Assessing the Efficacy of Oil-Based Formulations for Controlling Red Spider Mite in Tea Plantations

ABSTRACT

Home-madesesameandmustardoilbasedformulationsweretakenforlaboratoryexperimentationonredspidermite,*Oligonychuscoffeae*(Nietner)at0.5%,0.75%and1%concentrationaloneandincombinationwithcowurinetostudyitsefficacyon ovipositionrate, egg hatchability,mortalityofnymphandadultmites.Allthetreatmentsofsesameoil and sesameoil1%, sesame oil1%+cowurine5%were found to be effectiveinreducing the rateoviposition and egghatchability of mites respectively whichwereatparwithcommercialneem(1:1500).Sesameoil0.75%+cowurine5%,sesameoil1%, sesameoil1%+cowurine5% and sesame oil 0.75%, sesame oil 0.75% + cow urine 5%, sesame oil 1%, sesame oil 1% + cow urine 5%werefoundtobeeffectiveformortalityofnymphs and adults ofredspidermiterespectivelywhichwereatparwithcommercialneem.

Keywords:Commercial neem, cow urine, mustard oil, Red spider mite,sesameoil

1. INTRODUCTION

Tea[*Camelliasinensis*(L).OKuntze]isanexportoriented,perennial,plantationcropgrowninmorethan50countriesaroundtheworld.Themajorteaproducingcountriesinclude China,India,KenyaandSriLanka.TheteagrowingareasofIndiaarecategorizedintotworegionsnamelyNorthIndiaandSouthIndia.NorthEastIndiafallsundertheNorthIndiaregionwhichliesbetween24^0 and27^0 Northlatitudesand88^0 and95^0 Eastlongitudesandatanelevationrangingfrom20minplainsanduptoaheightof2000minDarjeeling.Theredspidermite,*Oligonychuscoffeae*(Nietner),belongstothefamilyTetranychidaeoftheorderAcarina.Itisapolyphagouspestwhichisfoundinawidedistributioninalmostallteagrowingregions.Redspidermitenormallyattackstheuppersurfaceofthematureleavesbut,inseverecasesitspreadstotheyoungleavesandalsototheundersurfaceofleaves.Thedamageismainlycausedbytheynymphsandadultstagesofthemitewhichfeedonthesapoftheleaves.Theattackstartsalongthemid-ribandveins,onthedepressionsofleavesandgraduallyspreadstothewholesurface.Thedamageischaracterisedbyreddishbrownmarkswhichdevelopatthefeedingpointsandasaresultofrepeatedsucking,brownpatchesareformedontheuppersurfacewhichturnsultimatelybronze.Thebushesarebadlydefoliatedinsevereinfestationaffectingtheyieldofthecrop.Thisresultsincroplossfrom17to46%(Roy*etal*.,2014).

Redspidermitebreedsthroughouttheyearandcanbefoundatanytimeontheteabushes.Thepopulationstartsincreasingfromearly March andreachestheirpeakduringearlyApril.Injurybecomesmostsevereduring May andcontinuestillthemonsoonrainswashofftheactiveforms.Aslightattackmaydevelopin September or October.Duringthecoldweather,themultiplicationratedecreasesandthemitespresentonthebushesisinsmallnumber.Butthissmallpopulationisalsoresponsibleforthedamagecausedinthenextseason.Manyfactorssuchasdrought,plantingmaterials,typeofpruning,roadsidebushes,defoliation,shadetrees,typeofmanuring,drainage,cultivationpractices,weatherconditionsareinvolvedintheo

ccurrenceofredspidermite.Manyacaricidesbeingusedworldwideplayamajorroleinthemanagementof*Oligonychuscoffeae*.Butapplicationoftheseacaricideshaveseriousdrawbackssuchastoxicitytonon-targetorganisms,pesticideinducedresistancebecauseoffrequentapplication,healthhazardandpresenceofhigherlevelsofresiduesinmadetea(Sharaby,1988).Asaresultofdissatisfactionofconsumersandimportersregardingpesticideresiduestheproblemhasbecomeamajorconcerntotheteaindustry.Inordertominimizesuchcrisisintheteaindustryandtoprotectcropsinmodernagriculture,itisaneedofthehourtolimittheuseofsyntheticacaricidesandtopromotealternativepracticesthatarebasedonnon-chemicalmethodswhicharelesstoxictoman,easilyadoptable,costeffectiveandeasilyavailable.Thuswiththeaboveframeofreference,theuseofplantbasedoilsmayrepresentanovelclassofcropprotectantswhichareeadilyavailableinthemarketandtheirpreparationiseasyandlesstimeconsuming.Theadvantageofplantbasedoilsisthatitcontainscomplexmixturesofmonoterpenes,phenols,sesquiterpeneswhichnotonlyrepelinsectsandmitesbutalsohavecontactandfumigantactivity(Koul*etal*.,2008).Several studies pointed out the neurotoxic action of essential oils by acetylcholinesterase (AchE) inhibition or by blocking the octopamine receptors. The essential oils varied in their activity which may be due to variation of their chemical constituents (Enan, 2001). TherearealsoseveralreportsoncowurinehavingpesticidalpropertieswhicharepresentlybeingusedbymanyteagrowersofAssam.Cowurinesprayingontheinfestedbushescanminimizetheharmfuleffectsofsyntheticpesticidesanditwasreportedthatstoredstockispreferredoverfreshurinebecauseitcancauseleafscorchingandplantwilting(Gahukar,2013).Keepingtheabovefactsinmindthepresentinvestigationwasundertakenwhichmayserveasanattractivealternativetosyntheticchemicalinsecticides.

2. MATERIALS AND METHODS

2.1 Collection and preparation of oil based formulations

Home made mustard and sesame oil were taken for experimentation on red spider mite, *Oligonychuscoffeae*. The aqueous solution of 0.5%, 0.75% and 1% of both these oils were made and 2-3 drops of teepol was added to it, (Teepol - AG, National Organic Chemical Industries Limited, Mumbai, India) which acts as an emulsifier.

Cow urine

Cow urine was collected from the dairy farm of Assam Agricultural University, Jorhat during November - December, 2020. A 5% solution of cow urine was made and was added to the oils, which served as the treatment.

Tea clone

Mature leaves of clone TV 21 maintained at the Experimental Garden for Plantation Crops (EGPC), Assam Agricultural University, Jorhat was utilized for mass rearing of mites and experimentation.

Mass culture of test insect

Maintenence of *Oligonychuscoffeae* culture was done based on detached leaf technique proposed by Das *et al*. (2012) in the laboratory during 2019 - 2021.

2.2 Application of treatment on *Oligonychuscoffeae*

From the stock culture of *O. coffeae* reared on detached leaves, ten numbers of one-day old adults were allowed to settle for 24 hours on a TV 21 clone leaf disc of 2.5 cm^2 and sprayed with oil formulation with and without cow urine at different desired concentrations by hand atomizer (Make: Axiva, Capacity: 50ml). Each treatment was replicated six times and data on adult mortality were recorded at 24, 48 and 72 hours after treatment (HAT) visually with the help of a stereoscopic microscopic. A control treatment of water spray was maintained to compare bioefficacy against *O. coffeae*. Moreover, commercial neem formulation (1 : 1500) dilution) was also applied to compare the bioefficacy. Same method was followed against the nymphal stage of red spider mite.

To evaluate the ovicidal property of different oil formulations along with cow urine or without cow urine, ten spider mite gravid females were allowed to lay eggs on leaf disc for 24 hours. Thirty eggs were counted for each replication and the other eggs were discarded off from the leaves along with the adult mites. Then the newly laid eggs were sprayed with different concentrations of oil based formulations. Each treatment was replicated six times. The first observation was recorded as soon as the eggs in the control hatched. Those eggs which did not hatch during this period were regarded as non - viable.

2.3 Experimental details

1. Total number of treatments : 14

2. Total number of replications : 6

3. Design of the experiment : Completely Randomized Design

The details of the treatments are given as below:

T1 - Mustard oil (0.5%)

T2 - Mustard oil (0.5%) + cow urine (5%)

T3 - Mustard oil (0.75%)

T4 - Mustard oil (0.75%) + cow urine (5%)

T5 - Mustard oil (1%)

T6 - Mustard oil (1%) + cow urine (5%)

T7 - Sesame oil (0.5%)

T8 - Sesame oil (0.5%) + cow urine (5%)

T9 - Sesame oil (0.75%)

T10 - Sesame oil (0.75%) + cow urine (5%)

T11 - Sesame oil (1%)

T12 - Sesame oil (1%) + cow urine (5%)

T13 - Commercial neem (1 : 1500)

T14 - Water (Control)

2.4 Observations and statistical analysis

The observations that were recorded on parameters included rate of oviposition, percent reduction in egg hatchability, nymph and adult mortality at different time interval. Analysis of variance was carried out as per the design following standard statistical procedure. The treatment mean values was compared by least significance difference based on ANOVA (Gomez and Gomez, 1984). All computations was carried out by using MS Excel 2007 and OPSTAT software.

3. RESULTS AND DISCUSSION

3.1 Rate of oviposition

The data on oviposition rate of *O. coffeae* are presented in Table 1. During the period October - November, 2020 T12(2.20%) was found to be effective among the oil based formulations followed by T11 (3.88%) and T10 (4.72%). During the period March - April, 2021 T12 (6.11%) was found to be effective among the oil based formulations followed by T11 (6.61%) and T10 (7.71%). Among the two selected oil based formulations, sesame oil showed more efficacy on rate of oviposition than mustard oil in both the periods. Mustard oil and sesame oil when sprayed with and without cow urine showed effective results than control (water) in both the periods. For both the periods, all the treatments of sesame oil were at par with commercial neem (1:1500). The results of the experiment were almost in conformity with the findings of Roy *et al*., (2015). They observed that clove oil (an essential oil from the clove plant, *Syzygiumaromaticum*) inhibit oviposition of tea red spider mite. The rate of deposition of eggs by mites on treated leaf surfaces as well as the viability rate of eggs decreased significantly with the application of the oil. Likewise, Dam *et al*., (2021) evaluated acaricidal properties of *Simarouba glauca* and *Hydnocarpuspentandra* seed oils against *O. coffeae* under laboratory conditions. The oviposition deterrence study revealed that the least number of eggs were laid on the treatments of *H. pentandra*seed oil which can confirm the present study.

Table 1. Effect of oil based formulations on rate of oviposition of red spider mite during both the periods

Treatments	Rate of oviposition (%)	
	72 Hours after treatment	
	October - November, 2020	March - April, 2021
T_1	23.88	27.22
T_2	20.00	24.50
T_3	18.50	23.00
T_4	16.00	20.66
T_5	16.11	19.33
T_6	15.33	18.67

T_7	9.33	12.33
T_8	6.11	9.22
T_9	7.11	9.77
T_{10}	4.72	7.71
T_{11}	3.88	6.61
T_{12}	2.20	6.11
T_{13}	2.19	6.10
T_{14}	50.66	65.22
S.Ed	7.99	7.67
CD p = 0.05	12.98	12.33

3.2 Reduction in egg hatchability

The data on percent reduction in egg hatchability of red spider mite during both the periods are presented in Table 2. During the period October - November, 2020T12 (62.22%) was found to be most effective among the oil based formulations followed by T11 (55.55%) and T10 (51.66%). During the period March - April, 2021 T12 (58.88%) was found to be most effective among the oil based formulations followed by T11 (52.21%) and T10 (49.33%). Among the two selected oil based formulations, sesame oil showed more efficacy on percent reduction in egg hatchability than mustard oil in both the periods. Mustard oil and sesame oil when sprayed with and without cow urine showed effective results than control (water) in both the periods. For both the periods, T11 and T12 were at par with commercial neem (1 : 1500). The findings are in agreement with the findings of Roy, 2018. They found that the oils of *Jatropha curcus* and *Allium sativum* showed outstanding ovicidal activity even at low concentrations. The finding is also comparable with the work of Roy *et al*., (2018). They observed that among the plant oils of castor, sesame, rose, olive, mustard, groundnut and karanja, the egg hatchability was significantly affected in all treatments with rose oil being most toxic ovicide among the plant oils followed by karanja oil and olive oil. Plant based oils, in general, posses excellent ovicidal properties and found to be effective even at few parts per million (Benelli, 2015). The oils affected the eggs hatchability without any morphological changes by disrupting or inhibiting embryogenesis and making them unable to come out of the egg shells (Ibrahim, 2019). Five plant oil based formulations prepared by considering individual as well as combination of *Sesamum indicum* and *Millettia pinnata* seed oil at different ratios against eggs of *O. coffeae* also showed significant ovicidal activity (Sarmah *et al*., 2020) which is in line with the present study.

Table 2. Effect of oil based formulations on percent reduction in egg hatchability of red spider mite during both the periods

Treatments	Percent reduction in egg hatchability (%) 72 Hours after treatment	
	October - November, 2020	March - April, 2021
T_1	39.44	34.44
T_2	40.77	38.32
T_3	44.44	41.10
T_4	49.99	46.66
T_5	48.88	46.11
T_6	49.99	46.66
T_7	44.44	42.55
T_8	46.66	42.77
T_9	47.77	44.44
T_{10}	51.66	49.33
T_{11}	55.55	52.21
T_{12}	62.22	58.88
T_{13}	63.77	60.33
T_{14}	23.33	20.22
S.Ed	4.97	5.06
CD p= 0.05	9.95	10.11

3.3 Nymph mortality

The mean data on percent mortality of nymphs after 24, 48 and 72 hours of treatment during both the periods are presented in Table 3. In case of nymphs, highest mortality was observed on T12 among the oil based formulations in both the periods. Significant reduction was recorded upto90.67%, 94.33% and 98.00% in 24, 48 and 72 hours after application respectively during the period October-November, 2020 and 88.00%, 95.00% and 96.67% in 24, 48 and 72 hours after application during the period March-April, 2021 respectively, However, T10, T11 and T12 were at par with commercial neem (1:1500) after 72 hours of treatment in both the periods.

Table 3. Effect of oil based formulations on nymph mortality of red spider mite during both the periods

Treatments	Nymph mortality (%)					
	October - November, 2020			March - April, 2021		
	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT
T_1	46.67	65.00	73.00	38.33	61.67	70.33
T_2	50.33	70.00	78.32	43.33	63.33	73.67
T_3	51.67	75.00	82.33	46.67	65.00	74.33
T_4	61.33	80.00	85.00	65.00	70.33	75.67
T_5	63.33	76.67	83.00	63.80	72.67	76.33
T_6	78.33	80.67	87.00	70.33	73.00	77.00
T_7	80.00	81.33	88.33	73.67	79.00	82.33
T_8	81.33	83.67	90.00	75.33	81.67	85.22
T_9	79.97	86.33	90.67	76.90	86.33	86.67
T_{10}	83.00	91.33	94.33	81.67	88.67	93.00
T_{11}	85.33	93.00	95.67	84.33	92.33	96.33
T_{12}	90.67	94.33	98.00	88.00	95.00	96.67
T_{13}	91.33	98.67	99.33	88.67	95.33	98.67
T_{14}	7.33	8.33	8.67	6.33	7.67	8.33
S.Ed	5.85	4.45	3.82	6.52	5.01	4.35
CD p=0.05	11.70	8.90	7.64	13.05	10.01	8.68

HAT : Hours after treatment

3.4 Adult mortality

The mean data on percent mortality of adults after 24, 48 and 72hours of treatment during both the periods are presented in Table 4. In case of adults, highest mortality was observed on T12 among the oil based formulations in both the periods. Significant reduction was recorded upto 89.67%, 93.33% and 97.00% in 24, 48 and 72 hours respectively after application during the period October - November, 2020 and 88.33%, 93.00% and 96.67% in 24, 48 and 72 hours after application respectively during the period March - April, 2021. However, T9, T10, T11 and T12 were at par with commercial neem (1 : 1500) after 24, 48 and 72 hours after treatment in both the periods. The toxic effect of oils is due to their fumigant (Ayvaz *et*

al., 2009) and/or contact toxicities (Kim *et al*., 2003) of the major components of these oils or by inhibition of acetylcholinesterase activities. Some authors also reported that monoterpenoids present in oils cause insect mortality by inhibiting acetylcholinesterase enzyme activity (Sertkaya *et al*., 2010) possibly by activation of octopaminergic receptors (Kostyukovsky, 2002). The present findings can be compared with the findings of Roy *et al*., (2018). They evaluated the anti-mite properties of seven plant based oils viz., castor oil, sesame oil, rose oil, olive oil, mustard oil, groundnut oil and karanja oil against *O. coffeae* and found that among the plant oils, karanja oil was the most toxic adulticide followed by mustard oil and olive oil. Likewise, Sarmah *et al*., (2020) evaluated the efficacy of five plant oil based formulations prepared by considering individual as well as combination of *S. indicum* and *M. pinnata* seed oil against adults' stages of *O. coffeae*. Two season field bio-efficacy results indicated that the formulations are highly effective against *O. coffeae* and were superior to commonly used chemical acaricide, Ethion 50EC which can be comparable with the present study. Also another work evaluated that the acaricidal properties of *Simarouba glauca* and *Hydnocarpuspentandra* achieved significant mortality over adult red spider mite which can be related with the present study (Dam *et al*., 2021).

Thus, the present study demonstrated the efficacy of different oil based formulations separately or in combination with cow urine for the management of red spider mite in tea.

Table 4. Effect of oil based formulations on adult mortality of red spider mite during both the periods

Treatments	Adult mortality (%)					
	October - November, 2020			March - April, 2021		
	24 HAT	48 HAT	72 HAT	24 HAT	48 HAT	72 HAT
T_1	38.33	65.67	73.33	33.33	51.67	60.00
T_2	46.63	67.63	75.67	38.33	55.00	58.33
T_3	46.67	69.33	79.33	40.00	60.00	70.00
T_4	68.33	75.00	82.33	60.00	72.33	78.33
T_5	76.67	83.00	83.66	65.00	75.33	79.33
T_6	78.00	83.33	84.00	70.00	77.67	84.00
T_7	80.67	84.67	85.33	72.00	81.00	85.33
T_8	81.00	85.00	87.33	75.00	82.33	86.67
T_9	82.00	85.27	93.67	76.22	86.67	89.33

T_{10}	82.33	90.33	94.00	81.67	90.00	91.33
T_{11}	83.33	92.67	94.67	83.33	91.67	93.67
T_{12}	89.67	93.33	97.00	88.33	93.00	96.67
T_{13}	93.67	96.00	98.33	89.67	95.33	98.67
T_{14}	7.00	8.23	8.36	6.35	7.33	8.00
S.Ed	7.93	7.31	4.91	7.98	6.59	5.70
CD p=0.05	12.35	10.61	9.80	13.95	12.18	11.40

HAT : Hours after treatment

4. CONCLUSION

In this present investigation, the laboratory experimentation conducted on red spider mite, *Oligonychuscoffeae*, using homemade formulations based on sesame oil and mustard oil at various concentrations, both alone and in combination with cow urine, has yielded promising results. The formulations containing sesame oil at 0.5%, 0.75%, and 1% concentrations,particularly in combination with cow urine at 5%, demonstrated significant efficacy in reducing the rate of oviposition and egg hatchability of the mites. These effects were comparable to those achieved with commercial neem-based products, a widely recognized natural pesticide. Moreover, the sesame oil-based formulations, especially at 0.75% and 1% concentrations in conjunction with cow urine, exhibited notable mortality rates for both nymphs and adult mites, which were also on par with the commercial neem treatment. These findings highlight the potential of these homemade formulations as effective and eco-friendly alternatives for managing red spider mite infestations in agricultural settings, offering a sustainable and cost-effective approach to pest control. Further research and field trials may be warranted to validate and optimize these formulations for practical use in pest management strategies.

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