Pest Management in Horticultural Ecosystems
Vol. 24, No.1 pp 44-49 (2018)

Efficacy of plant extracts against *Tetranychus urticae* under *in-vitro* conditions

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ABSTRACT: The acaricidal activity of aqueous extracts of 20 plant species at 10 per cent concentration was evaluated against red spider mite, *Tetranychus urticae* Koch under laboratory condition by the leaf disc method. Among the plants, the extract of *Solanum virginianum* and *Eucalyuptus deglupta* caused the highest mortality of 93.33 and 85.57 43 percent of *T. urticae* respectively at 72 hours after treatment (HAT) followed by *Strychonas nux-vomica* (82.23%), *Colacasia esculenta* (81.10%) and *Cympogan schaenanthus* (81.10%). Next in the order of efficacy were *Curcuma longa, Dodonia viscosa, Melia azedarach, Piper nigrum, Phylanthus niruri, Cyprus rotantus, Azadirachta indica, Cynodon dactylon* and *Andropogan murigatus* which caused statistically similar acaricidal activity ranging from 72.23 to 64.43 percent Moderate acaricidal action was noticed in *Cardiospermum halicabum* (56.67%) and *Antigonon leptopus* (51.10%). The least effective plants were *Spathodea campanulata* (45.57%), *Murraya koenigii* (42.23%)> *Lantana camera* (30.00%), *Pedalium murex* (30.00%) and *Ocimum tenuiflorum* (27.77%).

Keywords: Red spider mite, *Tetranychus urticae*, aqueous extract, acaricidal activity

INTRODUCTION

Two-spotted spider mite (TSSM), *Tetranychus urticae* Koch (Acari: T*e*tranychidae) is a cosmopolitan herbivorous pest of agricultural crops worldwide (Antonious *et al*., 2007) as it infests more than thousand host plants in both field and greenhouse (Migeon and Dorkeld, 2007), especially herbaceous annuals, including beans, fruit trees and ornamental plants (Lee *et al*., 2003). This mite feeds by pen*et*rating the cells of the leaf with its stylets and sucking out the cell contents that causes cell collapse and manifests as spotting on the upper leaf surface. Heavy infestations by this mite disturb the water balance in leaf and accelerate transpiration resulting in hyper-necrosis, leaf drying and leaf drop (Landeros *et al*., 2004). Finally, the yield is decreased while the quality is also lower or unacceptable for the market.

To combat these problems, pesticides under different groups i.e. organochlorines, organophosphates, pyrethroids, carbamates and some unclassified group have been used against these pests. Different group of pesticides such as sulphur, ethion, quinalphos, propargite, abamectin, dim*et*hoate, fenvalerate, fenpropathrin, fenazaquin, bifenthrin, hexythiazox, spiromesifen and fenpyroxymate, etc. are being used as the commonly used miticides for the control of red spider mite (Mamun *et al*. 2014). However, overzealous use of synthe*t*ic pesticides led to numerous problems unforeseen at the time of their introduction: acute and chronic poisoning of applicators, farm workers, and even consumers; destruction of fish, birds, and other wildlife; disruption of natural biological control and pollination; extensive groundwater contamination, potentially threatening human and environmental health.

Due to those negative effects, a botanical pesticide can be employed as an alternative source to control pests where there are concerns of biodegradability, contamination in environment and human health hazards (Grange and Ahmed, 1988; Devlin and Zettel, 1999). Plants contain a rich source of bioactive chemicals which show some biological activities to specific target pests. Many plant extracts are known to be acaricidal on *T. urticae* (Shi *et al*., 2006). Extracts from the subfamilies Ajugoideae, Scutellarioideae, Chloanthoideae, Viticoideae and Nepe*t*oideae have acaricidal activity (Rasikari *et al*., 2005).

Many workers (Yang and Tangs, 1988; Mmbone *et al*., 2014; Kumaran *et al*., 2007 and Kanniammal and Chinniah (2012) have identified the acaricidal properties of plant products against *T. urticae.* For example, the extracts of *Azadirachta indica* effective against *Oligonychus coffeae* (Al-Mamun *et al*., 2015); *Cyperus rotundus was effective against eriophyid mite, Aceria guerreronis* (Bhat and Kempraj, 2014); *Melia azedarach*, *Eucalyptus* sp. Effective against stored grain mite, *Rhizoglyphus tritici* (Bashir *et al.,* 2013).

The objective of the present study was to investigate the acaricidal activity of selected plant extracts against *T. urticae* under laboratory conditions. In this respect, we compared the activities of extracts of seventeen plant species belonging to the families Araceae, Bignoniaceae, Cyperaceae, Lamiaceae, Loganiaceae, Meliaceae, Myrtaceae, Pedaliaceae, Phyllanthaceae, Piperaceae, Poaceae, Polygonaceae, Rutaceae, Sapindaceae, Solanaceae, Verbenaceae, Zingiberaceae. The information from these studies not only provides an insight on bioacaricidal properties of the selected plant species, but also exploites as an alternative way to control such pests in a safe and environmental friendly way and incorporate these acaricides rate for integrated pest management programs.

MATERIALS AND METHODS

Laboratory experiments were conducted in 2017-18 at the Acarology Laboratory, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore, to test various botanical extracts for their bioefficacy against spider mites.

Table 1. List of botanicals evaluated for acaricidal activities against red spider mite, *T. urticae.*

Common name	Scientific name	Family	Plant parts used	Concentration
Elephant-ear	*Colocasia esculenta L.*	*Araceae*	Leaves	10%
Fountain tree	*Spathodea campanulata P. Beauv*	Bignoniaceae	Flower	10%
Cyperus grass	*Cyperus rotundus L.*	Cyperaceae	Leaves	10%
Holy Basil	*Ocimum tenuiflorum* (L.) Heynh.	Lamiaceae	Leaves	10%
Strychnine	*Strychonos nux-vomica L.*	Loganiaceae	Leaves	10%
Neem	*Azadirachta indica* A. Juss.	Meliaceae	Leaves	10%
Chinaberry	*Melia azedarach* L.	Meliaceae	Leaves	10%
Eucalyptus	*Eucalyptus deglupta Blume*	Myrtaceae	Leaves	10%
Large caltrops	*Pedalium murex L.*	Pedaliaceae	Leaves	10%
Keezha Nelli	*Phylanthus niruri L.*	Phyllanthaceae	Leaves	10%
Black pepper	*Piper nigrum* L.	Piperaceae	Leaves	10%
Beard grass	*Andropogan muricatus* L.	Poaceae	Leaves	10%
Lemon grass	*Cymbopogon schoenanthus* (L.) Urban	Poaceae	Leaves	10%
Bermuda grass	*Cynodon dactylon* L.	Poaceae	Leaves	10%
Mexican creeper	*Antigonon leptopus* Hook & Arn	Polygonaceae	Leaves	10%
Curry leaf	*Murraya koenigii* L.	Rutaceae	Leaves	10%
Balloon plant	*Cardiospermum halicacabum* L.	Sapindaceae	Leaves	10%
hopbush	*Dodonia viscosa* Jacq.	Sapindaceae	Leaves	10%
Yellow-fruit nightshade	*Solanum virginianum* L.	Solanaceae	Fruit	10%
Lantana	*Lantana camara* L.	Verbenaceae	Leaves	10%
Turmeric	*Curcuma longa* L.	Zingiberaceae	Leaves	10%

Mass culturing of two spotted spider mite *T. urticae* Koch. in screen house condition

The Okra, *Abelmoschus esculentus* (L.) plants were raised in earthen pots for culturing mites as per the m*e*thodology suggested by Sreenivasulu (1979). These potted plants were kept separately under green house conditions at (25 ± 5°C, 60 % ± 10% RH), so as to avoid infestation from outside sources. The plants were allowed to grow and at the age of 40 days (okra), the field collected population of two spotted spider mites, *T. urticae* was released over the host plant by stapling the infested leaves over the fresh potted plant leaves, to facilitate easy transformation, after confirming the identity of the species. The two spotted spider mite, *T. urticae* from infested okra were transferred to the potted plants and allowed for multiplication for further studies.

Collection of plant species

Healthy leaves of the twenty plants (Table 1) have been collected during morning hours from the orchard, botanical garden and adjoining area of Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. The plant parts were shade dried for 5 days and coarsely ground by using Willy mills and passed through 20 mesh sieve and kept in an airtight container and subjected to extraction using distilled water.

Preparation of aqueous extract

Aqueous extraction was carried out by infusion m*et*hod. Ten per cent aqueous extract of each botanical was prepared by soaking 10g of the plant powder in 100ml of distilled water and left to stand for 12h, then filtered through muslin cloth. Then the filtrates were used for conducting bioassay. All the extracts were (treatment and untreated control) mixed with teepol at the rate of 1ml/lit. to facilitate adherence of the extracts to the plant surface

Effect of the extracts of botanicals on *T. urticae*

The acaricidal effect of plant extracts was evaluated under laboratory condition (25 ± 2°C; RH 75%). The assay was carried out by leaf disc method (Siegler, 1947). Leaf discs were prepared from matured mulberry leaves collected from insectary at Tamil Nadu Agricultural University. Leaf discs of 6cm diameter was prepared and placed with its ventral surface down over the wet cotton taken in a petriplate (9cm diameter) and each disc represents a replicate. Thirty adult mites were released on each disc with a brush and allowed to s*et*tle in the disc. Three replicates were maintained for each treatment and a water dipped disc served as untreated control. Individual petridish was examined under a stereo binocular after 24, 48 and 72 hours of treatment for counting the live and dead mites. The adult mortality at different intervals was subjected to ANOVA to infer about the difference among the treatments at $p<0.05$ for variance, Least Significant Difference. Adult mortality rate was calculated as; Mortality = (Dead mites/ Total number of mites) X 100.

RESULTS

Aqueous extracts of *S. virginianum* and *E. deglupta* at 10% were significantly superior to all other treatments with the highest per cent mortality (62.23 and 57.77%) at 24 HAT (Table 2). Followed by *C. esculenta* (46.67%), *C. longa* (45.57%) and *D. viscose* (43.33%) which were statistically on par in their efficacy. The sixth best treatment was *S. nux-vomica* at 10% which caused 34.47 per cent mortality and it was on par with *M. azedarach* and *C. rotundus*. At 48 HAT, *S. virginianum* and *E. deglupta* was found to be the most effective treatment with 81.10 per cent and 78.90 per cent mortality, which was significantly different from all other treatments. The next best treatment was *S. nux-vomica* (65.57%), *C. esculenta* (62.23%), *D. viscosa* (61.10%), *C. longa* (60.00%), *C. schoenanthus* (58.90%), *P. niruri* (57.77%) were statistically on par with each other of their efficacy. *S. campanulata* exhibited 50.00% mortality, which was statistically on par with *P. nigrum*.

Similar trend was observed at 72HAT, *S. virginianum* and *E. deglupta* was found to be the superior in acaricidal action on *T. urticae* with highest mortality (93.33% and 85.57%) at 10 per cent concentration and it was statistically different from all other treatments and also on par with each other in terms of efficacy. Next to *E. deglupta*, aqueous extracts of *S. nux- vomica* (82.23%), *C. esculenta* (81.10%) and *C. schoenanthus* (81.10%) were statistically on par in their acaricidal activity. *C. longa, D. viscosa, M. azedarch, P. nigrum, S. campanulata, P. niruri, C. rotundus* and *C. dactylon* registered 72.23, 67.77, 67.77, 66.67,66.67, 65.57, 65.57 and 64.43 per cent mortality respectively and these eight treatments were statistically on par with each other but significantly differ from all other treatments. Besides the above mentioned plant extracts, *A. muricatus, C. halicacabum, A. leptopus* extracts also exhibited pronounced acaricidal action (61.10% to 51.10%) at 72 HAT. Moderate acaricidal action was noticed in *M. koenigii* (42.23%)> *L. camera* (30.00%)> *P. mures* (30.00%)> *O. tenuiflorum* (27.77%). All the plant extracts taken for this study did not showed any phytotoxic symptoms.

Table 2. Acaricidal action of aqueous extracts of different plant species against *T. urticae* in in-vitro condition

Treatment	Cumulative per cent mortality		
	24 h	48 h	72 h
Colocasia esculenta	46.67 (43.08)^{b}	62.23 (52.15)^{b}	81.10 (64.87)^{bc}
Spathodea campanulata	30.00 (33.17)^{e}	50.00 (45.01)^{cd}	66.67 (54.78)^{de}
Cyperus rotundus	32.23 (34.57)^{de}	43.33 (41.16)^{def}	65.57 (54.13)^{de}
Ocimum tenuiflorum	18.90 (25.73)^{fg}	20.00 (26.53)^{g}	27.77 (31.76)^{i}

Strychonos nux-vomica	34.47 (35.94)^{de}	65.57 (54.11)^{b}	82.23 (65.30)^{bc}
Azadirachta indica	22.23 (28.12)^{f}	37.77 (37.91)^{ef}	64.43 (53.43)^{de}
Melia azedarach	33.33 (35.24)^{de}	45.57 (42.45)^{de}	67.77 (55.54)^{de}
Eucalyptus deglupta	57.77 (49.53)^{a}	78.90 (63.59)^{a}	85.57 (71.02)^{ab}
Pedalium murex	15.57 (23.22)^{g}	22.23 (28.11)^{g}	30.00 (33.19)^{hi}
Phylanthus niruri	38.90 (38.55)^{cd}	57.77 (49.50)^{bc}	65.57 (54.18)^{de}
Piper nigrum	43.33 (41.16)^{bc}	50.00 (45.00)^{cd}	66.67 (54.78)^{de}
Andropogan muricatus	8.90 (17.35)^{h}	43.33 (41.16)^{def}	61.10 (51.44)^{ef}
Cymbopogon schoenanthus	17.77 (24.90)^{fg}	58.90 (50.17)^{bc}	81.10 (64.87)^{bc}
Cynodon dactylon	8.90 (17.32)^{h}	41.10 (39.85)^{def}	64.43 (53.55)^{de}
Antigonon leptopus	21.10 (27.33)^{f}	35.57 (36.59)^{ef}	51.10 (45.63)^{fg}
Murraya koenigii	22.23 (28.09)^{f}	33.33 (35.23)^{f}	42.23 (40.51)^{gh}
Cardiospermum halicacabum	23.33 (28.87)^{f}	43.33 (41.16)^{def}	56.67 (48.84)^{ef}
Dodonia viscosa	43.33 (41.16)^{bc}	61.10 (51.44)^{bc}	67.77 (55.47)^{de}
Solanum virginianum	62.23 (52.15)^{a}	81.10 (64.87)^{a}	93.33 (75.54)^{a}
Lantana camara	3.33 (10.50)^{i}	10.00 (18.40)^{h}	30.00 (33.17)^{hi}
Curcuma longa	45.57 (42.45)^{bc}	60.00 (50.80)^{bc}	72.23 (58.32)^{cd}
Untreated check (Water+ Teepol)	3.33 (10.50)^{i}	5.83 (13.95)^{h}	9.73 (18.14)^{j}
S E	2.03	3.29	3.74
CD (p = 0.05)	4.08	6.22	7.53
CV%	7.92	9.53	8.95

Each value is mean of three replications.

Figures in parentheses are arc sine transformed values.

In a column, means followed by common l*et*ter (s) do not significantly differ by LSD at P=0.05%.

DISCUSSION

In the present study among the twenty one botanical extracts tested, the maximum mortality (93.33%) was recorded in aqueous extract of *S. virginianum* fruits. This is the first report on the acaricidal effect of *S. virginianum* on *T. uricae.* Though, the phytochemicals in *S. virginianum* (Syn: *S. xanthocarpum*) had been reported to be responsible for various pharmacological actions like Antifertility activity, Anticancer activity, Antifungal, Molluscicidal, Anti allergy, Anti inflammatory activity (Singh and Singh, 2010), the acaricidal activity has not been reported y*et*.

The acaricidal action of aqueous extracts of *S. virginianum* might be due to the biochemical compounds viz., Estra-1,3,5 (10)-trien-17-ol; Aspidospermidin-17-ol; 1-ac*et*yl-19,21-epoxy-15,16-dimethoxy; L-(+)-Ascorbic acid 2, 6-dihexadecanoate; L-Mannopyrnoside, M*et*hyl 6-deoxy-2,4-di-o-methyl-acetate; Cholesten,3-ol-2-methylene; Pyrrotidine-2-ylene, thioacetic acid; N,N-Dibezylidene-3, 3'-dichlorobenzidine; 16-Allopregnen,3a,7a,11a-triol-20-one, triacetate; Ascorbic acid 2; 6-dihexadecanoate, furanone, dihyro-5-tetradecyl; Furanone, dihydro-5-tetradecyl; Pyrimidin-2-ol-4(3,4-dimethoxy phynyl) 6-phynyl; 2-cyclohexen-1-one,3-methoxy-2(2,4,5-trimethoxyphynyl). Among the twelve compounds present in *S. virginianum,* the compounds like 6-dihexadecanote (Antonious *et al*., 2007 and Wang *et al*., 2009), Furanone (Habashy *et al*., 2016) have been reported to exhibit acaricidal activity. However the acaricidal action could be attributed due to the L-(+)- Ascorbic acid 2,6-dihexadecanote (652.94 gm/mol) which had identified as a major compound.

Next to *S. virginianum, E. deglupta* (10%) caused (85.57%) mortality. The result could be corroborated with the findings of Idrees *et al*. (2016). Ether extract of *Eucalyptus* sp. at 8 per cent concentration resulted more than 80% mortality after 3 weeks after spraying. The result pertaining to *C. longa, C. citrates, M. azedarch, P. nigrum, A. indica* are in conformity with the earlier work done by Arutselvi *et al*. (2013), Hanifah *et al*. (2011),

Attiah (2011), Dabrowski and Seredynska (2007) and Al-mamun (2015) on *Panchaetothrips indicus*, house dust mite (*Dermatophagoides* sp), *T. urticae, T. urticae, Oligonychus coffeae.*

CONCLUSION

The botanicals used in this experiment had acaricidal action on red spider mite. Aqueous extracts of *S. virginianum* showed highest acaricidal action on *T. urticae*, followed by *E. deglupta, S. nux-vomica, C. esculenta* and *C. schoenanthus.* Further study is needed to identify the active compounds of these plant extracts responsible for their acaricidal action. Plants mentioned above are abundant in and around garden lands which could be effectively utilized in Integrated Mite Management Program for sustainable crop protection in Olericultural eco-system.

REFERENCES

Al Mamun, M.S, Hoque, M.M, Ahmed, M, Sarkar. A and Kabir. H. 2015. Evaluation of some indigenous plant extracts against red spider mite, *Oligonychus coffeae* Nietner (Acari: Te*t*ranychydae) in tea. *Persian Journal of Acarology*, 4(**4**), 425–435.

Antonious, G.F, Meyer, J.E, Rogers, J.A, Hu, Y.H. 2007. Growing hot pepper for cabbage looper, *Trichopulsia ni* (Hubner) and spider mite, *Tetranychus urticae* (Koch) control. *Journal of Entomological Science and Health*, **42**, 559-567.

Arutselvi, R, Ponmurugan. P, Saravanan TB and Suresh R. 2012. Formulation of natural insecticides against *Panchaetothrips indicus* Bagnall in *Curcuma longa* L. leaves of PTS and Erode varie*t*ies. *Journal of Biopesticides* **5**, 77-81.

Attla, S, Grissa, K.L, Zeineb, G.G, Mailleux, A.C, Lognay, G and Rancel T. 2011. Assessment of the acaricidal activity of several plant extracts on the phytophagous mite *Tetranychus urticae* (Te*t*ranychidae) in Tunisian cltrus orchards. Bulletin S.R.B.E./K.B. V.E., **147**, 71-79

Bashir, M.H, Gogi M.D, Ashfaq, M, Afzal, M, Khan, M.A and Ihsan, M. 2013. The efficacy of crude aqueous extracts of some plants as grain protectants against the stored grain mite, *Rhizoglyphus tritici.* Turkish Journal of Agriculture and Forestry **37**, 585-594.

Bhat, S.K and Kempraj, V. 2008. Evaluation of acaricidal potential of essential oils of plants against coconut mite. Research gate.

Dąbrowski, Z.T, and Seredynska, U. 2007. Characterisation of the Two-Spotted Spider Mite (*Tetranychus Urticae* Koch, Acari*:* Tetranychidae) response to aqueous extracts from selected plant species. *Journal of Plant Protection Research,* 47(**2**), 113-124.

Devlin, J.F and Ze*t*tel, T. 1999. Ecoagriculture: Initiatives in eastern and southern Africa. Weaver Press, Harare, Zimbabwe.

Grange, N. and Ahmed, S. 1988. Handbook of plants with pest control properties. Wiley, New York, USA.

Habashy, G.M, Al-Akhdar, H.H, Boraie, D.M and Ghareeb ZE. 2016. Laboratory and semi field evaluation of garlic aqueous extract as acaricide against two tetranychid mites (Acari: Tetranychidae). *Journal of Plant Protection and Pathology Mansoura University,* 7(**10**), 623-628.

Hanifah, A.L, Awang, S.H, Ming, H.T, Abidin, S.Z and Omar, M.H. 2011. Acaricidal activity of *Cymbopogon citratus* and *Azadirachta indica* against house dust mites. *Asian Pacific Journal of Tropical Biomedicine,* 1(**5**), 365-369.

Idrees, A, Qasim, M, Ali, H, Qadir, Z.A, Idrees, A, Bashir, M.H, Qing, e.J. 2016. Acaricidal potential of some botanicals against the stored grain mites, *Rhizoglyphus tritici. Journal of Entomology and Zoology Studies*, 4(**1**), 611-617.

Kanniammal, R. and Chinniah, C. 2012. 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, 135.

Kumaran, N., Douressamy. S, and Ramaraju, K. 2007. Bioefficacy of botanicals to two spotted spider mite, *Tetranychus urticae* (Acari: Te*t*ranychidae) infesting okra (*Abelmoschus esculentus* L.). *Pestology*, **31**: 43- 49.

Landeros, J, Guevara, L.P, Badiim, H, Flores, A.E and Pamanes A. 2004. Effect of different densities of the two spotted spider mite *Tetranychus urticae* on Co2 assimilation, transpiration, and stomatal behaviour in rose leaves. *Experimental & Applied Acarology*, **32**: 187-198.

Lee Y.S, Song, M.H, Ahn, K.S, Lee, K.Y, Kim JW and Kim GH. 2003. Monitoring of acaricide resistance in two-spotted spider mite (*Tetranychus urticae*) populations from rose greenhouses in Korea. *Journal of Asia and Pacific Entomology,* **6:** 91-96.

Mamun, M.S.A, Paul, S.K and Ahmed, M. 2014, Approved insecticides, miticides and nematicides for tea (Revised & Updated). BTRI Circular no. 137, Bangladesh Tea Research Institute, Srimangal, Moulvibazar. 7pp.

Migeon, A. and Dorkeld, F. 2007. Spider mites web: a comprehensive database for the T*et*ranychidae. Available source:htt:/www.monotpellier.inra.fa/CBGP/spmweb.

Mmbone, S, Mulaa, M, Wanjala, F.M, Nyukuri, R.W, Cheramgoi E. 2014. Efficacy of *Tagetes minuta* and *Tephrosia vogelii* crude leaf extracts on *Tetranychus urticae* (Acari: T*et*ranychidae) and *Aphis fabae* (Homoptera: Aphididae). *African Journal of Food Science and Technology,* 5(**8**), 168-173.

Rasikari, H.L, Leach, D.N, Waterman, P.G, Spoonerhart R.N, Basta AH, Banbury LK. and Forster PI. 2005. Acaricidal and cytotoxic activities of extracts from selected genera of Australian Lamiaceae. *Journal of Economic Entomology,* **98,** 1259-1266.

Shi GL, Zhao LL, Liu LL, Cao H, Clarke SR and Sun JH. 2006. Acaricidal activities of extracts of Kochia scoparia against *Tetranychus urticae, Tetranychus cinnabarinus*, and *Tetranychus viennensis* (Acari: Tetranychidae). Journal of Economic Entomology **99**, 858-863.

Siegler, E.H. 1947. Leaf-disk technique for laboratory tests of acaricides. *Journal of Economic Entomology*, 40(**2**), 280-280.

Singh, O.M and Singh TP. 2010. Phytochemistry of *Solanum xanthocarpum*: an amazing traditional healer. *Journal of Scientific and Industrial Research,* **69**, 732-740.

Sreenivasalu, K. Further studies on the okra red spider mite, *Tetranychus cinnabarinus.* M. Sc., (Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore, 90.

Wang, Y.N, Wang, H.X, Shen, Z.J, Zhao, L.L, Clarke S.R, Sun JH, Du YY and Shi GL. 2009. M*et*hyl palmitate, an acaricidal compound occurring in green walnut husk. *Journal of Economic Entomology*, 102(**1**), 196-202.

Yang, R.Z, Tangs CS. 1988. Plant used for pest control in china: a literature review. *Economic Botany*, **42**, 376-406

MS Received : 15 April 2018
MS Accepted : 17 May 2018