

Effect Of Temperature On The Efficacy Of Oil Formulations Against *Sitophilus Oryzae*(Coleoptera: Curculionidae) In Maize

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ABSTRACT

Laboratory experiments were conducted to study the effect of temperature on the effectiveness of the oil formulation i.e., neem oil, eucalyptus oil, and canola oil against rice weevil, *Sitophilus oryzae* (Linn.) on stored maize seeds during 2021-22. The treated maize seeds were maintained at different temperature ranges within BOD incubators, recording percent adult mortality and rice weevil population growth. The results showed that 3 days after treatment (3DAT) neem and eucalyptus oils were most effective against *S. oryzae* with 65.33 and 63.97 percent mortality respectively at 25°C which reduced to 63.33 and 62.41 percent respectively at 36°C. The Cannola oil showed alike results at 25°C to 36 °C. Seven and fourteen days after treatment, neem and eucalyptus oil showed a reduction in percent mortality with an increase in temperature whereas percent mortality in cannola oil-treated seeds at different temperatures remains unaffected. In case of population growth up to 3 months of storage, neem and eucalyptus oil showed an increase in the population of *S. oryzae* as the temperature increased but canola oil remains unaffected while after 6 months all tested oil formulations indicated a positive correlation with temperature.

Keywords: *S. oryzae*, neem oil, eucalyptus oil, canola oil, efficacy, and temperature.

INTRODUCTION

Maize (*Zea mays*. L) is reported to be highly susceptible to insect-pest attack in the field and in storage conditions (Gimma *et al.*, 2008). The maize harvested grains are basically used as food, feed, and fodder (Padin *et al.*, 2002). Stocked grains and their derived products have significant losses due to infestation of various insect pests under stored conditions (Pérez Mendoza *et al.*, 2004). Rice weevil, *Sitophilus* spp (Linn), Lesser grain borer, *Rhyzopertha domonica* (Fabricius); Red flour beetle, *Tribolium castaneum* (Herbest); Rice moth, *Corcyra cephalonica* (Stainton); Angoumois grain moth, *Sitotroga cerealella* (oliver) are insect-pests of economic importance in stored maize. Among these, *S. oryzae* is primary pests whose infestation causes major losses as high as 100 percent in stored maize in India as well as other countries (Irabagon, 1959, Singh *et al.*, 1974). Though these quantitative and qualitative losses by rice weevil can be reduced by using synthetic insecticides but the problem of resistance development, residue and toxicity has created the necessity to find more effective and healthier alternatives. So, Neem oil, eucalyptus oil, and canola oil are the most tested products against various insect-

pests under storage conditions. The toxic effect of neem oil at various concentrations against *S. oryzae* was studied by Shanmugapriyan and Kingly (2001), Dayal *et al.*, (2003), and Adarkwah *et al.*, (2010). The essential oil of *Eucalyptus* spp was found to be more stable and also showed potential toxicity against rice weevil (Imtiaz *et al.*, 2001; Negahban and Moharramipour, 2007; Aref and Valizadega, 2015; and Jayakumar *et al.*, 2017). The oil formulations used for the prevention of insect-pest may be exposed to various temperature ranges during storage which in turn can affect their efficacy. Hence, a laboratory study was conducted to find the effect of various temperatures on the efficacy of neem oil, eucalyptus oil, and canola oil.

MATERIAL AND METHODS

Maintenance of culture: - For initiation of the experiment, the culture of *S. oryzae* was taken from the Department of Entomology, GPBUA&T, Pantnagar. As per the requirement of the experiment the culture of *S. oryzae* was maintained separately in BOD incubator at various temperature range between 25°C to 36°C and relative humidity of 70 percent at Quantum University, Biochemistry Laboratory. The pure culture of *S. oryzae* was maintained on wheat grains, which were sterilized at 50°C for 4 hours. The sterilized grains were brought to room temperature before inoculation of *S. oryzae*. The culture was observed for contamination by other insect species as well as pathogens at regular intervals.

Experiment process: The three oil formulations i.e. neem oil @ 15 ml/kg seed, eucalyptus oil @ 20 ml/kg seed, and canola oil @ 20 ml/kg seed were evaluated on maize variety HQPM 1 with three replications in Completely Randomized Design (CRD). To determine the effect of temperature on the efficacy of oil formulations, 50 g of maize seeds treated with neem oil, canola oil, and eucalyptus oil were taken in the plastic container (6.5 × 6.5 × 10 cm³). The treated seeds were inoculated with ten adult rice weevils. The mouth of the container was covered with muslin cloth and fastened with a rubber band. The containers were kept in an incubator at different temperature ranges (25°C to 36 °C) for 6 months. The adult mortality was estimated by counting the number of dead insects in each container for different treatments at the intervals of 1, 3, and 14 days after treatment. The number of dead insects in each replication was converted into proportions of the total number of adults introduced and expressed as percent adult mortality data was corrected for natural mortality using Abbott's correction formula (Abbott, 1925). Similarly, for estimation of population growth, the *S. oryzae* was inoculated in treated maize and maintained in a different temperature range in an incubator. After 7 days of inoculation, *S. oryzae* was discarded from each plastic container manually by spreading them on white chart paper. The observations on a number of adults (live+dead) of *S. oryzae* developed in each replication were recorded 3 and 6 months after storage.

RESULTS AND DISCUSSION

The data presented in Table 1 showed that as temperature increased by 0.5°C slight decreases in percent adult mortality was recorded in maize seeds treated with neem oil at 3 DAT. The 64.59 mean percent adult mortality was observed in a temperature range of 25°C to 36°C when neem oil was used as seed protectant. Based on correlation studies, it was found that temperature showed a negative (-0.99) and significant correlation with neem oil efficacy. At 25°C, the percent adult mortality of *S.oryzae* in maize seed treated with eucalyptus oil was higher (63.97%) which was found to be reduced as the temperature increase with a significant negative (-.90) correlation. The canola oil was found to be effective against *S. oryzae* but a negative non-significant correlation with temperature indicates that fluctuation in temperature has no adverse effect on its efficacy.

Table 1: Percent adult mortality of *S.oryzae* in response to oil formulations 3 days after treatment at various temperature.

Percent adult mortality 3 DAT					
Sr.No.	Temperature s range (°C)	Treatments			Mean percent mortality
		Neem oil	Cannola oil	Eucalyptus oil	
1	25	65.33*	61.96	63.97	63.75
2	25.5	65.31	61.93	63.95	63.73
3	26	65.21	61.94	63.92	63.69
4	26.5	65.17	61.93	63.9	63.67
5	27	65.08	61.98	63.86	63.64
6	27.5	65.02	61.97	63.83	63.61
7	28	64.99	61.95	63.79	63.58
8	28.5	64.86	61.92	63.77	63.52
9	29	64.82	61.91	63.73	63.49
10	29.5	64.8	61.93	63.71	63.48
11	30	64.74	61.95	63.75	63.48
12	30.5	64.62	61.78	63.72	63.37
13	31	64.51	61.89	63.7	63.37
14	31.5	64.42	61.95	63.69	63.35
15	32	64.4	61.96	63.54	63.30
16	32.5	64.32	61.34	63.41	63.02
17	33	64.21	61.98	63.36	63.18
18	33.5	64.13	62.01	63.29	63.14
19	34	64.07	61.86	63.18	63.04

20	34.5	64.02	61.88	63.04	62.98
21	35	63.98	62.04	62.78	62.93
22	35.5	63.87	62.01	62.65	62.84
23	36	63.59	61.98	62.41	62.66
Mean percent mortality		64.59	61.92	63.52	63.34
Correlation (temperature & treatments)		-0.99**	-0.05 ^{NS}	-.90**	

DAT= days after treatment * Mean of 3 replications ** significant at 0.01 % NS non significant

At 7 DAT, neem oil showed a maximum of 78.63 mean percent adult mortality which was followed by eucalyptus oil (76.99%) and canola oil (73.59 %) but it was recorded that as the temperature range increased the efficacy of neem oil reduced (Table 2). A negative (-0.93) significant correlation was observed between temperature and neem oil. A similar trend was recorded for eucalyptus oil in which extreme reduction was observed at 31°C. The canola oil efficacy was not affected by temperature fluctuation as a non-significant correlation was observed between temperature and canola oil-treated maize seeds.

Table 2: Percent adult mortality of *S.oryzae* in response to oil formulations 7 days after treatment at various temperature.

Percent adult mortality 7 DAT					
Sr.No.	Temperature range (°C)	Treatments			Mean mortality
		Neem oil	Cannola oil	Eucalyptus oil	
1	25	79.45*	73.67	77.56	76.89
2	25.5	79.31	73.66	77.58	76.85
3	26	79.20	73.61	77.54	76.78
4	26.5	79.16	73.57	77.46	76.73
5	27	79.08	73.68	77.44	76.73
6	27.5	79.02	73.03	77.89	76.65
7	28	79.99	73.64	77.26	76.96
8	28.5	78.86	73.97	77.16	76.66
9	29	78.82	73.89	77.09	76.60
10	29.5	78.80	73.55	77.02	76.46
11	30	78.73	73.78	77.18	76.56
12	30.5	78.62	73.54	77.01	76.39
13	31	78.51	73.32	76.96	76.26
14	31.5	78.42	73.73	76.74	76.30
15	32	78.40	73.61	76.83	76.28

16	32.5	78.31	73.37	76.74	76.14
17	33	78.21	73.26	76.51	75.99
18	33.5	78.13	73.60	76.43	76.05
19	34	78.07	73.62	76.31	76.00
20	34.5	78.02	73.94	76.14	76.03
21	35	77.97	73.99	76.78	76.25
22	35.5	77.86	73.07	76.65	75.86
23	36	77.58	73.55	76.41	75.85
Mean percent mortality		78.63	73.59	76.99	76.40
Correlation (temperature & treatments)		-0.93**	-0.08 ^{NS}	-0.91**	-

DAT= days after treatment * Mean of 3 replications ** significant at 0.01 % NS non-significant

Table 3 represented that after 14 days of treatment with neem oil, canola oil and eucalyptus oil maize seeds showed up to 9.19 %, 89.24 %, and 92.20 % mean mortality, respectively against *S. oryzae* however, when the effect of temperature was studied on the efficacy of these oil formulation it was observed that a negative significant correlation exists between temperature and neem oil as well as eucalyptus oil which indicated that as temperature increased the percent mortality decreased. The canola oil was found to be not affected by a change in temperature.

Table 3: Percent adult mortality of *S.oryzae* in response to oil formulations 7 days after treatment at various temperature.

Percent adult mortality 14 DAT					
Sr.No.	Temperature range (°C)	Treatments			Mean mortality
		Neem oil	Cannola oil	Eucalyptus oil	
1	25	95.86*	89.46	92.94	92.75
2	25.5	95.79	89.43	92.74	92.65
3	26	95.77	89.40	92.63	92.60
4	26.5	95.68	89.54	92.60	92.61
5	27	95.62	89.61	92.57	92.60
6	27.5	95.56	89.78	92.55	92.63
7	28	95.54	89.46	92.51	92.50
8	28.5	95.47	89.16	92.45	92.36
9	29	95.40	89.11	92.40	92.30
10	29.5	95.36	89.05	92.33	92.25
11	30	95.28	89.01	92.36	92.22
12	30.5	95.25	88.74	92.21	92.07

13	31	95.24	89.03	92.18	92.15
14	31.5	95.09	89.06	92.13	92.09
15	32	95.03	89.03	92.11	92.06
16	32.5	94.85	89.28	92.04	92.06
17	33	94.82	89.13	91.89	91.95
18	33.5	94.70	89.42	91.76	91.96
19	34	94.65	89.49	91.74	91.96
20	34.5	94.72	89.02	91.71	91.82
21	35	94.73	89.13	91.64	91.83
22	35.5	94.53	89.06	91.66	91.75
23	36	94.41	89.16	91.51	91.69
Mean percent mortality		95.19	89.24	92.20	92.21
Correlation (temperature & treatments)		-0.99**	-0.48 [#]	-0.99**	-

DAT= days after treatment * Mean of 3 replications ** significant at 0.01 % # significant at 0.05%

At the beginning of the experiment, ten adults were inoculated in neem oil treated maize seeds which were 14.03 mean population growth after 3 months indicates that neem oil has a significant effect on population growth (table 4). Although when observations were taken at various temperature intervals it was found that as temperature increased the population growth of *S. oryzae* also increased which indicates a positive and significant correlation. The canola oil and eucalyptus oil showed mean population growth of 15.86 and 15.05, respectively while canola oil had no significant correlation with changing temperature whereas eucalyptus oil showed a positive (0.93) significant correlation with temperature. After 6 months of treatment, a modest increase in population was recorded for neem oil (14.11) and eucalyptus oil (15.41) however as the temperatures range from 25 °C to 36 °C the population growth found to be increased with positive (0.96) and significant correlation with temperature. The canola oil showed like 15.86 mean population growth as it was 3 months later with a positive significant correlation.

Table 4: Population growth of *S.oryzae* in response to oil formulations 3 and 6 months after treatment at various temperature.

Population growth (no. of dead + live adult insects)								
Temperature range (°C)	3MAT				6 MAT			
	Neem oil	Cannola oil	Eucalyptus oil	Mean	Neem oil	Cannola oil	Eucalyptus oil	Mean
25	13.92*	15.80	14.94	14.89	14.11	15.83	15.41	15.12
25.5	13.96	15.78	14.96	14.90	14.13	15.86	15.59	15.19
26	13.94	15.93	14.94	14.94	14.09	15.80	15.63	15.17

26.5	13.97	15.73	14.97	14.89	14.14	15.81	15.45	15.13
27	13.99	15.92	14.99	14.97	14.08	15.77	15.40	15.08
27.5	13.95	15.91	14.95	14.94	14.16	15.72	15.50	15.13
28	13.91	15.90	14.91	14.91	14.21	15.68	15.53	15.14
28.5	13.98	15.88	14.98	14.95	14.28	15.75	15.55	15.19
29	13.95	15.84	14.95	14.91	14.22	15.89	15.65	15.25
29.5	13.93	15.83	15.01	14.92	14.34	15.90	15.61	15.28
30	13.95	15.86	14.98	14.93	14.36	15.91	15.63	15.30
30.5	13.94	15.79	14.99	14.91	14.44	15.93	15.74	15.37
31	13.98	15.76	15.06	14.93	14.47	15.95	15.70	15.37
31.5	13.95	15.87	15.04	14.95	14.41	15.87	15.71	15.33
32	14.07	15.91	15.07	15.02	14.46	15.88	15.69	15.34
32.5	14.11	15.90	15.11	15.04	14.61	15.80	15.80	15.40
33	14.1	15.85	15.10	15.02	14.93	15.93	15.83	15.56
33.5	14.13	15.97	15.13	15.08	14.95	15.92	15.85	15.57
34	14.16	15.99	15.16	15.10	14.92	15.91	15.80	15.54
34.5	14.19	15.91	15.19	15.10	14.94	15.95	15.79	15.56
35	14.2	15.84	15.20	15.08	14.96	15.94	15.88	15.59
35.5	14.23	15.72	15.23	15.06	15.04	15.76	15.87	15.56
36	14.25	15.93	15.25	15.14	15.11	15.93	15.93	15.66
Mean	14.03	15.86	15.05	14.98	14.49	15.86	15.68	15.34
Correlation (temperature &treatments)	0.87**	0.21 ^{NS}	0.93**	-	0.96**	0.51 [#]	0.92**	-

MAT= Month after treatment * Mean of 3 replications ** significant at 0.01 % # significant at 0.05%

The most important finding of the experiment was that the temperature degraded neem oil and eucalyptus oil and also reduced its efficacy whereas canola oil found to be stable at a varied range of temperature these findings were in agreement with David *et. al* (2003) who reported that neem is effective against the cowpea weevil, *Callosobruchus maculatus* (F.), due to the presence of chemical compound azadirachtinA which breaks down rapidly at high temperature, oviposition deterrence tendency of neem reduced due to which cowpea weevil become destructive. The mortality of *S. zeamais* was significantly higher at 27°C compared to 20°C and 31°C irrespective of treatment concentrations of Eucalyptus leaf extract and exposure duration. Similar findings showed that *B. bassiana* at different treatment concentrations resulted in maximum mortality of *S. zeamais* only at temperatures range of 15°C and 25°C and it was found to be inactive at 10°C and 35°C (Amarasekare et al., 2004). These studies indicated that the toxicity of the botanical was affected by variation in temperature. Arthur et al. (1999) reported

that Pyrethroid was negatively correlated with temperature while which correlation was found to be effective by chemical structure, target species, insecticides, the temperature range, and various additives which prevent the degradation by heat or temperature. Frank, H. *et al.*, 1999, reported that at 27°C with the lowest number of emergences of F1 progeny compared with 31C

irrespective of the time of emergence of adult *S. zeamais*. Which supports the fact that at moderate temperature (25°C), *S. zeamais* were more active increasing the contact rate with the active ingredient of Eucalyptus leaf extract. It was confirmed with studies from Kaushalya *et al.* (2004) also indicated that temperature affected the efficacy of botanicals against grasshopper nymphs at different ranges of 0°C to 35°C with levels of mortality higher at 25°C and not active at 10°C or a higher temperature of 35°C.

Table 5: Regression equation between oil formulations and temperature on percent adult mortality and population growth against *S. oryzae*.

Treatments	Percent adult mortality						Population growth			
	3 DAT		7 DAT		14 DAT		3 MAT		6 MAT	
	Regression equation	R ²	Regression equation	R ²	Regression equation	R ²	Regression equation	R ²	Regression equation	R ²
Neem oil	Y=- 0.073x+65.4 6	0.988	Y=- 0.08x+79.59	0.861	Y=- 0.064x+95.96	0.9 82	Y=0.014x+1 3.86	0.76 3	Y=0.050x+13 .89	0.914
Cannola oil	Y= 0.001x+61.9 2	0.003	Y=0.003x+73 .63	0.006	Y=- 0.017x+89.45	0.2 33	Y=0.002x+1 5.83	0.04 6	Y=0.006x+15 .78	0.256
Eucalyptus oil	Y=- 0.058x+64.2 2	0.825	Y=- 0.062x+77.73	0.828	Y=- 0.058x+92.90	0.9 79	Y=0.014x+1 4.87	0.87 2	Y=0.021x+15 .42	0.843

CONCLUSION

Neem oil, canola oil, and eucalyptus oil can be used as natural grain protectants as they significantly reduced population growth and increased mortality of *S. oryzae* in stored maize grains as shown by this study. These oil formulations can be used as an alternative for

synthetic pesticides with no or little adverse effects on human health. These oil formulations were effective for preserve the quality and quantity of the maize against *S. oryzae* up to storage period for 6 months. At 25°C neem oil and Eucalyptus oil were most effective against *S. oryzae* compared to 36°C where canola oil showed a similar effect at various temperature ranges which indicated that temperature affects the efficacy of neem and eucalyptus oil whereas canola oil, efficacy was not affected by temperature variation.

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