $77.7 \pm 7.7$  |               |                       |                  |
| Mean 55.5 68.8 69.26 75.52  1 53.3 ± 3.3 60.0 ± 3.8 64.4 ± 5.8 66.6 ± 6.6 6 6 40.0 ± 10.1 60.0 ± 3.8 64.4 ± 5.8 70.0 ± 15.2 24 40.0 ± 10.1 57.7 ± 4.4 60.0 ± 4.4 80.0 ± 3.8 48 51.1 ± 2.2 55.5 ± 8.0 44.4 ± 8.0 77.7 ± 4.4 72 42.2 ± 11.1 51.1 ± 5.8 46.6 ± 3.8 53.3 ± 6.6  Mean 45.3 56.8 55.96 69.52  24 73.3 ± 3.3 80.0 ± 5.7 83.3 ± 3.3 83.3 ± 3.3  24 73.3 ± 6.6 80.0 ± 5.7 80.0 ± 5.7 90.0 ± 5.7  Mean 74.6 79.3 80.0 ± 5.7 80.0 ± 5.7 90.0 ± 5.7  83.3 ± 3.3 86.5 ± 6.6 90.0 ± 3.3 90.0 ± 5.7  848 73.3 ± 6.6 80.0 ± 5.7 80.0 ± 5.7 90.0 ± 5.7  Mean 60.0 ± 11.5 66.5 ± 12 70.0 ± 5.7 73.3 ± 8.8 6 50.0 ± 5.7 83.3 ± 6.6 83.0 ± 3.3 86.5 ± 6.6 72 80.0 ± 5.7 83.3 ± 6.6 80.0 ± 5.7 86.5 ± 3.3  Mean 66.6 81.6 77.9 86.5 ± 3.3 86.5 ± 3.3  6 36.6 ± 6.6 43.3 \$6.0 ± 10.0 \$6.6 ± 3.3  6 36.6 ± 6.6 43.3 \$6.0 ± 5.7 40.0 ± 15.2  20.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  22 20.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  24 30.0 ± 5.7 36.5 ± 6.6 40.0 ± 5.7  25 20.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  27 20.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  28 30.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  29 20.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  20 0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  21 20.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  22 20.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  24 30.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  25 20.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  26 26 ± 8.8 36.5 ± 6.6 40.0 ± 5.7  27 20.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  28 20.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  29 20.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  20 20.5 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  21 20.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  22 20.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  24 30.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  25 20.0 ± 5.7 33.3 ± 3.3 46.5 ± 3.3 60.0 ± 5.7  26 26 ± 5.0   |                     | 72       | $33.4 \pm 7.8$  | $45.5 \pm 9.1$  | $57.6 \pm 2.3$             | $69.0 \pm 5.8$  | $71.1 \pm 5.8$  |               |                       |                  |
| 1 533±3.3 60.0±3.8 64,4±5.8 66.6±6.6 6 6 0.0±3.8 64,4±5.8 70.0±15.2 24 40.0±10.1 57.7±4.4 60.0±4.4 80.0±3.8 48 51.1±2.2 55.5±8.0 44.4±8.0 77.7±4.4 72 42.2±11.1 51.1±5.8 46.6±3.8 53.3±6.6 69.52    Mean 45.3 56.8 55.96 69.52    3.3±3.3 80.0±5.7 83.3±3.3 80.0±5.7 76.6±6.6 48 73.3±6.6 80.0±5.7 80.0±5.7 80.0±5.7 80.0±5.7 83.3±3.3 80.0±5.7 80.0±5.7 80.0±5.7 83.3±3.3 80.0±5.7 80.0±5.7 83.3±3.3 80.0±5.7 80.0±5.7 83.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 66.6±3.3 60.0±0.0 56.6±3.3 66.0±0.0 56.0±5.7 86.6±3.3 60.0±0.0 56.0±5.7 86.6±3.3 60.0±0.0 56.0±5.7 86.6±3.3 66.0±0.0 56.0±5.7 86.6±3.3 66.0±0.0 56.0±5.7 86.6±3.3 66.0±0.0 56.0±5.7 86.6±3.3 66.0±0.0 56.0±5.7 86.6±3.3 66.0±0.0 56.0±5.7 86.6±3.3 66.0±0.0 56.0±5.7 86.6±3.3 66.0±0.0 56.0±5.7 86.6±3.3 60.0±0.0 56.0±5.7 86.6±3.3 60.0±0.0 56.0±5.7 86.6±3.3 60.0±5.7 86.6±3.3 60.0±5.7 86.6±3.3 60.0±5.7 86.6±3.3 60.0±5.7 86.6±3.3 60.0±0.0 56.0±5.7 86.6±3.3 66.0±5.7 86.6±3.3 66.0±5.7 86.6±3.3 66.0±5.7 86.6±3.3 66.0±5.7 86.0±5.7   |                     | Mean     | 55.5            | 8.89            | 69.26                      | 75.52           | 81.925          |               |                       |                  |
| 6 40.0 ± 10.1 60.0 ± 3.8 64.4 ± 5.8 70.0 ± 15.2 24 40.0 ± 10.1 57.7 ± 4.4 60.0 ± 4.4 80.0 ± 3.8 45.1 ± 2.2 55.5 ± 8.0 44.4 ± 8.0 77.7 ± 4.4 42.2 ± 11.1 51.1 ± 5.8 46.6 ± 3.8 53.3 ± 6.6 69.52    Mean 45.3 56.8 55.96 69.52 69.52    1 70.0 ± 11.5 73.3 ± 6.6 76.6 ± 3.3 80.0 ± 5.7 76.4 ± 6.6 73.3 ± 8.8 76.6 ± 8.8 76.6 ± 8.3 76.6 ± 6.6 73.3 ± 8.8 76.6 ± 6.6 90.0 ± 5.7 79.0 ± 5.7 72 83.3 ± 3.3 80.0 ± 5.7 79.3 ± 8.8 6.6 ± 6.6 73.3 ± 8.8 70.0 ± 5.7 70.0 ±  | Methanol            | 1        | $53.3 \pm 3.3$  | $60.0 \pm 3.8$  | $64.4 \pm 5.8$             | $9.9 \pm 9.99$  | $80.0 \pm 3.8$  | 2.5%          | $11.0 \pm 1.4$        | 71.1             |
| 24  40.0±10.1 57.7±4,4 60.0±4.4 80.0±3.8 48.0±1.2 55.5±8.0 44.4±8.0 77.7±4,4 72 ±11.1 51.1±5.8 46.6±3.8 53.3±6.6 69.52 Mean 45.3 56.8 55.96 69.52 69.52 60.0±1.5 73.3±6.6 76.6±3.3 80.0±5.7 72 83.3±3.3 80.0±5.7 80.0±5.7 76.6±6.6 48 73.3±6.6 80.0±5.7 80.0±5.7 76.6±6.6 48 73.3±6.6 80.0±5.7 80.0±5.7 76.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±6.6 73.3±8.8 66.6±3.3 60.0±0.0 56.6±3.3 60.0±0.0 56.6±3.3 46.6±3.3 46.6±3.3 60.0±5.7 70.0  |                     | 9        | $40.0 \pm 10.1$ | $60.0 \pm 3.8$  | $64.4 \pm 5.8$             | $70.0 \pm 15.2$ | $82.2 \pm 4.4$  | 2%            | $9.2 \pm 0.3$         | 76.8             |
| ## \$1.1 ± 2.2 \$5.5 ± 8.0 \$44,4 ± 8.0 \$77.7 ± 4,4 \$7.2 ± 11.1 \$1.1 ± 5.8 \$46.6 ± 3.8 \$5.3 ± 6.6 \$9.5 \$2 \$8.8 \$5.3 ± 6.6 \$9.5 \$2 \$8.8 \$5.3 ± 6.6 \$9.5 \$2 \$9.0 ± 5.7 \$9. |                     | 24       | $40.0 \pm 10.1$ | $57.7 \pm 4.4$  | $60.0 \pm 4.4$             | $80.0 \pm 3.8$  | $84.4 \pm 2.2$  | 7.5%          | $3.6 \pm 0.5$         | 90.5             |
| 72       42.2 ± 11.1       51.1 ± 5.8       46.6 ± 3.8       53.3 ± 6.6         Mean       45.3       56.8       55.96       69.52         m sativum       1       70.0 ± 11.5       73.3 ± 6.6       76.6 ± 3.3       80.0 ± 5.7         6       73.3 ± 8.8       76.6 ± 8.8       76.6 ± 3.3       80.0 ± 5.7         48       73.3 ± 6.6       80.0 ± 5.7       83.3 ± 3.3       83.3 ± 3.3         72       83.3 ± 3.3       86.6 ± 6.6       90.0 ± 5.7       90.0 ± 5.7         72       83.3 ± 3.3       86.6 ± 6.6       90.0 ± 3.7       90.0 ± 5.7         80.0 ± 5.7       80.0 ± 5.7       81.3       83.3 ± 8.8         6       50.0 ± 5.7       53.3 ± 8.8       66.6 ± 6.6       73.3 ± 8.8         8       80.0 ± 5.7       83.3 ± 6.6       83.0 ± 3.3       86.6 ± 6.6         72       80.0 ± 5.7       83.3 ± 3.3       86.6 ± 6.6       77.9       86.6 ± 6.6         8       80.0 ± 5.7       83.3 ± 3.3       86.6 ± 3.3       86.6 ± 3.3       66.6 ± 3.3       86.6 ± 3.3         9       1       26.6 ± 8.8       36.6 ± 6.6       40.0 ± 5.7       40.0 ± 15.2         1       26.6 ± 8.9       36.6 ± 6.6       40.0 ± 5.7       40.0 ± 5.7   |                     | 48       | $51.1 \pm 2.2$  | $55.5 \pm 8.0$  | $44.4 \pm 8.0$             | $77.7 \pm 4.4$  | $73.3 \pm 7.7$  |               |                       |                  |
| m sativum       45.3       56.8       55.96       69.52         m sativum       1       70.0 ± 11.5       73.3 ± 6.6       76.6 ± 3.3       80.0 ± 5.7         6       73.3 ± 8.8       76.6 ± 8.8       76.6 ± 3.3       80.0 ± 5.7         48       73.3 ± 6.6       80.0 ± 5.7       80.0 ± 5.7         72       83.3 ± 3.3       86.6 ± 6.6       90.0 ± 3.7       90.0 ± 5.7         Mean       74.6       79.3       81.3       83.9 ± 8.8         5 60.0 ± 11.5       66.6 ± 12       70.0 ± 5.7       73.3 ± 8.8         6 50.0 ± 5.7       53.3 ± 8.8       66.6 ± 6.6       73.3 ± 8.8         8 60.0 ± 5.7       83.3 ± 6.6       83.0 ± 3.3       86.6 ± 6.6         72       80.0 ± 5.7       83.3 ± 6.6       83.0 ± 3.3       86.6 ± 6.6         8 60.0 ± 5.7       83.3 ± 3.3       86.6 ± 3.3       86.6 ± 6.6         9 1       26.6 ± 8.8       36.6 ± 3.3       80.0 ± 5.7       80.0 ± 6.0         1       26.6 ± 8.8       36.6 ± 6.6       40.0 ± 5.7       40.0 ± 15.2         1       26.6 ± 8.8       36.6 ± 6.6       40.0 ± 5.7       40.0 ± 15.2         1       26.0 ± 5.7       36.6 ± 6.6       40.0 ± 5.7       40.0 ± 5.7         <   |                     | 72       | $42.2 \pm 11.1$ | $51.1 \pm 5.8$  | $46.6 \pm 3.8$             | $53.3 \pm 6.6$  | $62.2 \pm 5.8$  |               |                       |                  |
| m sativum  1 70.0 ± 11.5 73.3 ± 6.6 76.6 ± 3.3 80.0 ± 5.7 6.7 8.3 ± 3.3 80.0 ± 5.7 83.3 ± 3.3 80.0 ± 5.7 83.3 ± 3.3 80.0 ± 5.7 80.0 ± 5.7 70.0 ± 5.7 80.0   |                     | Mean     | 45.3            | 8.95            | 55.96                      | 69.52           | 76.42           |               |                       |                  |
| 1 70.0±11.5 73.3±6.6 76.6±3.3 80.0±5.7 6.5±3.3 24.3 80.0±5.7 83.3±3.3 24 73.3±6.6 80.0±5.7 83.3±3.3 83.3±3.3 24 73.3±6.6 80.0±5.7 80.0±5.7 70.0±5.7 90.0±5.7 83.3±3.3 86.6±6.6 90.0±3.3 90.0±5.7  | Lepidium sativum    |          |                 |                 |                            |                 |                 |               |                       |                  |
| 6 73.3 ± 3.3 80.0 ± 5.7 83.3 ± 3.3 83.3 ± 3.3<br>24 73.3 ± 8.8 76.6 ± 8.8 76.6 ± 3.3 76.6 ± 6.6<br>48 73.3 ± 6.6 80.0 ± 5.7 80.0 ± 5.7 90.0 ± 5.7<br>Mean 74.6 79.3 81.3 80.0 ± 5.7 90.0 ± 5.7<br>6 50.0 ± 5.7 53.3 ± 8.8 66.6 ± 6.6 73.3 ± 8.8<br>24 80.0 ± 5.7 53.3 ± 8.8 66.6 ± 6.6 73.3 ± 8.8<br>65.0 ± 5.7 83.3 ± 6.6 83.0 ± 3.3 86.6 ± 6.6<br>72 80.0 ± 5.7 83.3 ± 6.6 83.0 ± 3.3 86.6 ± 6.6<br>81.6 77.9 86.6 ± 3.3 86.6 ± 6.6<br>81.6 77.9 80.0 ±   | Hexane              | 1        | $70.0 \pm 11.5$ | $73.3 \pm 6.6$  | $76.6 \pm 3.3$             | $80.0 \pm 5.7$  | $83.3 \pm 12$   | 2.5%          | $18.8 \pm 0.4$        | 50.5             |
| 24 73.3 ± 8.8 76.6 ± 8.8 76.6 ± 3.3 76.6 ± 6.6 48 73.3 ± 6.6 80.0 ± 5.7 80.0 ± 5.7 72 83.3 ± 3.3 86.6 ± 6.6 90.0 ± 3.3 90.0 ± 5.7  Mean 74.6 79.3 81.3 81.3 83.9 8  tate 1 60.0 ± 11.5 66.6 ± 12 70.0 ± 5.7 73.3 ± 8.8  24 80.0 ± 5.7 53.3 ± 8.8 66.6 ± 6.6 73.3 ± 8.8  24 80.0 ± 5.7 83.3 ± 6.6 83.0 ± 3.3 86.6 ± 6.6  72 80.0 ± 5.7 83.3 ± 6.9 83.0 ± 3.3 86.6 ± 6.6  1 26.6 ± 8.8 86.6 ± 3.3 86.6 ± 6.6  81.6 77.9 80.0 ± 0.0  24 30.0 ± 5.7 36.5 ± 3.3 46.6 ± 3.3  46.6 ± 3.3 46.6 ± 3.3 46.6 ± 5.7  77.9 80.0 ± 5.7 33.3 ± 8.8  77.9 80.0 ± 5.7 36.5 ± 6.6  77.9 80.0 ± 5.7 36.5 ± 6.6  77.9 80.0 ± 5.7 36.5 ± 6.6  77.9 80.0 ± 5.7 36.5 ± 6.6  77.9 80.0 ± 6.0  77.9 80.0 ± 5.7 30.0 ± 5.7 40.0 ± 15.2  77.0 ± 5.7 33.3 ± 3.3 46.6 ± 5.3 60.0 ± 5.7  77.0 ± 5.7 33.3 ± 3.3 46.6 ± 5.3 60.0 ± 5.7  |                     | 9        | $73.3 \pm 3.3$  | $80.0 \pm 5.7$  | $83.3 \pm 3.3$             | $83.3 \pm 3.3$  | $86.6 \pm 3.3$  | 2%            | $15.4 \pm 0.7$        | 59.5             |
| 48 73.3 ± 6.6 80.0 ± 5.7 80.0 ± 5.7 72 83.3 ± 3.3 86.6 ± 6.6 90.0 ± 3.3 90.0 ± 5.7 81.3 81.3 81.3 81.3 81.3 81.3 81.3 81.3  |                     | 24       | $73.3 \pm 8.8$  | $76.6 \pm 8.8$  | $76.6 \pm 3.3$             | $9.9 \pm 9.97$  | $83.3 \pm 3.3$  | 7.5%          | $1.8 \pm 0.8$         | 95.3             |
| 72 83.3 ± 3.3 86.6 ± 6.6 90.0 ± 3.3 90.0 ± 5.7  Mean 74.6 79.3 81.3 83.98  1 60.0 ± 11.5 66.6 ± 12 70.0 ± 5.7 73.3 ± 8.8  24 80.0 ± 5.7 83.3 ± 8.8 66.6 ± 6.6 73.3 ± 8.8  48 63.3 ± 3.3 80.0 ± 5.7 86.6 ± 3.3 86.6 ± 6.6  72 80.0 ± 5.7 83.3 ± 6.6 83.0 ± 3.3 86.6 ± 6.6  73 80.0 ± 5.7 83.3 ± 6.6 83.0 ± 3.3 86.6 ± 6.6  1 26.6 ± 8.8 80.0 ± 5.7 86.6 ± 3.3 86.6 ± 6.6  1 26.6 ± 8.8 36.6 ± 3.3 80.0 ± 0.0  24 30.0 ± 5.7 33.3 ± 8.8 46.6 ± 3.3 60.0 ± 15.2  48 36.6 ± 5.7 33.3 ± 3.3 46.6 ± 5.7 40.0 ± 15.2  77 20.0 ± 5.7 33.3 ± 3.3 46.6 ± 6.6 66.6 ± 3.3  78 20.0 ± 5.7 33.3 ± 3.3 46.6 ± 5.3 60.0 ± 5.7   |                     | 48       | $73.3 \pm 6.6$  | $80.0 \pm 5.7$  | $80.0 \pm 5.7$             | $90.0 \pm 5.7$  | $90.0 \pm 5.7$  |               |                       |                  |
| Mean       74.6       79.3       81.3       83.98         tate       1       60.0 ± 11.5       66.6 ± 12       70.0 ± 5.7       73.3 ± 8.8         6       50.0 ± 5.7       53.3 ± 8.8       66.6 ± 6.6       73.3 ± 8.8         24       80.0 ± 5.7       83.3 ± 6.6       83.0 ± 3.3       83.3 ± 3.3         48       63.3 ± 3.3       80.0 ± 5.7       86.6 ± 6.6         72       80.0 ± 5.7       83.3 ± 3.3       86.6 ± 6.6         80.0 ± 5.7       83.3 ± 3.3       86.6 ± 3.3       86.6 ± 3.3         80.6 ± 6.6       81.6       77.9       80.62         1       26.6 ± 8.8       36.6 ± 3.3       50.0 ± 10.0       56.6 ± 3.3         6       36.6 ± 6.6       43.3 ± 8.8       46.6 ± 3.3       60.0 ± 0.0         24       30.0 ± 5.7       36.6 ± 6.6       40.0 ± 5.7       40.0 ± 15.2         48       36.6 ± 3.3       46.6 ± 3.3       46.6 ± 5.3       60.0 ± 5.7         72       20.0 ± 5.7       33.3 ± 3.3       46.6 ± 5.3       60.0 ± 5.7   |                     | 72       | $83.3 \pm 3.3$  | $9.9 \pm 9.98$  | $90.0 \pm 3.3$             | $90.0 \pm 5.7$  | $93.3 \pm 3.3$  |               |                       |                  |
| tate 1 60.0 ± 11.5 66.6 ± 12 70.0 ± 5.7 73.3 ± 8.8 66.6 ± 6.6 73.3 ± 8.8 66.6 ± 6.6 73.3 ± 8.8 24 80.0 ± 5.7 83.3 ± 6.6 83.0 ± 3.3 83.3 ± 3.3 80.0 ± 5.7 8  |                     | Mean     | 74.6            | 79.3            | 81.3                       | 83.98           | 87.3            |               |                       |                  |
| 6 50.0±5.7 53.3±8.8 66.6±6.6 73.3±8.8 24 80.0±5.7 83.3±6.6 83.0±3.3 83.3±3.3 48 63.3±3.3 80.0±5.7 86.6±3.3 86.6±6.6 72 80.0±5.7 83.3±3.3 83.3±3.3 86.6±3.3 Mean 66.6 81.6 77.9 80.62 1 26.6±8.8 36.6±3.3 50.0±10.0 56.6±3.3 6 36.6±6.6 43.3±8.8 46.6±3.3 60.0±0.0 24 30.0±5.7 36.6±6.6 40.0±5.7 40.0±15.2 48 36.6±3.3 46.6±3.3 46.6±6.6 66.6±3.3 72 20.0±5.7 33.3±3.3 46.6±5.3 60.0±5.7   | Ethyl acetate       | 1        | $60.0 \pm 11.5$ | $66.6 \pm 12$   | $70.0 \pm 5.7$             | $73.3 \pm 8.8$  | $80.0 \pm 3.8$  | 2.5%          | $24.2 \pm 0.4$        | 36.3             |
| 24 80.0±5.7 83.3±6.6 83.0±3.3 83.3±3.3 48 63.3±3.3 80.0±5.7 86.6±3.3 86.6±6.6 72 80.0±5.7 83.3±3.3 83.3±3.3 86.6±3.3 Mean 66.6 81.6 77.9 80.62 1 26.6±8.8 36.6±3.3 50.0±10.0 56.6±3.3 6 36.6±6.6 43.3±8.8 46.6±3.3 60.0±0.0 24 30.0±5.7 36.6±6.6 40.0±5.7 40.0±15.2 48 36.6±3.3 46.6±3.3 46.6±6.6 66.6±3.3 72 20.0±5.7 33.3±3.3 46.6±5.3 60.0±5.7   |                     | 9        | $50.0 \pm 5.7$  | $53.3 \pm 8.8$  | $9.9 \pm 9.99$             | $73.3 \pm 8.8$  | $80.0 \pm 5.7$  | 2%            | $21 \pm 2.4$          | 44.7             |
| 48 63.3 ± 3.3 80.0 ± 5.7 86.6 ± 3.3 86.6 ± 6.6 72 80.0 ± 5.7 83.3 ± 3.3 83.3 ± 3.3 86.6 ± 3.3  Mean 66.6 81.6 77.9 80.62  1 26.6 ± 8.8 36.6 ± 3.3 50.0 ± 10.0 56.6 ± 3.3  6 36.6 ± 6.6 43.3 ± 8.8 46.6 ± 3.3 60.0 ± 0.0  24 30.0 ± 5.7 36.6 ± 6.6 40.0 ± 5.7 40.0 ± 15.2  48 36.6 ± 3.3 46.6 ± 3.3 46.6 ± 3.3 60.0 ± 5.7  72 20.0 ± 5.7 33.3 ± 3.3 46.6 ± 3.3 60.0 ± 5.7  |                     | 24       | $80.0 \pm 5.7$  | $83.3 \pm 6.6$  | $83.0 \pm 3.3$             | $83.3 \pm 3.3$  | $93.3 \pm 6.6$  | 7.5%          | $10 \pm 1.6$          | 73.7             |
| 72 80.0±5.7 83.3±3.3 83.3±3.3 86.6±3.3  Mean 66.6 81.6 77.9 80.62  1 26.6±8.8 36.6±3.3 50.0±10.0 56.6±3.3  6 36.6±6.6 43.3±8.8 46.6±3.3 60.0±0.0  24 30.0±5.7 36.6±6.6 40.0±5.7 40.0±15.2  48 36.6±3.3 46.6±3.3 46.6±3.3 60.0±5.7  72 20.0±5.7 33.3±3.3 46.6±3.3 60.0±5.7   |                     | 48       | $63.3 \pm 3.3$  | $80.0 \pm 5.7$  | $86.6 \pm 3.3$             | $9.9 \pm 9.98$  | $9.9 \pm 9.96$  |               |                       |                  |
| Mean       66.6       81.6       77.9       80.62         1       26.6 ± 8.8       36.6 ± 3.3       50.0 ± 10.0       56.6 ± 3.3         6       36.6 ± 6.6       43.3 ± 8.8       46.6 ± 3.3       60.0 ± 0.0         24       30.0 ± 5.7       36.6 ± 6.6       40.0 ± 5.7       40.0 ± 15.2         48       36.6 ± 3.3       46.6 ± 3.3       46.6 ± 5.7       60.0 ± 5.7         72       20.0 ± 5.7       33.3 ± 3.3       46.6 ± 3.3       60.0 ± 5.7  |                     | 72       | $80.0 \pm 5.7$  | $83.3 \pm 3.3$  | $83.3 \pm 3.3$             | $86.6 \pm 3.3$  | $86.6 \pm 3.3$  |               |                       |                  |
| 1 26.6 ± 8.8 36.6 ± 3.3 50.0 ± 10.0 56.6 ± 3.3<br>6 36.6 ± 6.6 43.3 ± 8.8 46.6 ± 3.3 60.0 ± 0.0<br>24 30.0 ± 5.7 36.6 ± 6.6 40.0 ± 5.7 40.0 ± 15.2<br>48 36.6 ± 3.3 46.6 ± 3.3 46.6 ± 3.3 60.0 ± 5.7<br>72 20.0 ± 5.7 33.3 ± 3.3 46.6 ± 3.3 60.0 ± 5.7  |                     | Mean     | 9.99            | 81.6            | 77.9                       | 80.62           | 87.3            |               |                       |                  |
| $36.6 \pm 6.6$ $43.3 \pm 8.8$ $46.6 \pm 3.3$ $60.0 \pm 0.0$<br>$30.0 \pm 5.7$ $36.6 \pm 6.6$ $40.0 \pm 5.7$ $40.0 \pm 15.2$<br>$36.6 \pm 3.3$ $46.6 \pm 3.3$ $46.6 \pm 6.6$ $66.6 \pm 3.3$<br>$20.0 \pm 5.7$ $33.3 \pm 3.3$ $46.6 \pm 3.3$ $60.0 \pm 5.7$   | Methanol            | 1        | $26.6 \pm 8.8$  | $36.6 \pm 3.3$  | $50.0 \pm 10.0$            | $56.6 \pm 3.3$  | $70.0 \pm 5.7$  | 2.5%          | $26 \pm 0.7$          | 31.6             |
| $30.0 \pm 5.7$ $36.6 \pm 6.6$ $40.0 \pm 5.7$ $40.0 \pm 15.2$ $36.6 \pm 3.3$ $46.6 \pm 6.6$ $66.6 \pm 3.3$ $20.0 \pm 5.7$ $33.3 \pm 3.3$ $46.6 \pm 3.3$ $60.0 \pm 5.7$   |                     | 9        | $36.6 \pm 6.6$  | $43.3 \pm 8.8$  | $46.6 \pm 3.3$             | $0.0 \pm 0.0$   | $63.3 \pm 3.3$  | 2%            | $23.6 \pm 0.8$        | 37.9             |
| $36.6 \pm 3.3$ $46.6 \pm 3.3$ $46.6 \pm 6.6$ $66.6 \pm 3.3$ $20.0 \pm 5.7$ $33.3 \pm 3.3$ $46.6 \pm 3.3$ $60.0 \pm 5.7$   |                     | 24       | $30.0 \pm 5.7$  | $36.6 \pm 6.6$  | $40.0 \pm 5.7$             | $40.0 \pm 15.2$ | $53.3 \pm 15.2$ | 7.5%          | $16.6 \pm 1.4$        | 56.3             |
| $20.0 \pm 5.7$ $33.3 \pm 3.3$ $46.6 \pm 3.3$ $60.0 \pm 5.7$   |                     | 48       | $36.6 \pm 3.3$  | $46.6 \pm 3.3$  | $46.6 \pm 6.6$             | $66.6 \pm 3.3$  | $73.3 \pm 3.3$  |               |                       |                  |
|   |                     | 72       | $20.0 \pm 5.7$  | $33.3 \pm 3.3$  | $46.6 \pm 3.3$             | $60.0 \pm 5.7$  | $66.6 \pm 5.7$  |               |                       |                  |
| 1 29.9 39.2 45.9 56.  |                     | Mean     | 29.9            | 39.2            | 45.9                       | 56.6            | 65.3            |               |                       |                  |

contd...

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Table contd...

| Azadirachta indica |      |                |                |                |                |                 |      |                |      |
|--------------------|------|----------------|----------------|----------------|----------------|-----------------|------|----------------|------|
| Hexane             | 1    | $76.6 \pm 3.3$ | $83.3 \pm 3.3$ | $86.6 \pm 3.3$ | $86.6 \pm 3.3$ | $93.3 \pm 6.6$  | 2.5% | $17.8 \pm 0.8$ | 53.2 |
|                    | 9    | $76.6 \pm 6.6$ | $86.6 \pm 3.3$ | $86.6 \pm 3.3$ | $83.3 \pm 3.3$ | $96.6 \pm 3.3$  | 2%   | $11.6 \pm 0.6$ | 69.5 |
|                    | 24   | $83.3 \pm 3.3$ | $80.0 \pm 5.7$ | $93.3 \pm 3.3$ | $93.3 \pm 3.3$ | $96.6 \pm 3.3$  | 7.5% | $2.2 \pm 0.9$  | 94.2 |
|                    | 48   | $73.3 \pm 3.3$ | $83.3 \pm 3.3$ | $86.6 \pm 3.3$ | $93.3 \pm 3.3$ | $93.3 \pm 3.3$  |      |                |      |
|                    | 72   | $73.3 \pm 3.3$ | $86.6 \pm 3.3$ | $83.3 \pm 3.3$ | $93.3 \pm 6.6$ | $93.3 \pm 3.3$  |      |                |      |
|                    | Mean | 9.9/           | 83.9           | 87.2           | 89.9           | 94.6            |      |                |      |
| Ethyl acetate      | 1    | $73.3 \pm 8.8$ | $73.3 \pm 3.3$ | $80.0 \pm 0.0$ | $83.3 \pm 3.3$ | $93.3 \pm 3.3$  | 2.5% | $21.4 \pm 0.8$ | 43.7 |
|                    | 9    | $76.6 \pm 6.6$ | $76.6 \pm 6.6$ | $83.3 \pm 3.3$ | $86.6 \pm 3.3$ | $93.3 \pm 3.3$  | 5%   | $16 \pm 0.6$   | 57.9 |
|                    | 24   | $83.3 \pm 3.3$ | $86.6 \pm 3.3$ | $90 \pm 5.7$   | $93.3 \pm 3.3$ | $100 \pm 0.0$   | 7.5% | $13.4 \pm 0.8$ | 64.7 |
|                    | 48   | $83.3 \pm 3.3$ | $86.6 \pm 6.6$ | $90 \pm 5.7$   | $93.3 \pm 3.3$ | $96.6 \pm 3.3$  |      |                |      |
|                    | 72   | $73.3 \pm 3.3$ | $83.3 \pm 3.3$ | $83.3 \pm 3.3$ | $93.3 \pm 3.3$ | $93.3 \pm 3.3$  |      |                |      |
|                    | Mean | 6.77           | 81.2           | 85.3           | 6.68           | 95.3            |      |                |      |
| Methanol           | 1    | 46.6 ±         |                |                |                |                 | 2.5% | $25.2 \pm 0.9$ |      |
|                    |      | 14.5           | $53.3 \pm 12$  | $53.3 \pm 6.6$ | $60.0 \pm 5.7$ | $60.0 \pm 11.5$ |      |                | 33.7 |
|                    | 9    | 53.3 ±         | $\pm 0.09$     |                |                |                 | 5%   | $16.6 \pm 1.8$ |      |
|                    |      | 12.0           | 5.78           | $60.0 \pm 5.7$ | $70.0 \pm 5.7$ | $70.0 \pm 5.7$  |      |                | 56.3 |
|                    | 24   | €0.0 ±         |                |                |                |                 | 7.5% | $15.4 \pm 0.6$ |      |
|                    |      | 5.78           | $66.6 \pm 6.6$ | $73.3 \pm 6.6$ | $73.3 \pm 3.3$ | $76.6 \pm 12.0$ |      |                | 59.5 |
|                    | 48   |                |                |                | 80.0∓          |                 |      |                |      |
|                    |      | $66.6 \pm 3.3$ | $70.0 \pm 5.7$ | $80.0 \pm 5.7$ | 10.0           | $86.6 \pm 3.3$  |      |                |      |
|                    | 72   |                |                | 76.6 ±         |                |                 |      |                |      |
|                    |      | $53.3 \pm 3.3$ | $70 \pm 10.0$  | 10.0           | $86.6 \pm 6.6$ | $90.0 \pm 10.0$ |      |                |      |
|                    | Mean | 55.9           | 63.9           | 9.89           | 77.47          | 8.08            |      |                |      |

reported that diethyl ether fruit extract of *Toddalia* asiatica (L.) Lam. exhibited 100% repellent activity against *S. oryzae* adults at 20 iL concentration.

As regards F, progeny emergence, significantly lower number of progeny (1.4 to 26) (F = 50.28; df =112; p<0.0001) was produced in most of the treatments in comparison to the untreated control (38). The F<sub>1</sub> progeny emergence was minimum in ethyl acetate extract of S. nuxvomica (1.4) followed by hexane extracts of L. sativum (1.8) and A. indica (2.2) at 7.5% w/w. Even at lower dose of 2.5% w/w, few progeny emerged (8.2) from maize treated with ethyl acetate extract of S. nuxvomica. Similarly, the % reduction in F, progeny was also higher with ethyl acetate extract of S. nuxvomica (96.3%), hexane extract of L. sativum (95.3%) and hexane and methanol extracts of A. indica (94.2%, 90.5%) at 7.5% w/w. There was 31.6 to 78.4% reduction in  $F_1$ progeny emergence when maize treated with the remaining plant extracts at 2.5 and 5.0% w/w concentrations. The F<sub>1</sub> progeny reduction in maize treated with plant extracts might be due to increased adult mortality and inhibition of oviposition by S. oryzae.

The results revealed that at all the concentrations, ethyl acetate extract of *S. nux-vomica* reduced the F<sub>1</sub> progeny emergence to maximum extent followed by hexane and methanol extracts. These agree with those of other authors who reported such reduction. Yankanche and Gadache (2010) reported that ethanol extracts of *Clerodendron inerme* (L.) and *Withania somnifera* (Dunal) completely suppressed progeny emergence of *S. oryzae* at 2.5 and 5% concentration. Similarly, Udo (2005) reported significant reduction of F<sub>1</sub> progeny emergence in maize treated with *Dennetia tripetala* Bak. f. leaf powder at 10% concentration. Recently, Akter and Akter (2016) reported reduced adult emergence of *S. oryzae* with neem leaf powder @ 1g/100g grain.

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#### REFERENCES

Akhtar, M., Arshad, M., Raza, A. B. M., Chaudhary, M. I., Iram, N., Akhtar, N., Mahmood, T., 2013. Repellent effects of certain plant extracts against rice weevil, Sitophilus oryzae L. (Coleoptera: Curculionidae). International Journal of Agriculture and Applied Sciences, 5: 69-73.

- Akter, M. and Akter, S. 2016. Effect of botanicals against Sitophilus oryzae on wheat grain in the laboratory. European International Journal of Science and Technology, 5 (7): 51-57.
- Butler, J.H., Rodriguez, J.M. 1996. Methyl bromide in the atmosphere. In: Bell CH, Price N, Chakrabarti B, editors. The methyl bromide issue, Vol. 1. West Sussex: Willey; 1996. pp. 27–90.
- Daglish, G.J., Nayak, M.K., Pavic, H., 2014. Phosphine resistance in *Sitophilus oryzae* (L.) from Eastern Australia: Inheritance, fitness and prevalence. *Journal of Stored Products Research*, 59: 237-244.
- Duke, J. A., Bogenschutz-Godwin, M. J., Ducelliar, J and Duke, P. A. K. 2002. Handbook of Medicinal Herbs, CRC Press, Boca Raton, Fla, USA.
- Giolebiowska, Z. 1969. The feeding and fecundity of Sitophilus granarius (L), Sitophilus oryzae (L) and Rhizopertha dominica (F) in wheat grain. Journal of stored Products Research, 5: 143-155.
- Hossain, F., Lacroix, M., Salmieri, S., Khanh Vua., Peter A. Follet., 2014. Basil oil fumigation increases radiation sensitivity in adult Sitophilus oryzae (Coleoptera: Curculionidae). Journal of Stored Products Research, 59:108-112.
- Jilani, G., Saxena, R.C., 1990. Repellent and feeding deterrent effects of turmeric oil sweetflag oil, neem oil, and a neem-based insecticide against lesser grain borer (Coleoptera, Bostrychidae). *Journal of Economic Entomology*, 83: 629-634.
- Khani, M., Awang, R. M., Omar, D., Rahmani, M., Rezazadeh, S., 2013. Tropical medicinal plant extracts against rice weevil, Sitophilus oryzae L. Journal of Medicinal Plants Research, 5: 259-265.
- Lakshmi Soujanya, P., Sekhar, J.C. and Kumar, P. 2013. Maize grain losses due to *Sitophilus oryzae* (L). and *Sitotroga cerealella* (Oliv.) infestation during storage. *Maize Journal*, 2: 57-59.
- Lee, S.E., Lee, B.H., Choi, W.S., Park, B.S., Kim, J.G., Campbell, B.C., 2001. Fumigant toxicity of volatile natural products from Korean spices and medicinal plants towards the rice weevil, Sitophilus oryzae (L). Pest Management Science, 57: 548-553.
- Mathivanan, K., Rengasamy, D., Rajesh, V., Palani, R., Jayaraman, P., 2014. Phytochemical potential of Euphorbia hirta and Strychnos nux vomica with reference to anti diabetic and antioxidant properties. International Journal of Pharmacognosy and Phytochemical Research 6: 1024-1031.
- Mors, W.B., Nascimento, M.C., Pereira, B.M.R., Pereira, N. A., 2000. Plant natural products active against snake bite-the molecular approach. *Phytochemistry*, 55: 627-642.
- Nattudurai, G., Irudayaraj, S.S., Paulraj, M.G., Baskar, K., Ignacimuthu, S. 2015. Insecticidal and repellent activities of Toddalia asiatica (L.) Lam. extracts against three major stored product pests. Entomology Ornithology Herpetology, 4: 148.
- Nerio, L., Olivero-Verbel, J., Stashenko, E., 2009. Repellency activity of essential oil from seven aromatic plants grown in Colombia against Sitophilus zeamais Motschulsky (Coleoptera). Journal of Stored Products Research, 45: 212-214.
- Pretheep-Kumar, P., Mohan, S., and Ramaraju, K. 2004. Proteinenriched pea flour extract stored milled rice against the rice weevil, *Sitophilus oryzae*. *Journal of Insect Science*, 4:26.
- Raval, N. 2016. A comprehensive review of Lepidium sativum

- Linn. A traditional medicinal plant. World Journal of Pharmacy and Pharmaceutical Sciences, 5(5): 1593-1601.
- Santos, A.C.V., Fernandes, C.C., Lopes, L.M., Sousa, A.H., 2015. Use of plant oils from the Southwestern Amazon for the control of maize weevil. *Journal of Stored Products Research*, 63: 67-70.
- Tavares, W.D., Faroni, A., Fouad, RCHA, Freitas, S., Colazanuncio, J., 2014. Effects of astilbin from *Dimorphandra mollis* (Fabaceae) flowers and Brazilian plant extracts on *Sitophilus zeamais* (Coleoptera: Curculionidae). *Florida Entomologist*, 97: 892-901.
- Talukder, F. A., Howse, P. E., 1994. Repellent, toxic and food protectant effects of pithraj, *Aphanamixis polystachya* extracts against the pulse beetle, *Callosobruchus chinensis* in storage. *Journal of Chemical Ecology*, 20: 899-908.
- Utono, I. M. and Gibson, G., 2015. New stimuli-enriched laboratory

- bioassay used to identify improved botanical repellent treatment, Lem-ocimum, to control the stored-grain pest *Tribolium castaneum. Journal of Stored Products Research*, 64: 27-35
- Udo, I. O 2015 Laboratory evaluation of pepper fruit (*Dennetia tripetala*) against maize weevil (*Sitophilus zeamais*) on stored maize grains. Swift Journal of Agricultural Research, 1 (6): 67-69.
- Wei, L.L., Hua, R.M., Li, M.Y., Huang, Y.Z., Li, S.G., He, Y.J., Shen, Z.H., 2014. Chemical composition and biological activity of star anise *Illiciumverum* extracts against maize weevil, Sitophilus zeamais adults. Journal of Insect Science, 14: 1-13.
- Yankanchi, S.R. and Gadache, A. H., 2010. Grain protectant efficacy of certain plant extracts against rice weevil, Sitophilus oryzae L. (Coleoptera: Curculionidae). Journal of Biopesticides, 3: 511-513.

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