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Evolving an integrated management strategy for effective suppression of mite pests infesting tomato

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Abstract
Two spotted spider mite, *Tetranychus urticae* Koch. is one of the major pests of tomato in south India. The use of various synthetic chemicals for the control of this pest has lead to various environmental hazards. Botanical insecticides have long been augmented as a feasible alternate strategy for pest management because plant derivatives are safer, specific in action, biodegradable and potentially suitable for use in integrated pest management programmes. The commonly available plant derivatives such as *V. negundo* (10%), *O. sanctum* (10%), *C. colocynthis* (10%), *A. calamus* (10%) and among the oil formulations rosemary oil (3%), neem oil (3%), citronella oil (3%), lemon grass oil (3%) were integrated as one of the components. The popular acaricide (Fenpyroximate 5.0 EC) was used as a standard check for comparison of the relative efficacy of the treatments. The formulations were evaluated for mortality percentage of egg and adults of red spider mites under field condition. Among the plant derivatives, the *O. sanctum* (10%), *V. negundo* (10%) and *A. calamus* (10%) were found more promising with maximum percent reduction of eggs (72.36%, 72.20% and 72.00%) and mites (73.62%, 73.41% and 73.20%) over untreated check., coupled with least mean number of eggs (8.76, 8.81 and 8.88) and mites (7.11, 7.17 and 7.23) respectively, which were statistically on par in their efficacy, followed by rosemary oil (3%) which recorded a mean reduction of eggs (70.10%) and mites (71.9%), neem oil (3%) with the reduction of eggs (68.41%) and mites (69.55%). The remaining plant derivatives show moderate effect on two spotted spider mite.

Keywords: Two spotted spider mite, Botanical pest control, Essential plant oils, IPM

Introduction
Every year, gardeners face several insect pests and mite problems infesting vegetables and fruit crops [19].Tomato is the prominent vegetable crop in India. Tomato is one of the world's most popular vegetables; with an annual production of 18.73 mMt in India under 0.88 million hectors of area. Out of this, 0.33 million metric tons under 0.025 million hector are produced in Tamil Nadu [2]. The tomato is now grown and consumed around the world as raw salads, and processed into ketchup or tomato soup. Unripe green tomatoes can also be breaded and fried, used to make salads or pickles. Tomato suffers attack by an array of insect pests, such as Colorado potato beetle (*Leptinotarsa decemlineata*), Tomato fruit worms (*Vasates lycopersici*), Corn Earworm (*Heliothis zea*), Tomato Hornworm (*Protoparce quinquemaculata*), Tomato pinworm (*Keiferia lycopersicella*), Green Peach Aphid (*Myzus persicae),* Stinkbug (*Acrosternum hilare),* plant feeding mites like Tetranychidae (*Tetranychus urticae, Tetranychus ludeni, Tetranychus neocaledonicus* and *Tetranychus cinnabarinus,* Cutworms (*Spodopetra exigua*), Whiteflies (*Trialeurodes vaporariorum),* Thrips (*Heliothrips haemorrhoidalis),* Leafminer (*Liriomyza brassicae).* Nowadays synthetic pesticides are normally used to control the two spotted spider mite, because these chemicals are easy to apply, effective and do not generally require identification of the species. However, continuous use of certain active ingredients, the reduction or elimination of beneficial species and create environmental pollutions [33, 22].

Unfortunately, *T. urticae* is one of the most striking examples of polyphagy among herbivores with an unmatched ability to develop resistance to pesticides. Pesticides formulated with herbal extracts are thus in practice as a safer alternative and have become part of leading research all over the world [7]. Plant compounds such as extracts are used as insecticides [25, 22], antifeedant [3, 18, 1], oviposition deterrents [27, 10, 1], acaricidals [29, 12] and repellents [37]. Since plant extract are found in nature, they do not release toxic substances into the environment and

do not cause water pollution by decomposing quickly. Besides, since plant extracts are suitable to use with natural enemies, they can be used safely instead of synthetic pesticides [11].

Studies have demonstrated that chemicals derived from plants are safer, specific in action, biodegradable and potentially suitable for use in integrated pest management programs. More than 2000 plant species including medicinal plants and spices are known to have insecticidal and acaricidal properties [13]. They constitute a rich source of bioactive compounds which might act deadly on physiological system to kill them [9].

2. Materials and Methods

A field experiment was conducted in a farmer's holding at the Thadagoundanpatti village of Alanganallur block, Madurai district, during Kharif 2016, which is a traditional vegetable tract, using the very popular variety PKM 1. The soil type was sandy loam, with a pH 8.79, well suited for vegetable cultivation in irrigated condition.

2.1. Treatment details

Treatments	Common name	Scientific name	Concentration
T_1	Vitex	*Vitex negundo* L.	10%
T_2	Tulsi	*Ocimum sanctum* L.	10%
T_3	Citrullus	*Citrullus colocynthis* L.	10%
T_4	Sweet Flag	*Acorus calamus* L.	10%
T_5	Rosemary oil	*Rosemarinus officinalis* L.	3%
T_6	Neem oil	*Azadirachta indica* A. Juss.	3%
T_7	Citronella oil	*Cymbopogan nardus* L.	3%
T_8	Lemon grass oil	*Cymbopogan citrates* Dc.	3%
T_9	Fenpyroximate 5.0 EC	-	1.0 ml / lit.
T_{10}	Untreated check	-	-

Two rounds of foliar sprays at 15 days interval were applied on tomato crop using high volume sprayer. Apart from pre-treatment count, the post treatment counts were recorded on 1, 3, 7 and 15 days after each spray.

2.2. Preparation of ethanolic extracts of botanicals

The botanicals which are indigenous and locally available were collected from medicinal plant garden maintained at our institute. Plant parts like leaves / rhizome / fruits were shade dried, before preparing the ethanolic extracts, (Soxhlet's apparatus method) meant for foliar application. The plant parts were washed with water, followed by shade drying and ground separately from which 50g of the well powdered material was soaked in 100ml of solvent (Ethanol) for 48 hrs at room temperature. The content was often stirred, after complete soaking, the extract was decanted. It was filtered through Whatman No.1filter paper. The filtrate was then made up to 100 ml. by adding 5ml of Triton X 100 (emulsifier) and the required quantity of solvent. Similarly to bee propolis the filtrate was diluted with ethanol, in the ratio of 1mg propolis in 1 ml of ethanol. The final product was equivalent to 50EC of the respective plant product. Emulsions of 10 % concentration were prepared for field application.

2.3 Preparation of ethanol based oil formulation for field application

The botanical oils purchased from commercial venders were diluted in ethanol + water (70 + 30 by volume) mixtures then the solutions was made up to 100 ml by adding 5ml of Triton X 100 (emulsifier) and the required quantity of solvent. The final material was equivalent to 50EC of the respective plant oil formulations. Emulsions of 10% concentration were prepared for conducting bio-efficacy testing in field conditions.

2.4. Assessment of egg and mite population

The spider mite population was assessed by adopting the following methodology. Five plants were selected at random from each plot @ three leaves one each from top, middle and bottom which were examined for the presence of mite. The lower and upper sides of the leaves were carefully observed. The number of eggs and mites (Adults & nymphs) was observed in an area of 2 cm^2 using a square card. A stereo zoom binocular microscope was used for counting the eggs in the laboratory, while a 10x magnifying hand lens was used in field condition to count the mites. The mean population was worked out, before subjecting the data to square root transformation to compare the active stage of mite populations and to find out the most effective treatment by LSD

$$\% \text{ Mortality} = \frac{\text{Number of mite in untreated check} - \text{Number of mite in treated plot}}{\text{Number of mite in untreated check}} \times 100$$

2.5. Assessment of yield

The yield of tomato fruit was recorded from each plot, treatment wise and the fruits were weighed and recorded as and when harvested for statistical analysis. The yield was computed in terms of kg/ha and the percent increase in yield in treated plots over the untreated check was worked out after log transformation.

2.6. Cost- Benefit Ratio

The cost- benefit ratio (CBR) was worked out adopting the formula to assess the economic viability of the management strategies evaluated.

$$CBR = \frac{\text{Net return}}{\text{Cost of cultivation}}$$

2.7. Statistical Analysis

The method suggested by Goulden (1972) was adapted for statistical analysis for the data obtained from field experiments. Prior to analysis, the data on the egg and mite counts were subjected to square root transformation, whereas for yield data, log transformation was adopted. The mean values of treatments were then compared using Least significant difference (LSD) to identify the most effective treatments.

3. Results and Discussion

The plant derivatives tested against two spotted spider mite, *T. urticae* under field condition showed a varied response on their acaricidal property, which is presented and discussed below.

3.1. Evolving an integrated management strategy against two spotted spider mite *T. urticae* Koch. on tomato.

Among the various treatments tested (Table 1) *O. sanctum* leaf extract (10%), *V. negundo* leaf extract (10%) and *A. calamus* rhizome extracts (10%) recorded the maximum per cent reduction of eggs (78.50%, 78.38% and 78.23%) and mites (79.90%, 79.71% and 79.54%) over untreated check, which were statistically superior and on par in their efficacy, which synchronize with the findings of Kanniammal and Chinniah (2012) [21] who reported that *O. canum* recorded 72.94 and 75.07 per cent mortality of eggs and adults of *T. urticae.* The finding of Gosh and Chakraborthy (2014) [15] also confirms that the leaf extracts of tulsi (*O. tenuiflorum*) @ 5% exhibited 29.32 per cent of overall efficacy against red spider mite (*Tetranychus* sp) on brinjal. The report of Arutselvi *et al* (2012) [4] further strengthens our findings that the leaf extract (10%) of *O. tenuiflorun* registered 44.67% mortality against *Panchaetothrips indicus* on brinjal.

The report of Sugeetha and Srinivasa (1999) [34] has also been in conformity with this findings that methanolic leaf extracts of *V. negundo* (@ 6% concentration) recorded 76 % adult mortality of red spider mites *Tetranychus* sp. Gurusubramanian *et al* (2008) [17] have reported that aqueous extracts of sweet flag reduces the infestation of red spider mites (60-88%) on tea, similar result was reported by Sarmah *et al* (2009) [32] that aqueous extracts of *A. calamus* 10% causing 88.70% mortality of *Oligonychus coffeae* eggs under field condition 72 hrs. after treatment, all these reports undoubtedly prove that the herbal extracts serve as excellent acaricides.

The next treatments in the order of efficacy are rosemary oil (3%) with the reduction of eggs (76.47%) and mites (77.92%) closely followed by neem oil (3%) with the mortality of eggs (74.88%) and mites (76.29%), *C. colocynthis* (10%) which recorded 73.29% eggs mortality and 74.66% mortality of mites. These findings are well supported by Salman *et al* (2014) [30] who proved that rosemary oil 2% caused 82.2% mortality on *T. urticae*. Ramaraju (2004) [28] has published a fool proof evidence that neem oil caused as high as 70.56 to 91.85% mortality of *T. urticae* on bhendi. These reports serve as concrete evidences to prove the excellent efficacy of plant derivatives against mite pests. Sarmah *et al* (2009) [32] also proved that azadirachtin (0.03%) recorded 67.7% mortality of spider mites. The finding of Patnaik *et al* (2011) [26] undoubtedly prooved that *C. winterianus* was effective in suppressing the mite infestation (59.33%) of *Aceria guerreronis* on coconut. Ursani *et al* (2014) [35] reported that neem, tobacco and *Datura* leaf extracts were so effective as it recorded the mortality of 98.36%, 93.75% and 69.03% of jassid population on brinjal. The report of Arain (2009) [3] proved that tobacco extract registered the highest mortality of (98.60%) of mealy bugs followed by neem oil, neem extract and garlic extracts with the mortality of 89.32%, 80.37% and 75.82% respectively. However fenpyroximate 5.0 EC (standard check) @ 1.0 ml / lit. was significantly superior to all other treatments with the highest per cent reduction of eggs (85.57%) and mites (86.37%) over untreated check.

3.2. Evolving an integrated management strategy against two spotted spider mite *T. urticae* Koch. on tomato – Impact on fruit yield and Cost benefit ratio

The highest fruit yield was recorded (Table 1) in case *O. sanctum* (28.70 t/ha), *V. negundo* (28.50 t/ha) and *A. calamus* (28.35 t/ha) which are outstanding and statistically on par, followed by rosemary oil (26.85 t/ha) and Neem oil (25.35 t/ha), in the second position, with the corresponding per cent yield increase of 56.45%, 56.14%, 55.91%, 53.45% and 50.69% respectively. The other treatments which are worth mentioning in terms of fruit yield being *C. colocynthis* (23.85% t/ha), citronella oil (22.35 t/ha) and lemon grass oil (20.85 t/ha). However, the highest fruit yield of 32.25 t/ha could be recorded in case of fenpyroximate 5.0 EC @ 1.0ml/lit. Which served as the standard check for comparison of mean values. The studies conducted by Ghosh *et al* (2014) [15] firmly support our findings that 5% leaf extracts of *O. sanctum* and 1% pungam oil recorded higher fruit yield of brinjal (25.65 t/ha and 25.55 t/ha.). The report of Kottalagi *et al* (2014) [24] also vouched similar finding.

Apart from the standard check (fenpyroximate) which recorded the highest cost benefit ratio of 1:2.66, among the candidate products, *O.sanctum* (1:2.35), *V. negundo* (1:2.35) and *A. calamus* (1:2.33) are outstanding and statistically on par. The other treatments which need special mention are rosemary oil (1:2.21) and neem oil (1:2.09), followed by *C. colocynthis* (1:1.96), citronella oil (1:1.84) and lemon grass oil (1:1.72). Thus in terms of increase in yield and cost benefit ratio the three promising plant derivatives (*O. sanctum* 10%, *V. negundo* 10% and *A. calamus* 10%) and two plant oils viz., rosemary oil 3% and neem oil 3% can be well fit in as a viable component in the IPM package against two spotted spider mites on tomato which are certainly cost effective and eco-friendly.

Table 1: Evolving an integrated management strategy against two spotted spider mite *T. urticae* Koch. on tomato

Treatments	Egg %reduction over untreated check	Adult + Nymphs %reduction over untreated check	Yield (tonnes /ha)	% increase over untreated check	Cost benefit ratio
T_1- *Vitex negundo* (10%)	79.72	78.38	28.50 (4.45)^b	56.14	1:2.35
T_2- *Ocimum sanctum* (10%)	79.90	78.50	28.70 (4.46)^b	56.45	1:2.36
T_3- *Citrullus colocynthis* (10%)	74.66	73.29	23.85 (4.38)^e	47.59	1:1.96
T_4- *Acorus calamus* (10%)	79.54	78.23	28.35 (4.45)^b	55.91	1:2.33
T_5- Rosemary oil (3%)	77.92	76.47	26.85 (4.43)^c	53.45	1:2.21
T_6- Neem oil (3%)	76.29	74.88	25.35 (4.40)^d	50.69	1:2.09
T_7- Citronella oil (3%)	73.02	71.70	22.35 (4.35)^f	44.07	1:1.84
T_8- Lemon grass oil (3%)	71.31	70.00	20.85 (4.32)^g	40.05	1:1.72
T_9- Fenpyroximate 5.0EC (1.0 ml / lit.)	86.37	85.57	32.25 (4.51)^a	61.24	1:2.66
T_{10}- Untreated check	-	-	12.50(4.10)^h	-	-

3.3. Impact of integrated management strategy on the diversity of arthropod natural enemies in tomato ecosystem

Observations were recorded at regular interval in tomato ecosystem, for the activities/diversity and abundance of various arthropod natural enemies, the diversity and abundance revealed that (Table 2) occurrence of predatory mites (*Amblyseius* spp.) population (3.50/plant) was more in

untreated check, closely followed by botanical formulations, whereas the population varied between 1.40 to 2.50/plant and the lowest population (1.20/plant) could be observed in standard check, fenpyroximate 5.0 EC @ 1ml/lit. The population of coccinellids (*C. septumpunctata* L. and *M. sexmaculatus* Fab.) population (3.00/plant) were abundant in untreated check which was on par with botanical treatments (1.30 to 2.30/plant). The lowest predatory population (1.10/plant) was observed in standard check namely fenpyroximate 5.0 EC @ 1ml/lit. Similar trend was observed with reference to predatory thrips (*S. indicus* Priesner.) population (4.50/plant) also the population was obviously abundant in untreated check plots, where as in treated plots the predatory thrips population ranged between 2.40 to 3.40/plant. The lowest predatory population (2.00/plant) could be noticed in standard check fenpyroximate 5.0 EC @ 1ml/lit. treated plots. Green lace wings (*C. zastrowi sillemi* Esben.), anthocorid bugs and predatory thrips population have also been abundant in untreated check and botanical treated plots. In all probability the plots treated with fenpyroximate 5.0 EC @ 1ml/lit. recorded the least population of all natural enemies, including predatory mites.

The plant derivatives and plant oils did not suppress the abundance / diversity / activities and of these natural enemies which are natural visitors in the field compared to the standard acaricide tested (Fenpyroximate 5.0 EC @ 1ml/lit.). The reports of Ursani *et al* (2014) [35] proves that neem, tobacco and datura leaf extracts seem to have no hazardous effect to beneficial insects. The present finding fall in line with the findings of Gosh (2013) [14] which confirmed that the botanical extracts were much safer towards predators in okra fields. Neem oil at 3% was found to be safer to the predatory coccinellid, *M. sexmaculatus* Fab. Jayasree (1984) [20] and Saminathan (1997) [31].

Table 2: Impact / Safety of integrated management strategy on the diversity of arthropod natural enemies in tomato ecosystem

Treatments	Population of natural enemies / Plant						
	Predatory mites	**Coccinellids**	**Predatory thrips**	**Green lace wings**	**Anthocorid bugs**	**Praying mantids**	**Spiders**
T_1- *Vitex negundo* (Leaf extract 10%)	1.40 (1.18)^g	1.30 (1.14)^g	2.40 (1.55)^g	1.60 (1.25)^g	1.40 (1.18)^g	1.20 (1.10)^g	1.70 (1.30)^g
T_2- *Ocimum sanctum* (Leaf extract 10%)	1.40 (1.18)^g	1.30 (1.14)^g	2.40 (1.55)^g	1.60 (1.27)^g	1.40 (1.18)^g	1.20 (1.10)^g	1.70 (1.30)^g
T_3- *Citrullus colocynthis* (Fruit extract 10%)	2.10 (1.45)^d	1.90 (1.38)^d	3.00 (1.73)^d	2.20 (1.51)^d	1.70 (1.30)^d	1.50 (1.22)^d	2.30 (1.52)^d
T_4- *Acorus calamus* (Rhizome extract 10%)	1.50 (1.18)^g	1.30 (1.14)^g	2.40 (1.55)^g	1.60 (1.26)^g	1.40 (1.18)^g	1.20 (1.10)^g	1.70 (1.30)^g
T_5- Rosemary oil (3%)	1.70 (1.26)^f	1.50 (1.22)^f	2.60 (1.61)^f	1.80 (1.34)^f	1.50 (1.22)^f	1.30 (1.14)^f	1.90 (1.38)^f
T_6- Neem oil (3%)	1.90 (1.38)^e	1.70 (1.30)^e	2.80 (1.67)^e	2.00 (1.41)^e	1.60 (1.26)^e	1.40 (1.18)^e	2.10 (1.45)^e
T_7- Citronella oil (3%)	2.30 (1.52)^c	2.10 (1.45)^c	3.20 (1.79)^c	2.40 (1.55)^c	1.80 (1.34)^c	1.60 (1.26)^c	2.50 (1.58)^c
T_8- Lemon grass oil (3%)	2.50 (1.58)^b	2.30 (1.52)^b	3.40 (1.84)^b	2.60 (1.59)^b	1.90 (1.38)^b	1.70 (1.30)^b	2.70 (1.64)^b
T_9- Fenpyroximate 5.0 EC (@ 1.0 ml / lit.)	1.20 (1.10)^h	1.10 (1.05)^h	2.00 (1.41)^h	1.30 (1.15)^h	1.20 (1.10)^h	1.00 (1.00)^h	1.10 (1.05)^h
T_{10}- Untreated check	3.50 (1.87)^a	3.00 (1.73)^a	4.50 (2.12)^a	2.90 (1.73)^a	2.50 (1.58)^a	1.90 (1.38)^a	3.10 (1.76)^a
SE	0.0220	0.0163	0.0198	0.0150	0.0152	0.0107	0.0161
CD(0.05)	0.0462	0.0342	0.0415	0.0316	0.0318	0.0225	0.0339
CV%	1.97	1.53	1.44	1.31	1.46	1.12	1.38

Each value is the mean of ten observations.
Figures in parentheses are square root transformed values.
In a column, means followed by common letter (s) is / are not significantly different by LSD at P=0.05%.

4. Conclusion

From the present study, it is crystal clear that plant based products have promising effects against mite pests, at the same time, highly safer/alternative to chemical acaricides. The investigation of the exploitation of native/endemic herbal flora which are available in plenty in India should be given more impetus in order to gradually replace the use of synthetic chemicals for pest/disease management in future.

Reference

1. Abbasipour H, Mahmoudvand M, Rastegar F, Basij M. Insecticidal activity of *Peganum harmala* seed extract against the diamond back moth, *Plutella xylostella*, Bulletin of Insectology. 2010; 63:259-263.
2. Anonymous. Annual report -2013-2014 of Indian institute of vegetable research, Varanasi, Uttar Pradesh, 221305, India (In press), 2014, 255.
3. Arain MI. Effect of botanical pesticides against mealy bugs on cotton. *M. Sc. (Ag.) Thesis*, Sindh Agricultural University, Tandojam, 2009, 23-30.
4. Arutselvi R, Ponmurugan P, Bala Saravanan P, Suresh R. Formuation of natural insecticides against *Panchaetothrips indicus* Bagnall in *Curcuma longa* L. leaves of PTS and Erode varieties. Journal of Biopesticides. 2012; 5:77-81.
5. Ben Jannet H, Skhiri FH, Mighri Z, Simmonds MSJ, Blaney WM. Antifeedant activity of plant extracts and new natural diglyceride compounds isolated from *Ajuga pseudoiva* leaves against *Spodoptera littoralis* larvae. Industrial Crops and Production. 2001; 14:213-222.
6. Clemente S, Mareggiani G, Broussalis A, Martino V, Ferraro G. Insecticidal effects of Lamiaceae species against stored products insects. Boletín de Sanidad Vegetal. Plagas. 2003; 29:1-8.
7. Daoubi M, Deligeorgopoulou A, Macias-Sanchez AJ, Hermamdez-Galan R, Hitchcock PB, Hanson JR *et al*. Antifungal activity and biotrans formation of diisophorone by Botrytiscinerea. Journal of Agricultural

and Food Chemistry. 2005; 53:6035-6039.
8. Elango G, Rahuman AA, Bagavan A, Kamaraj C, Zahir AA, Venkatesh C. Laboratory study on larvicidal activity of indigenous plant extracts against *Anopheles subpictus* and *Culex*. Parasitology Research. 2009; 104(6):1381-1388.
9. El-Sharabasy HM. Acaricidal activities of *Artemisia judaica* L. extracts against *Tetranychus urticae* Koch. and its predator *Phytoseiulus persimilis* Athias Henriot (Acari:Phytoseiidae). Journal of biopesticides. 2010; 3(2):514-551.
10. Fernandes FF, Freitas EPS. Acaricidal activity of an oleoresinous extract from *Copaifera reticulata* (Leguminosae: Caesalpinioideae) against larvae of the southern cattle tick, *Rhipicephalus (Boophilus) microplus* (Acari: Ixodidae). Veterinery Parasitolology. 2007; 147:150-154.
11. Garcia RM, Perez PR, Rodríguez HC, Soto HM. Toxicidad de alcaloides de *Eythrina americanaen* larvas de mosqui to *Culex quinquefasciatus*. Fitotecnia Mexicana. 2004; 27:297-303.
12. Ghosh KR. Harmful Effect of Insecticides in the Population Dynamics of Spiders on Lady'sfingers *Abelmoschusesculentus* (L.) Moench at Field Level. American-Eurasian, Journal of Agriculture and Environmental Science. 2013; 13(9):1181-1186.
13. Gosh SK, Chakraborthy K. Bio-efficacy of plant extracts against red spider mite (*Tetranychus sp.*) infesting brinjal (*Solanum melongene* L.). Research Journal of Agriculture and Environmental Science. 2014; 1(1):26- 31.
14. Goulden CH. Methods of statistical analysis. Wiley International Science Publications, John Wiley and Sons, New York, 1972, 467.
15. Gurusubramanian G, Rahaman A, Samrah M, Roy S, Bora S. Pesticide usage pattern in tea ecosystem, their retrospect and alternative measures. Journal of Environmental Biology. 2008; 29(6):813-826.
16. Han MK, Kim SI, Ahn YJ. Insecticidal and antifeedant activities of medicinal plant extracts against *Attagenus unicolor japonicus* (Coleoptera: Dermestidae). Journal of Stored Product Research. 2006; 42:15-22.
17. Jackman J. Managing insect and mite pests in vegetable gardens. Texas AgriLife Extension Service Publication Number B-1300. Texas AgriLife Extension, Texas A & M University System, College Station, 1998, 55.
18. Jayasree S. Studies on the efficacy of neem products against the pests of cotton. Unpubl. M.Sc., (Agri.) Thesis, Tamil Nadu Agric. Univ., Coimbatore, 1984, 90.
19. Kanniammal R, Chinniah C. Studies on exploitation of indigenous medicinal herbs for the management of two spotted spider mite, *Tetranychus urticae* Koch on okra and broad mite of chilli *Polyphagotarsonemus latus* Banks. M. Sc. (Agri.) Thesis, Tamil Nadu Agricultural University, Madurai, 2012, 135.
20. Kim SI, Roh YJ, Kim DH, Lee HS, Ahn YJ. Insecticidal activities of aromatic plant extracts and essential oils against *Sitophilus oryzae* and *Callosobruchus chinensis*. Journal of Stored Product Research. 2003; 39:293-303.
21. Kim YJ, Lee SH, Lee SW, Ahn YJ. Fenpyroximate resistance in *Tetranychus urticae* (Acari: Tetranychidae): cross-resistance and biochemical resistance mechanisms. Pest Management Science. 2004; 60(10):1001-1006.
22. Kottalagi P, Jagginavar SB, Veerendra AC, Nagaraj H, Srikanth CD, Naveen R *et al*. Efficacy of Different Acaricides Against Acid Lime Mite *Schizotetranychus baltazari* Rimando, Predatory Mite and Grading of Fruits. Academic Journal of Entomology. 2014; 7(4):134-139.
23. Ofuya T, Okuku I. Insecticidal effect of some plant extracts on the cowpea aphid *Aphis craccivora* Koch (Homoptera: Aphididae). Anzeiger fur Schadlingskunde. 1994; 67:127-129.
24. Patnaik S, Rout K, Pal S, Panda PK, Mukherjee PS, Sahoo S. Essential oils of aromatic and medicinal plants as botanicals biocide for management of coconut Eriophyid mite (*Aceria guerreronis* Keifer). Hindawi puplishing corporation, Psyche. 2011, 5.
25. Prajapati V, Tripathi AK, Aggarwal KK, Khanuja SPS. Insecticidal repellent and oviposition deterrent activity of selected essential oils against Anopheles stephensi, Aedes aegypti and culex quinquefasciatus, Bioresource Technology. 2005; 96:1749-1757.
26. Ramaraju K. Evaluation of acaricides and TNAU neem oils against spider mite, *Tetranychus urticae* (Koch) on *bhindi* and brinjal. Madras Agricultural Journal. 2004; 91(7-12):425-429.
27. Rim IS, Jee CH. Acaricidal effects of herb essential oils against *Dermatophagoides farina* and *D. pteronyssinus* (Acari: Pyroglyphidae) and qualitative analysis of a herb *Mentha pulegium* (pennyroyal). Korean Jornal of Parasitology. 2006; 44:133-138.
28. Salman SY, Saritaş S, Kara N, Recep AY. Acaricidal and Ovicidal Effects of Sage (*Salvia officinalis* L.*)* and Rosemary (*Rosmarinus officinalis* L.) (Lamiaceae) extracts on *Tetranychus urticae* Koch (Acari: Tetranychidae). Journal of Agricultural Science. 2014; 20:358-367.
29. Saminathan VR. Studies on Chrysoperla carnea (Stephens) under cotton intercropping system. M.Sc., (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore, 1997, 167.
30. Sarmah M, Rahman A, Phukan AK, Gurusubramanian G. Effect of aqueous plant extracts on tea red spider mite, *Oligonychus coffeae*, Nietner (Tetranychidae: Acarina) and *Stethorus gilvifrons, Mulsant.* African Journal of Biotechnology. 2009; 8(3):417-423.
31. Stumpf N, Nauen R. Cross-Resistance, inheritance and biochemistry of mitochondrial electron transport inhibitor-acaricide resistance in *Tetranychus urticae* (Acari: Tetranychidae).Journal of Economic Entomology. 2001; 94(6):1577-1583.
32. Sugeetha S, Srinivasa N. Seasonal abundance of red spider mite, *Tetranychus macfarlanei* on okra varieties in Bangalore. Journal of Acarologia. 1999; 15(1, 2):10-14.
33. Ursani TJ, Malik S, Chandio JI, Palh ZA, Soomro NM, Lashari KH *et al*. Screening of biopesticides against brinjal. International Journal of emerging trends in science and technology. 2014; 1(6):918-931.
34. Venkatachalam MR, Jebanesan A. Repellent activity of *Ferronia elephantum* Corr. (Rutaceae) leaf extract against *Aedes aegypti* (L.). Bioresource Technology. 2001; 76:287-288.