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Effect of non-edible oils on the development of mite, *Tyrophagus putrescentiae* Schrank stored groundnut

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ABSTRACT

The effect of various non-edible oils on developmental parameters of mite, *Tyrophagus* putrescentiae were studied during 2017-18 and 2018-19 at Acarology laboratory, Department of Entomology, N.M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, India. The maximum percentage of adult emergence *i.e.* 50.33 was recorded when groundnut seeds were treated with alsi oil at 0.50 ml/kg concentration, while maximum reduction in adult emergence of acarid mite, *T. putrescentiae* was at 2.00 ml/kg concentration in *Neem* oil (10.20 %). The maximum longevity was observed at 0.50 ml/kg concentration in castor oil treated groundnut seeds (14.03 days). As the concentration increases the duration of egg stage also increases. In case of neem oil, the duration of egg stage was maximum (5.98 days) at 2.00 ml/kg followed by eucalyptus oil, castor oil, karanj oil and alsi oil with the duration of egg stage as 5.35, 4.60, 4.45 and 4.87 days, respectively at 2.00 ml/kg treatment. In *Neem* oil, the duration of larval stage was maximum (6.12 days) at 2.00 ml/kg concentration followed by eucalyptus oil (6.02 days), karanj oil (5.30 days), castor oil (5.25 days) alsi oil (5.20 days), respectively at 2.00 ml/kg concentration. In neem oil, the duration of nymphal stage was higher (14.08 days) at 2.00 ml/kg concentration followed by eucalyptus oil (13.68 days), castor oil (11.10 days), alsi oil (11.03 days) and karanj oil (11.93 days) at 2.00 ml/kg concentration.

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INTRODUCTION

Grain provides an abundant source of nutrients to variety of organisms. The interactions between grain and organisms/pests largely depend upon the micro-environment, the grains are stored in, which may lead to bio-deterioration of the grain (Shaaya *et al*., 1997). More approximate damage to stored grains and grain products is done by pests in tropical zone (20-30 %), which is very high as compared to temperate zone (5-10 %). Sometimes, damage is very high reaching up to 40 per cent, especially in developing and under developed countries as modern storage technologies have not been introduced (Shaaya *et al*., 1997). Mites act as secondary

invaders among storage pests as they cannot infest sound grain instead feed upon broken kernels, debris, high moisture seeds or damaged grain by primary insect pests. These invaders contribute directly to grain spoilage after establishment, just as primary pests do (Weaver and Petroff, 2009). Stored-grain mites damages usually go unnoticed until the grain is removed from the storage facility. Mites from family Acaridae are gaining importance as storage pests due to their increasing incidence and their association/ interaction with fungi and insects causing rapid qualitative and quantitative deterioration of grains (Weaver and Petroff, 2009). Studies on acarid mites infesting stored products have been conducted in several regions throughout the world (Weaver and Petroff, 2009). Among the stored grain mite *Tyrophagus putrescentiae* Schrank (Schrank, 1781) is a ubiquitous, agriculturally, medically important mite species and is considered a severe pest of number of stored commodities with high fat and protein content throughout world. The mite, *T. putrescentiae* is a common and serious pest of stored grains due to its ability to tolerate low humidity and a wide range of temperatures (Hughes, 1976). It can cause problems for many foodstuffs ranging from weight reduction and degradation of stored foods to accumulation of harmful residues (fungi, dead mites, faeces, eggs and bits of food) through their activities (Hughes, 1976 and Zdarkova, 1971). This makes the infested grain storage unhygienic. World over, there is an increasing trend among grain buyers towards zero-tolerance to these contaminants. For effective and economical management of the mite, *T. putrescentiae* it is very important to use economical and ecologically sound management practices. Among these practices use of plant oils serve as one suitable option. Therefore, to know the effect of different non-edible oils on various developmental parameters of mite, *Tyrophagus putrescentiae* Schrank, the present experiment were carried out under the laboratory conditions.

MATERIAL AND METHODS

The present experiment were carried out at Acarology Laboratory, Department of Entomology, N.M. College of Agriculture, Navsari Agricultural University, Navsari during 2017-18 and 2018-19. The details of the experiment were as under:

Mite culture:

Acarid mite, *T. putrescentiae* was reared in plastic Petri dishes (5 cm diameter) with groundnut and yeast flour as food (4:1). These were placed in a dessicator containing super saturated solution of Potassium chloride to provide desired humidity which in turn was placed in BOD. Thus, stock culture of *T. putrescentiae* was maintained in laboratory at 27±10ºC and 80-85% RH. Copulating pairs were picked from the culture and were released in observation arenas. Five non-edible oils were used against acarid mite, *T. putrescentiae* infesting stored groundnut seeds, 15 g of groundnut seeds were taken in a Petri dishes (11 cm x 2 cm) and 15 pairs of adult mite were released to it. Each non-edible oils treated at three specified concentrations (0.50 ml/kg, 1.0 ml/kg and 2.0 ml/kg) were mixed thoroughly by mechanical shaking with the groundnut seeds. Prior to application of the non-edible oil, the groundnut seeds were sterilized at 40^0 C for 24 hours in order to make them free from any other infestation. Observations were recorded daily in the observation arenas. The following observations were recorded:

– Per cent of adult emerged in different treatments and adult longevity

– Duration of the following developmental stages *i.e.* egg period, larval period and nymphal period

RESULTS AND DISCUSSION

The data on various aspects were presented under the following headings:

Adult longevity:

During the year 2017-18 all the five non-edible oils when applied at all the concentration *i.e.* 0.50, 1.00 and 2.00 ml/kg, it resulted decrease in the adult longevity as compared to the control. In control on an average 18.47 days adult longevity was recorded. The duration of the survival of the adult mite was less in *Neem* oil treated groundnut seeds. In *Neem* oil treated groundnut seeds, the duration of survival of adult mite at 0.50, 1.00 and 2.00 ml/kg concentrations was 12.23, 11.80 and 10.13 days, respectively. In case of eucalyptus oil and castor oil treated groundnut seeds the longevity of adult mite at 0.50, 1.00 and 2.00 ml/kg concentrations were 12.80, 12.70, 10.77 and 13.97, 13.33, 12.40 days, respectively (Table 1). The duration of survival of mite, *T. putrescentiae* at 0.50, 1.00 and 2.00 ml/kg concentrations

were 12.99, 11.90 and 11.40 days, respectively in case of karanj oil treated groundnut seeds and in case of alsi oil treated groundnut seeds, adult longevity observed were 13.67, 12.80 and 11.77 days, at 0.50, 1.00 and 2.00 ml/kg concentrations, respectively. The findings showed that duration of the survival of the adult mite was less in neem oil treatment at 2.00 ml/kg concentration (10.13 days). The highest longevity was observed at 0.50 ml/kg concentration in alsi oil treated groundnut seeds (13.67 days). The maximum duration of adult survival was observed in *Neem* oil treated groundnut seeds at 2.00 ml/kg concentration (10.13 days). In the year 2018-19, the adult longevity at all the concentrations *i.e.* 0.50, 1.00 and 2.00 ml/kg, resulted in a decrease in the longevity as compared to the control. In case of control, the adult longevity was 18.93 days. The duration of the survival of the adult mite in *Neem* oil treated groundnut seeds at 0.50, 1.00 and 2.00 ml/kg concentrations were 12.00, 11.17 and 9.90 days, respectively. In case of eucalyptus oil and castor oil treated groundnut seeds the longevity of adult mite at 0.50, 1.00 and 2.00 ml/kg concentrations was 13.03, 12.17, 11.57 and 14.10, 13.17, 12.13 days, respectively. In case of alsi oil the duration of survival of adult mite at 0.50, 1.00 and 2.00 ml/kg concentrations were 13.93, 12.78 and 11.70 days, respectively. The present finding showed that the duration of survival of the adult acarid mite was less in neem oil treatment at 2.00 ml/kg concentration (9.90 days), followed by eucalyptus oil, castor oil, karanj and alsi oil, which was 11.57, 12.13, 11.53 and 11.70 days, respectively at 2.00 ml/kg concentration (Table 1). The maximum longevity was noticed at 0.50 ml/kg, concentration of alsi oil treated groundnut seeds (13.93 days). The minimum duration of adult survival was observed in *Neem* oil treated groundnut seeds at 2.00 ml/kg concentration (9.90 days). The pooled over data of adult longevity of mite, *T. putrescentiae* when reared on various concentrations of different non-edible oils were presented in the Table 1 showed that all the five non-edible oils when applied at all the concentrations *i.e.* 0.50, 1.00 and 2.00 ml/kg, it resulted in an decrease in the longevity as compared to the control. In control on an average 18.70 days longevity was noticed. The duration of the survival of the adult acarid mite was less in *Neem* oil treated groundnut seeds. In neem oil treated groundnut seeds the duration of survival of adult acarid mite, at 0.50, 1.00 and 2.00 ml/kg concentrations were 12.12, 11.48 and 10.02 days, respectively. In case of eucalyptus oil and castor treated groundnut seeds the adult longevity at 0.50, 1.00 and 2.00 ml/kg concentrations were 12.92, 12.17, 11.17 and 14.03, 13.25, 12.27 days, respectively. In case of karanj oil, the duration of survival of adult mite at 0.50, 1.00 and 2.00 ml/kg concentrations were 12.98, 11.95 and 11.47 days, respectively. The adult longevity of acarid mite were 13.80, 12.79 and 11.73 days when groundnut seeds were treated with alsi oil at 0.5, 1.00 and 2.00 ml/kg concentrations, respectively. The present findings showed that the duration of the survival of the mite, *T. putrescentiae* was less in neem oil treatment at 2.00 ml/kg concentration (10.02 days), followed by eucalyptus oil (11.17 days), castor oil (12.27 days), karanj oil (11.47 days) and alsi oil (11.73 days). The higher longevity was observed at 0.50 ml/kg concentration in castor oil treated groundnut seeds (14.03 days). All the treatments were statistically differed from each other. The longevity of mite, *T. putrescentiae* was less at all the concentration of non-edible oils as compared to control. As the concentration of non-edible oil increased, the duration of adult survival decreased. The duration of adult survival significantly reduced upto maximum level in *Neem* oil while eucalyptus oil, castor oil, karanj oil and alsi oil proved to be next effective treatments. The present findings were more or less in accordance with the results obtained by Singh *et al*. (1978), Verma and Pandey (1978), Singh and Verma (1985), Chaudhary and Pathak (1989) and Rani (2000), who also reported that various non-edible oils prevented the emergence of adult pulse beetle and stored grain mite, *S. nesbitti* infesting different commodities.

Post embryonic development:

The mite, *T. putrescentiae* has three post embryonic development stages *i.e.* the egg, larval and nymphal (protonymphal and tritonymphal stages). The egg hatched out to release the first mobile developmental stage *i.e.* the larvae. The latter moults to be transformed into nymphal stage (protonymphal and tritonymphal stage), from the nymphal stage, the adults were emerged out. In case of mite, *T. putrescentiae* deutonymph stage was not recovered and as the available literature this stage is absent in *T. putrescentiae.*

Egg stage:

In the year 2017-18, mixing of non-edible oils with

groundnut seeds were found to be effective in increasing the duration of egg stage of the mite *T. putrescentiae*. In control, the duration of egg stage was 2.67 days. In alsi oil at 0.50, 1.00 and 2.00 ml/kg concentrations, the duration of egg stage was 3.20, 3.83 and 4.87 days, respectively. In case of karanj oil, the duration of egg stage was 3.53, 3.83 and 4.50 days at 0.50, 1.00 and 2.00 ml/kg concentration. In castor oil treated groundnut seeds, the duration of egg stages were 3.47, 3.90 and 4.57 days, at 0.50, 1.00 and 2.00 ml/kg concentrations, respectively. In eucalyptus oil, the egg duration was 3.50, 4.17 and 5.37 days at 0.50, 1.00 and 2.00 ml/kg concentrations. Moreover, in case of *Neem* oil treated groundnut seeds, the egg period was 3.67, 4.50 and 5.83 days at 0.50, 1.00 and 2.00 ml/kg concentrations. The data presented in the Table 2 showed that as the concentration increases, the duration of egg stages also increase. In *Neem* oil, the duration of egg stage was maximum (5.83 days) at 2.00 ml/kg concentration and was followed by eucalyptus oil (5.37 days), castor oil (4.57 days), karanj oil (4.50 days) and alsi oil (4.87 days), respectively at 2.00 ml/kg concentration. The duration of egg stage among non-edible oil treated groundnut seeds were found to be minimum in case of alsi oil at 0.50 ml/kg concentration (3.20 days). The egg stages was shortest at 0.50 ml/kg indicate that lowest concentration was least effective. The egg stage was maximum at 2.00 ml/kg concentration indicated that higher concentration *i.e*. 2.00 ml/kg was most effective, where the egg stage was prolonged upto control 5.83 days as compared to control (2.67days). In the year 2018-19 the data in the Table 2 revealed that mixing of various non-edible oils with groundnut seeds were found to be effective in increasing the duration of egg stage of the mite, *T. putrescentiae*. In control, the duration of egg stage was 3.00 days. In alsi oil at 0.50, 1.00 and 2.00 ml/kg concentrations the duration of egg stage was 3.43, 3.87 and 4.87 days, respectively. In karanj oil, the duration of egg stage was 3.43, 3.97 and 4.40 days, at 0.50, 1.00 and 2.00 ml/kg concentrations, respectively. Further, in castor oil, the egg duration was 3.43, 3.90 and 4.63 days at 0.50, 1.00 and 2.00 ml/kg concentrations, respectively. Further, in eucalyptus oil treated groundnut seeds at 0.50, 1.00 and 2.00 ml/kg concentrations, the egg period was 3.83, 4.33 and 5.33 days, respectively. The duration of egg stage was 3.87, 4.67 and 6.13 days at 0.50, 1.00 and 2.00 ml/kg concentrations when treated with *Neem* oil. In the present study, it was observed that as the concentration increases the duration of egg stage also increased. In *Neem* oil, the duration of egg stage was maximum (6.13 days) at 2.00 ml/kg concentration followed by eucalyptus oil (5.33 days), alsi oil (4.87 days), castor oil (4.63 days) and karanj oil (4.40 days), respectively at 2.00 ml/kg concentrations. The two years pooled over data on egg period of mite, *T. putrescentiae* were presented in the Table 2 clearly revealed that mixing of non-edible oils with groundnut seeds were found to be effective in increasing the duration of egg stage of mite, *T. putrescentiae*. In case of untreated groundnut seeds, the duration of egg stage was 2.83 days. In alsi oil at 0.50, 1.00 and 2.00 ml/kg concentrations, the duration of egg stages was 3.32, 3.85 and 4.87 days, respectively. In karanj oil, the duration of egg stage was 3.48, 3.90 and 4.45 days at 0.50, 1.00 and 2.00 ml/kg concentrations, respectively. In castor oil, the duration of egg stage was 3.45, 3.90 and 4.60 days at 0.50, 1.00 and 2.00 ml/kg concentrations, respectively. In eucalyptus oil treated groundnut seeds, the duration of egg stage was 3.67, 4.25 and 5.35 days at 0.50, 1.00, and 2.00 ml/kg concentrations. In case of neem oil, the duration of egg stage was 3.77, 4.58 and 5.98 days at 0.50, 1.00, and 2.00 ml/kg concentrations, respectively. The data presented in Table 2 showed that as the concentration increases the duration of egg stage also increases. In case of *Neem* oil, the duration of egg stage was maximum (5.98 days) at 2.00 ml/kg concentration followed by eucalyptus oil, castor oil, karanj oil and alsi oil with the duration of egg stage 5.35, 4.60, 4.45 and 4.87 days, respectively at 2.00 ml/kg concentrations. The duration of egg stage among non-edible oil treated groundnut seeds were found to be maximum in case of karanj oil (4.45 days at 2.00 ml/kg level of concentration). The egg stage was shortest at 0.50 ml/kg clearly indicates that lower concentrations of non-edible oil was less effective against *T. putrescentiae*. Further, the egg stage was longest at 2.00 ml/kg concentration clearly revealed that higher concentrations of non-edible oil was most effective, where the egg stage was prolonged upto 5.98 days in *Neem* oil treated groundnut seeds as compared to untreated control (2.83 days). Moreover, it was very much clear from the present investigation that neem oil was most effective in increase the duration of egg stage followed by eucalyptus oil, alsi oil, castor oil and karanj oil. All the five non-edible oils were found to be

significantly effective as compared to control in reducing the post embryonic development. *Neem* oil was significantly superior to other non-edible oil treatments. In case of *Neem* oil at 2.00 ml/kg the duration was 5.98 days. The present findings were more or less in accordance with the results obtained by Verma and Pandey (1978), against pulse beetle. Moreover, the non-edible oil prolonged the post embryonic development of stored mites, *S. nesbitti* when pigeonpea seeds were treated with various oils including *Neem* oil (Rani, 2000). In a study, Assis *et al*. (2011) also reported prolonged post embryonic development of *T. putrescentiae* and *S. pontifica* Oudemans when exposed to various essential oils. In a study Pumnuan and Insung (2011) reported delay in post embryonic development of mite, *S. pontifica* when exposed to 28 different oil formulations which include neem, eucalyptus and castor oils thus more or less closely support the present findings where different non-edible oils prolong the post-embryonic development of acarid mite, *T. putrescentiae*.

Larval stage:

In the year 2017-18 mixing of non-edible oils with groundnut seeds were found to be effective in increasing the duration of larval stage of the mite, *T. putrescentiae*. In control, the duration of larval stage of mite, was 3.33 days. In case of *Neem* oil at 0.50, 1.00, 2.00 ml/kg concentrations the duration of larval stage was 4.97, 5.63 and 6.13 days, respectively. Likewise, in eucalyptus oil, the larval duration was 4.93, 5.63 and 6.00 days at 0.50, 1.00 and 2.00 ml/kg concentrations. In castor oil, the duration of larval stage was 4.40, 4.70 and 5.27 days at 0.50, l.00 and 2.00 ml/kg. Moreover, in alsi oil, the larval duration at 0.50, 1.00 and 2.00 ml/kg was 4.27, 4.63 and 5.20 days, respectively. It is clear from the study, that the level of concentration increases the duration of larval stage also increase. In *Neem* oil, the duration of larval stage was maximum (6.13 days) at 2.00 ml/kg

Table 1 : Influence of different non-edible oils on adult emergence and longevity of *T. putrescentiae* on groundnut

Treatments	Conc. ml/kg	Year 2017-18		Year 2018-19		Pooled	
		% adult emergence	Adult longevity (Days)	% adult emergence	Adult longevity (Days)	% adult emergence	Adult longevity (Days)
Neem oil	0.5	26.05(19.33)	3.50 (12.23)	26.31(19.67)	3.46(12.00)	26.18(19.50)	3.48 (12.12)
	1.0	23.16 (15.47)	3.43 (11.80)	23.31 (15.67)	3.34(11.17)	23.24(15.57)	3.39 (11.48)
	2.0	18.34 (10.00)	3.18 (10.13)	18.77(10.40)	3.15(9.90)	18.55(10.20)	3.16 (10.02)
Eukalyptus oil	0.5	27.39 (21.17)	3.58 (12.80)	27.15(20.83)	3.61(13.03)	27.27(21.00)	3.59 (12.92)
	1.0	23.29 (15.67)	3.49 (12.17)	23.35(15.73)	3.49(12.17)	23.32(15.70)	3.49 (12.17)
	2.0	18.83 (10.43)	3.28 (10.77)	19.09(10.73)	3.40(11.57)	18.96(10.58)	3.34 (11.17)
Castor oil	0.5	37.88 (37.70)	3.74 (13.97)	37.90(37.73)	3.75(14.10)	37.89(37.72)	3.75 (14.03)
	1.0	33.08 (29.80)	3.65 (13.33)	33.15(29.90)	3.63(13.17)	33.12(29.85)	3.64 (13.25)
	2.0	29.98 (24.97)	3.53 (12.40)	29.93(24.90)	3.48(12.13)	29.95(24.93)	3.50 (12.27)
Karanj oil	0.5	36.73 (35.77)	3.60 (12.99)	36.61(35.57)	3.61(12.97)	36.67(35.67)	3.60 (12.98)
	1.0	33.07 (29.77)	3.45 (11.90)	33.01(29.68)	3.46(12.00)	33.04(29.73)	3.46 (11.95)
	2.0	29.78 (24.67)	3.38 (11.40)	29.80(24.70)	3.40(11.53)	29.79(24.68)	3.39 (11.47)
Alsi oil	0.5	45.20 (50.33)	3.70 (13.67)	45.20(50.33)	3.73(13.93)	45.19(50.33)	3.71 (13.80)
	1.0	42.23 (45.17)	3.58 (12.80)	42.43(45.52)	3.57(12.78)	42.33(45.35)	3.58 (12.79)
	2.0	36.35 (35.13)	3.43 (11.77)	36.50(35.37)	3.42(11.70)	36.42(35.25)	3.43 (11.73)
Control	-	67.80 (85.67)	4.30 (18.47)	68.68(86.67)	4.35(18.93)	68.24(86.17)	4.32 (18.70)
S.E. ±		0.634	0.038	0.586	0.036	-	-
Treatment						0.431	0.026
(Y × T)						0.610	0.037
C.D. (P=0.05)		1.826	0.108	1.687	0.104	-	-
Treatment						1.22	0.074
(Y × T)						NS	NS
CV (%)		3.32	1.84	3.05	1.75	-	-
CV (%) (Pooled)						3.19	1.80

Figures in parentheses are original value while those outside are square root transformed values for longevity of adult while arc sine transformed value for percentage adult emergence
NS=Non-significant

concentration followed by eucalyptus oil (6.00 days), karanj oil (5.30 days), castor oil (5.27 days) and alsi oil (5.20 days), respectively at 2.00 ml/kg concentration. Further in the year 2018-19 the data in the Table 2 revealed in control, the duration of the larval stage of mite was 3.60 days. In *Neem* oil at 0.50, 1.00 and 2.00 ml/kg concentrations the duration of the larval stage were 4.97, 5.60 and 6.10 days, respectively. Further, in eucalyptus oil, the duration of larval stage was 4.93, 5.53 and 6.03 days at 0.50, 1.00 and 2.00 ml/kg of concentration. In castor oil, the duration of larval stage was 4.37, 4.73 and 5.23 days at 0.50, 1.00 and 2.00 ml/kg concentrations, respectively. Moreover, in case of karanj oil treated groundnut seeds, the duration of larval stage was 4.57, 4.90 and 5.30 days at all three concentration, respectively while in case of alsi oil treated groundnut seeds the larval duration was 4.23, 4.63 and 5.19 days at 0.50, 1.00 and 2.00 ml/kg concentrations. Likewise, the larval duration in untreated control was 3.60 days. The data presented in the Table 2 clearly showed that as the as the concentration increases, the duration of larval stage also increases. In *Neem* oil, the duration of larval stage was maximum (6.10 days) at 2.00 ml/kg of groundnut seeds followed by eucalyptus oil, karanj oil, castor oil and alsi oil with the duration of 6.03, 5.30, 5.23 and 5.19 days, respectively at 2.00 ml/

Table 2 : Influence of different non-edible oil on post embryonic development stages of *T. putrescentiae* on groundnut

Treatments	Conc. (ml./kg)	Year 2017-18			Year 2018-19			Pooled		
		Egg period (Days)	Larval period (Days)	Nymphal period Days)	Egg period (Days)	Larval period (Days)	Nymphal period (Days)	Egg period (Days)	Larval period (Days)	Nymphal period (Days)
Neem oil	0.5	1.91	2.23	3.32	1.97	2.22	3.33	1.94	2.23	3.32
		(3.67)	(4.97)	(11.00)	(3.87)	(4.97)	(11.07)	(3.77)	(4.97)	(11.03)
	1.0	2.12	2.37	3.47	2.16	2.37	3.47	2.14	2.37	3.47
		(4.50)	(5.63)	(12.07)	(4.67)	(5.60)	(12.07)	(4.58)	(5.62)	(12.07)
	2.0	2.42	2.48	3.76	2.48	2.47	3.75	2.45	2.47	3.75
		(5.83)	(6.13)	(14.13)	(6.13)	(6.10)	(14.03)	(5.98)	(6.12)	(14.08)
Eukalyptus oil	0.5	1.87	2.22	3.31	1.96	2.22	3.30	1.91	2.22	3.30
		(3.50)	(4.93)	(10.93)	(3.83)	(4.93)	(10.87)	(3.67)	(4.93)	(10.90)
	1.0	2.04	2.37	3.47	2.08	2.35	3.46	2.06	2.36	3.47
		(4.17)	(5.63)	(12.03)	(4.33)	(5.53)	(12.00)	(4.25)	(5.58)	(12.02)
	2.0	2.32	2.45	3.71	2.31	2.46	3.69	2.31	2.45	3.70
		(5.37)	(6.00)	(13.77)	(5.33)	(6.03)	(13.60)	(5.35)	(6.02)	(13.68)
Castor oil	0.5	1.87	2.10	3.13	1.85	2.09	3.14	1.86	2.09	3.14
		(3.47)	(4.40)	(9.83)	(3.43)	(4.37)	(9.90)	(3.45)	(4.38)	(9.87)
	1.0	1.98	2.17	3.21	1.97	2.17	3.22	1.97	2.17	3.21
		(3.90)	(4.70)	(10.30)	(3.90)	(4.73)	(10.37)	(3.90)	(4.72)	(10.33)
	2.0	2.14	2.29	3.33	2.15	2.29	3.33	2.14	2.29	3.33
		(4.57)	(5.27)	(11.10)	(4.63)	(5.23)	(11.10)	(4.60)	(5.25)	(11.10)
Karanj oil	0.5	1.88	2.14	3.16	1.85	2.13	3.15	1.87	2.14	3.16
		(3.53)	(4.60)	(10.00)	(3.43)	(4.57)	(9.97)	(3.48)	(4.58)	(9.98)
	1.0	1.96	2.21	3.25	1.99	2.21	3.25	1.97	2.21	3.25
		(3.83)	(4.90)	(10.60)	(3.97)	(4.90)	(10.57)	(3.90)	(4.90)	(10.58)
	2.0	2.12	2.30	3.46	2.10	2.30	3.44	2.11	2.30	3.45
		(4.50)	(5.30)	(12.00)	(4.40)	(5.30)	(11.87)	(4.45)	(5.30)	(11.93)
Alsi oil	0.5	1.79	2.07	3.13	1.85	2.06	3.13	1.82	2.06	3.13
		(3.20)	(4.27)	(9.83)	(3.43)	(4.23)	(9.83)	(3.32	(4.25)	(9.83)
	1.0	1.96	2.15	3.20	1.97	2.15	3.20	1.96	2.15	3.20
		(3.83)	(4.63)	(10.27)	(3.87)	(4.63)	(10.27)	(3.85)	(4.63)	(10.27)
	2.0	2.21	2.28	3.32	2.21	2.27	3.32	2.21	2.28	3.32
		(4.87)	(5.20)	(11.07)	(4.87)	(5.19)	(11.00)	(4.87)	(5.20)	(11.03)
Control	-	1.63	1.82	2.79	1.73	1.90	2.79	1.68	1.86	2.79
		(2.67)	(3.33)	(7.77)	(3.00)	(3.60)	(7.80)	(2.83)	(3.47)	(7.78)
S.E. ±		0.047	0.065	0.078	0.048	0.065	0.080	-	-	-
Treatment								0.033	0.046	0.056
(Y × T)								0.047	0.065	0.079
C.D. (P=0.05)		0.134	0.186	0.225	0.139	0.188	0.230	-	-	-
Treatment								0.095	0.129	0.158
(Y × T)								NS	NS	NS
CV (%)	4.05	5.05	4.13	4.08	4.09	5.08	4.17	-	-	-
CV (%) (Pooled)								4.05	5.05	4.13

Figures in parentheses are original value while those outside are square root transformed values
NS=Non-significant

kg concentrations of non-edible oils. The duration of larval stage among the treated groundnut seeds were found to be minimum in case of alsi oil at 0.50 ml/kg concentration (4.23 days). The two years pooled over data on larval duration were presented in Table 2 revealed that mixing of non-edible oil with groundnut seed was found effective in increasing the duration of larval stage of acarid mite. However, in case of untreated control the duration of the larval stage of mite was 3.47 days, while in *Neem* oil treated groundnut seeds at 0.50, 1.00 and 2.00 ml/kg concentrations the duration of the larval stage was 4.97, 5.62 and 6.12 days, respectively. In eucalyptus oil, the duration of larval stage was 4.93, 5.58 and 6.02 days at 0.50, 1.00 and 2.00 ml/kg concentrations. In castor oil the duration of larval stage was 4.38, 4.72 and 5.25 days at 0.50, 1.00 and 2.00 ml/kg concentrations, respectively. Further, in karanj oil, the larval duration was 4.58, 4.90 and 5.30 days at 0.50, 1.00 and 2.00 ml/kg concentrations, respectively. Moreover, in alsi oil treated groundnut, the larval duration was 4.25, 4.63 and 5.20 days at all three concentrations *viz.*, 0.50, 1.00 and 2.00 ml/kg, respectively. It was very clear from the present study that as the concentration increase, the duration of larval stage also increase. In *Neem* oil, the duration of larval stage was maximum (6.12 days) at 2.00 ml/kg concentration followed by eucalyptus oil (6.02 days), karanj oil (5.30 days), castor oil (5.25 days), alsi oil (5.20 days), respectively at 2.00 ml/kg concentration. The duration of larval stage among all the non-edible oil treated groundnut seeds were found to be minimum in case of alsi oil at 0.50 ml/kg concentration (4.25 days). The shortest duration of larval stage at 0.50 ml/kg concentration indicated that low level concentration were least effective in increasing the duration of larval stage. The longest larval stage was noticed at 2.00 ml/kg indicated that higher concentrations were most effective in increasing the duration of larval stage upto 6.12 days as compared to control (3.47 days). Further, it is very much clear from the present investigation that *Neem* oil was most effective in increasing the duration of larval stage followed by eucalyptus oil and alsi oil. All the non-edible oils in the present experiment were found significantly effective as compared to control in prolonging the larval duration of mite, *T. putrescentiae*. Neem oil was significantly superior over all other non-edible oils. The larval period was maximum (6.12 days) at 2.00 ml/kg concentration. The present findings were more or less similar to the work of Rani (2000) who also recorded higher larval duration in case of neem oil treated pigeonpea seeds against stored mite, *S. nesbitti* at Hissar, Haryana. Moreover, in a study Rim and Jee (2006) reported that larval durations of mite, *D. farinae* and *D. pteronyssinus* were longer as compared to control when treated with different essential oils. The adverse effect of essential oils against stored product mite, *S. pontifica* was also reported by Pumnuan and Insung (2011). All these earlier research work thus more or less supports the present findings. However, slight difference may be due to the technique of experiment, nature of oils, food materials used etc.

Nymphal stage:

In the year 2017-18, in case of control, the duration of nymphal stage was 7.77 days. In *Neem* oil treated seeds at 0.50, 1.00 and 2.00 ml/kg concentrations, the duration of nymphal stage was 11.00, 12.07 and 14.13 days, respectively. In eucalyptus oil, the duration of nympahl stage was 10.93, 12.03 and 13.77 days at 0.50, 1.00, 2.00 ml/kg concentrations, respectively. Further, in castor oil, the duration of nymphal stage was 9.83, 10.30 and 11.10 days at all the three concentrations, respectively. However, in karanj oil, the duration of nymphal stage was 10.00, 10.60 and 12.00 days at 0.50, 1.00 and 2.00 ml/kg concentrations. Moreover, in case of alsi oil treated groundnut seeds, the nymphal duration was 9.83, 10.27 and 11.07 days at 0.50, 1.00 and 2.00 ml/kg concentrations, respectively. The data presented in the Table 2 revealed that as the concentration increases, the duration of nymphal stage also increase. In case of *Neem* oil, the duration of nymphal stage was maximum (14.13 days) at 2.00 ml/kg concentration followed by eucalyptus oil (13.77 days), karanj oil (12.00 days), castor oil (11.10 days) and alsi oil (11.07 days), respectively. However, the duration of nymphal stage among non-edible oil treated groundnut seeds were found to be minimum in alsi oil and castor oil at 0.50 ml/kg, concentration (9.83, 9.83 days). In the year 2018-19, the nymphal duration of the acarid mite, *T. putrescentiae* was shortest in untreated control (7.80 days). In *Neem* oil on an average the duration of nymphal stage was 11.07, 12.07 and 14.03 days, respectively at 0.50, 1.00 and 2.00 ml/kg concentrations. In eucalyptus oil the duration of nymphal stage was 10.87, 12.00 and 13.60 days at 0.50, 1.00 and 2.00 ml/kg concentrations,

respectively. In castor oil treated groundnut at 0.50, 1.00 and 2.00 ml/kg concentrations the nymphal duration were 9.90, 10.37 and 11.10 days, respectively. Further, in karanj oil treated groundnut seeds, the nymphal duration was 9.97, 10.57 and 11.87 days at 0.50, 1.00 and 2.00 ml/kg, respectively. Further, in alsi oil treated groundnut seeds at 0.50, 1.00 and 2.00 ml/kg concentrations, the nymphal period was 9.83, 10.27 and 11.00 days, respectively. In the present study, the duration of nymphal stage among non-edible oil treated groundnut seeds were found to be minimum in case of alsi oil at 0.50 ml/kg concentration (9.83 days). However, the nymphal duration was maximum in case of neem oil at 2.00 ml/kg concentration (14.03 days). The two year pooled over data on nymphal duration was presented in the Table 2 showed in control, the nymphal duration was 7.78 days. In neem oil treated groundnut seeds at 0.50, 1.00 and 2.00 ml/kg concentrations, the duration of nymphal stage was 11.03, 12.07 and 14.08 days, respectively. In eucalyptus oil, the duration of nymphal stage was 10.90, 12.02 and 13.68 days at 0.50, 1.00 and 2.00 ml/kg concentrations, respectively. In castor oil, the duration of nymphal stage was 9.87, 10.33 and 11.10 days at 0.50, 1.00 and 2.00 ml/kg concentrations, respectively. In karanj oil, the duration of nymphal stage was 9.98, 10.58 and 11.93 days at 0.50, 1.00 and 2.00 ml/kg concentrations, respectively. Further, in case of alsi oil at 0.50, 1.00 and 2.00 ml/kg concentrations the nymphal duration was 9.83, 10.27 and 11.03 days, respectively. In *Neem* oil, the duration of nymphal stage was maximum (14.08 days) at 2.00 ml/kg concentration followed by eucalyptus oil (13.68 days), castor oil (11.10 days), alsi oil (11.03 days) and karanj oil (11.93 days) at 2.00 ml/kg concentrations. The duration of nymphal stage among non-edible oil treated groundnut seeds were found to be minimum in case of alsi oil at 0.50 ml/kg concentration (9.83 days). Moreover, the nymphal stage was shorter at 0.50 ml/kg concentration indicated that low concentration was least effective. The lowest nymphal stage was noticed at 2.00 ml/kg concentrations indicated that higher concentrations were most effective, where the nymphal stage was prolonged (14.08 days) as compared control (7.78 days). It is very much clear from the present investigation that neem oil was most effective to increase the duration of nymphal stage followed by eucalyptus oil, castor oil, karanj oil and alsi oil. All the non-edible oils were found to be significantly more effective in comparison control in prolonging the nymphal duration of mite, *T. putrescentiae*. *Neem* oil was significantly superior over other non-edible oil treatments. The nymphal period was higher (14.08 days) at 2.00 ml/kg concentration. The present findings were more or less similar to the earlier work of Rani (2000) who also recorded longer nymphal duration in case of *Neem* oil treated pigeonpea seeds against stored mite, *S. nesbitti*. Further, in a study Rim and Jee (2006) reported that nymphal durations of mite, *Dermatophagoides farinae* and *D. pteronyssinus* were longer as compared to control when treated with essential oils. The adverse effect of essential oils against stored product mite, *S. pontifica* was also reported by Pumnuan and Insung (2011). All these earlier research work more or less support the present findings.

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