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# Bioassay on the effect of plant origin smoke and essential oils against mealworm (*Tenebrio molitor*) on stored wheat at Prayagraj, Uttar Pradesh

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**Abstract**
Studies on the effect of plant origin smoke (Neem, *Lantana camara* and Eucalyptus leaves in semi-dried condition) and essential oils on mortality and percent grain damage of adults of *Tenebrio molitor* under laboratory conditions in the Department of Entomology, SHUATS, Prayagraj, U.P. during 2019. The results showed that more than 50 per cent insect mortality was observed after 120 hrs of exposure to neem leaves smoke and more than 40 per cent mortality was observed after 120 hrs of exposure to *Lantana camera* and eucalyptus leaves smoke and followed by essential oils and lowest per cent grain damage was observed after the smoke generated of neem leaves with (12.47%) and it was followed by eucalyptus leaves and karanj seed oil with (14.33%) and (15.33%) respectively. Therefore, the present laboratory studies clearly shows that plant origin smoke and essential oils were lethal to storage insect pest were almost as effective when compared with coragen (Insecticide). Hence it may be concluded that the plant origin products are eco-friendly and can easily be incorporated for stored insect pests in wheat.

**Keywords:** stored wheat, *Tenebrio molitor*, mortality, grain damage, smoke, essential oils

## 1. Introduction
Wheat (*Triticum aestivum* L., *T. durum* Desf.) is an important cereal crop in India. It is widely grown throughout the temperate zones and in some tropical/sub-tropical areas at higher elevations. In India, according to the second advance estimate of the government, Wheat production touched 99.70 Million tonnes in 2017-18. The area under wheat crop in 2017-18 was 29.58 million hectares. Whereas in the Uttar Pradesh area under wheat production was 9.75 million hectares and total production was recorded up to 31.88 million tonnes (Directorate of economics & statistics, DAC & FW, 2018) [6]. The consumption of wheat in our country is about 89.90 lakh tons annually (Masolkar *et al*., 2018) [11].
Post-harvest losses around 9.3 to 42% of achievable wheat are due to biotic (insects, molds, rodents and birds) and abiotic (temperature and humidity) variables of environment, Insect pests of the environmental biotic part are the more common entities, which cause 10 to 20% storage losses (Humaira and Ghulam, 2016) [9]. The estimated post-harvest loss during 2003-04 in storage at farm level in wheat was 21.99 percent or 0.95 kg/q (Basavaraja *et al*., 2007) [2].
Insect infestation, causing losses are the most serious problems in grain storage, particularly in villages and towns in developing countries because of humid- tropical conditions, poor sanitation and inappropriate storage facilities. The most economically important insect pests of stored wheat are the rice weevils, *Sitophilus oryzae*, lesser grain borer, *Rhizopertha dominica*, rice moth, *Corcyra cephalonica*, Angoumois grain moth, *Sitotroga cerealella*, Indian meal moth, *Plodia interpunctella* and red rust flour beetle, *Tribolium castaneum* (Yadav and Tiwari, 2018) [18]. The insects and other pests severely deteriorated agricultural stored products and are responsible for worldwide losses of stored grains ranging from 10 to 40 percent per annum (Ahmed *et al*., 2013) [1].
*Tenebrio molitor* is a holometabolous insect that is considered to be a harmful pest of stored grain in South America (Schroeckenstein *et al*., 1990) [14]. However, its larvae, commonly referred to as mealworms, are used as pet food in many countries (cotton, 1927) [5].
The mealworm beetle, *Tenebrio molitor* Linnaeus (Coleoptera: Tenebrionidae) is a pest of stored products such as starches, food for cats and dogs, and pasta. This insect may also infest broken grains of *Zea mays* (L.) (Poales: Poaceae), *Triticum aestivum* (L.) (Poales: Poaceae), and *Glycine max* (L.) (Fabales: Fabaceae) (Punzo & Mutchmor, 1980 [12]; Fazolin *et al.*, 2007 [7]; Cosimi *et al.*, 2009) [4].

The control of these insect pests around the world is primarily dependent upon continued applications of organophosphorus and pyrethroid insecticide and fumigants such as methyl bromide and phosphine. The development of insect resistance to phosphine has been also reported (Collins *et al.*, 2005) [3]. Their uninterrupted and indiscriminate use not only had led to the development of resistant strains but also the accumulation of toxic residues on food grains used for human consumption that leads to health hazards (Sharma and Meshram, 2006) [15].
In this context, to avoid the injudicious use of synthetic chemicals the naturally produced smoke has a great potential for causing insect mortality and promoting seed germination and enhancing plant growth. This easily accessible technology is a good substitute for hazardous chemicals and can easily to adopt by the users without having any adverse effects on stored wheat grains and human health. (Yadav and Tiwari, 2018) [18]. *Tenebrio molitor* is considered as pest as it is causing damage to stored grains. Preventing long term storage and meager information is available on the management of this pest under storage,

## 2. Materials and Methods

The present investigation was carried out at Laboratory, Department of Entomology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India. Treatments: Eight treatments including control. The initial infested seeds of wheat were obtained from the college farm stores and surrounding warehouses and reared to obtain the culture of mealworm beetle (*Tenebrio molitor*)**.** Botanicals such as neem leaves, *Lantana camera* leaves and eucalyptus leaves karanj oil, castor oil, camphor oil, insecticide coragen, plastic vials of 1kg labels, weighing balance, conical flasks, bee smoker, labels, weighing balance, trays, etc., were used. The initial infested seeds of wheat were obtained from the college farm stores and surrounding warehouses and reared to obtain the culture of mealworm beetle (*Tenebrio molitor*)**.**

### 2.1 Collection of materials and Production of Smoke

The sound and healthy wheat grains of variety Lok-1 were cleaned and sieved to remove the fractions of grains or insects. The grains were sterilized at 60±5 °C for 8 hrs to eliminate both apparent and hidden infestation of insects and mites. The Neem leaves, *Lantana camara* leaves and Eucalyptus leaves were collected from the campus areas. Smoke was produced by burning semi-dried neem leaves, *Lantana camara* leaves and eucalyptus leaves separately in a smoker and aerosol smoke was collected for further process.

### 2.2 Mixing of grain protectants

One kg capacity labels were taken and each filled with 100g of wheat seeds and treated seed material was stored in one kg labels and covered with the muslin cloth and fastened with a rubber band, untreated served as control. 100g wheat seeds taken into different one kg labels to replicate the treatments three times

### 2.3 Recording observations

The laboratory bioassays were conducted on the effect of smoke generated by burning of Neem leaves, *Lantana camara* leaves and Eucalyptus leaves separately on the mortality of major stored insect pest *Tenebrio molitor* by releasing 50 adult insects each, separately in conical flasks in three replications (Total number of insects = 150/ treatment) containing 100gms of grains of wheat. After releasing insects, smoke was filled in conical flasks by burning of neem leaves, *Lantana camara* leaves and eucalyptus leaves, separately with the help of smoker and opening of the conical flasks were tightly closed with cotton plugs. The experiments were set up separately for the different intervals of time *i.e.* 3, 24, 48, 72, 96 and 120 hrs to find out the effect of smoke on all tested insects under smoke exposure for different time periods.

### 2.4 Observations on percent damage and percent mortality

The observations on percent damage per 100 seeds and percent mortality of *Tenebrio molitor* was estimated and recorded after 120 hrs from both oil treated and smoke treated treatments by using the following formulae

$$\text{Percent damage} = \frac{\text{No.of damaged grains}}{\text{Total no.of grains}} \text{X } 100$$

$$\text{Perent mortality} = \frac{\text{No. of healthy insects released}}{\text{Total no. of died insects}} \text{X } 100$$

This method of bioassay (Kumavat, 2009) [10] was repeated after 30, 60, 90 and 180 days of application of treatments and F1 adult emergence, percent grain damage and weight loss was assessed to find out the efficacy of tested indigenous products against storage insects, S. *oryzae* and R. *dominica.*

### 2.5 Statistical analysis

The Data was subjected to Complete Randomized Design using angular transformations. Statistical analysis and interpretation of results were done by calculating values of C.D. (critical difference) at 5% level of significance through analysis of variance technique as described by Gomez and Gomez (1984) [8].

## 3. Results and Discussion

### 3.1 Mortality of *Tenebrio molitor* at different time intervals of exposure to smoke

The cumulative mortality of *Tenebrio molitor* adults after smoke exposure of 3, 24, 48, 72, 96, and 120 hours application of the botanicals were significantly different and the data recorded is mentioned in table 1. All the botanicals used (Neem leaves, *Lantana camara* leaves and Eucalyptus leaves in semi-dried conditions) recorded significantly high adult mortality when compared with the control.
Among the all treatments applied, the higher mortality due to the application of the botanicals after 3 hours of exposure time was observed in treatment Neem leaves with 11.33 mortality which was highest amongst all treatments and was found significantly at par with treatment *Lantana camera* leaves with 8.00 mortality. The smoke exposure of Eucalyptus leaves was found next effective treatments with 6.33 mortality. The untreated check recorded no mortality.
Among the all treatments applied, the higher mortality due to the application of the botanicals after 24 hours of exposure time was observed in treatment Neem leaves with 13.67 mortality which was highest amongst all treatments and was found significantly at par with treatment *Lantana camera* leaves with 9.33 mortality. The smoke exposure of Eucalyptus leaves was found next effective treatments with 8.67 mortality. The untreated check recorded no mortality.
Among the all treatments applied, the higher mortality due to the application of the botanicals after 48 hours of exposure

time was observed in treatment Neem leaves with 17.00 mortality which was highest amongst all treatments and was found significantly at par with treatment *Lantana camera* leaves with 14.67 mortality. The smoke exposure of Eucalyptus leaves was found next effective treatments with 11.33 mortality. The least mortality was recorded in untreated check with 1.33 mortality.

Among the all treatments applied, the higher mortality due to the application of the botanicals after 72 hours of exposure time was observed in treatment Neem leaves with 22.00 mortality which was highest amongst all treatments and was found significantly at par with treatment *Lantana camera* leaves with 17.00 mortality. The smoke exposure of Eucalyptus leaves was found next effective treatments with 13.33 mortality. The least mortality was recorded in untreated check with 2.00 mortality.

Among the all treatments applied, the higher mortality due to the application of the botanicals after 96 hours of exposure time was observed in treatment Neem leaves with 24.67 mortality which was highest amongst all treatments and was found significantly at par with treatment *Lantana camera* leaves with 21.00 mortality. The smoke exposure of Eucalyptus leaves was found next effective treatments with 19.33 mortality. The least mortality was recorded in untreated check with 3.33 mortality.

Among the all treatments applied, the higher mortality due to the application of the botanicals after 120 hours of exposure time was observed in treatment Neem leaves with 26.33 mortality which was highest amongst all treatments and was found significantly at par with treatment *Lantana camera* leaves with 25.33 mortality. The smoke exposure of Eucalyptus leaves was found next effective treatments with 21.33 mortality. The least mortality was recorded in untreated check with 2.67 mortality.

### 3.2 Percent mortality

The data recorded on percent mortality of *Tenebrio molitor* adult after smoke exposure treatment at 120 hours of exposure time of application of the botanicals recorded was found significantly different and the data recorded is mentioned in table1. All the botanicals used (Neem leaves, *Lantana camara* leaves and Eucalyptus leaves in semi-dried conditions) recorded significantly high percent mortality when compared with the control. The data recorded after 120hrs of smoke exposure treatment ranged from 57.33 to 5.33 percent mortality. Among the all treatments applied, the highest percent mortality due to the application of the botanicals for 120 hours of exposure time was observed in treatment coragen with 57.33 percent mortality which was highest amongst all treatments and was found significantly at par with treatment Neem leaves with 51.33 percent mortality and it was followed by *Lantana camera* and Eucalyptus leaves with 44.67 and 42.67 percent mortality. The remaining treatment castor oil, camphor oil and karanj seed oil recorded the next effective treatments with 28.00, 32.67 and 36.67 percent mortality. The least percent mortality was observed in untreated check with 5.33 percent mortality. All the treatments were found significantly superior over the untreated check.

### 3.3 Percent grain damage

The data recorded on percent damage of *Tenebrio molitor* adult after smoke exposure treatment at 120 hours of exposure time of application of the botanicals were found significantly different and the data recorded is mentioned in table 2. All the botanicals used (Neem leaves, *Lantana camara* leaves and eucalyptus leaves in semi-dried condition) recorded significantly low percent damage when compared with the control. The data recorded after 120hrs of smoke exposure treatment ranged from 8.67 to 25.67 percent damage. Among the all treatments applied, the lowest percent damage due to the application of the botanicals for 120 hours of exposure time was observed in treatment coragen with 8.67 percent damage which was lowest amongst all treatments and was found significantly at par with treatment Neem leaves with 12.67 percent damage and it was followed by eucalyptus leaves and karanj seed oil with 14.33 and 15.33 percent damage. The remaining treatment Castor oil, *Lantana camera* leaves and Camphor oil recorded the next effective treatments with 19.00, 19.67 and 20.33 percent damage. The maximum percent damage was observed in untreated check with 25.67 percent damage. All the treatments were found significantly superior over the untreated check.

**Table 1:** Mortality of *Tenebrio molitor* at 3, 24, 46, 72, 96 and 120 hours after treatment

| Sr. No. | Smoke Treatment | Mortality (hours after treatment) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 3 hrs | 24 hrs | 48 hrs | 72 hrs | 96 hrs | 120 hrs |
| 1 | Neem leaves | 11.33 (3.44) | 13.67 (3.76) | 17.00 (4.18) | 22.00 (4.74) | 24.67 (5.02) | 26.33 (5.18)* |
| 2 | *Lantana camara* leaves | 8.00 (2.92) | 9.33 (3.14) | 14.67 (3.89) | 17.00 (4.18) | 21.00 (4.64) | 25.33 (5.08) |
| 3 | Eucalyptus leaves | 6.33 (2.61) | 8.67 (3.03) | 11.33 (3.44) | 13.33 (3.72) | 19.33 (4.45) | 21.33 (4.67) |
| 4 | Untreated check | 0.00 (0.00) | 0.00 (0.00) | 1.33 (1.35) | 2.00 (1.58) | 3.33 (1.96) | 2.67 (1.78) |
| | 'F' test | S | S | S | S | S | S |
| | SE (m) ± | 0.18 | 0.20 | 0.15 | 0.19 | 0.22 | 0.27 |
| | CD at 5% | 0.58 | 0.66 | 0.50 | 0.61 | 0.72 | 0.88 |

* Figures in parenthesis are √X +0.5 values

**Table 2:** Percent damage and percent mortality by *Tenebrio molitor*

| Sr. No. | Treatment On wheat grains | Dose per 100gm seeds | % Mortality | % damage/ 100 seeds |
|---|---|---|---|---|
| T1 | Karanj seed oil | 2 ml | 36.67 (37.27) | 15.33 (23.05)* |
| T2 | Castor oil | 2 ml | 28.00 (31.95) | 19.00 (25.84) |
| T3 | Camphor oil | 2 ml | 32.67 (34.86) | 20.33 (26.80) |
| T4 | Eucalyptus leaves (semi dried) | --- | 42.67 (40.78) | 19.67 (26.33) |
| T5 | Neem leaves (semi dried) | --- | 51.33 (45.76) | 12.67 (20.85) |
| T6 | *Lantana camara* leaves (semi dried) | ---- | 44.67 (41.94) | 14.33 (22.25) |
| T7 | Coragen (Rynaxypyr) | 10mg/ 100gms seed | 57.33 (49.22) | 8.67 (17.12) |
| T8 | Untreated (control) | | 5.33 (13.35) | 25.67 (30.44) |
| | 'F' test | | Sig. | Sig. |
| | SE (m) ± | | 2.78 | 2.04 |
| | CD at 5% | | 8.83 | 6.13 |

***** Value in parenthesis is angular transformed value.

All the treatments were found significantly superior to control in percent insect mortality of released adults was highest in treatments viz., Coragen (57.33%) Neem leaf smoke (51.33%), *Lantana Camara* leaf smoke (44.64%), and Eucalyptus Leaf smoke (42.67%) under the airtight conditions agreed with (Yadav and Tiwari, 2018) [18], the complete mortality of eggs of *C. maculatus* was observed by CO2 treatment under pressure Shazali *et al*., (2004) [16] with more than 80%, the mortality of pulse beetle, *C. maculatus* at 24 h exposure of cow dung cake smoke Srivastava *et al*., (2005) [17]. And remaining oil treatments Karanj oil, Castor oil and Camphor oil recorded (36.27%), (28.00%) and (32.67%) insect mortality respectively. All the treatments were found to be significantly superior to control in per cent damage. The lowest per cent grain damage was recorded in coragen with (8.67%) and maximum per cent grain damage in untread grains (25.67%). Among smoke treatments Neem leaf smoke, *Lantana Camara* smoke and Eucalyptus leaf smoke were found highly effective against *Tenebrio Molitor* with significantly minimum per cent grain damage of (12.67%), (14.33%) and (19.67%) and remaining oil treatmets Karanj oil, Castor oil and Camphor oil recorded (15.33%), (19.00%) and (20.33%) per cent damage respectively. Similar results were found in all the effectiveness of karanj oil aganist the pulse bettle were observed by Rolania and Bhargawa, 2015 [13] who reported that it minimize the seed damage. The remaining oil treatments expressed similar effects and found effective up on khapra beetle which were observed by Masolkar *et al*., (2018) [11]

## 4. Conclusion

The present studies showed the efficacy of the plant origin smoke and essential oils against the mealworm beetle *Tenebrio molitor* on stored wheat. Among all treatments given to seeds the highest mortality was observed in seeds treated with coragen (57.33%) and was found at par with smoke exposure by Neem leaves with (51.33 %) for 120 hrs of exposure and in essential oils treatments karanj oil with (36.67%) and lowest percent grain damage was observed in seeds treated with coragen (8.67%) which was lowest amongst all treatments and was found significantly at par with treatment Neem leaves with (12.67%) and it was followed by eucalyptus leaves and karanj seed oil with (14.33%) and (15.33%). All the treatments were recorded superior over the untreated check. The present studies on the effect of plant origin smoke and essential oils on storage insect pests were novel and preliminary studies conducted at prayagraj (U.P). These results indicate that the plant origin smoke and essential oils, which are cheap, eco-friendly, and household product which help in the control of insect infestation for small-scale farmers under storage conditions.

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