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Evaluation of plant products against red spider mite, *Tetranychus urticae* Koch infesting tuberose

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Abstract
Under laboratory conditions, the acaricidal efficacy of aqueous extracts from 15 different plant parts were evaluated against two spotted spider mite, *Tetranychus urticae* Koch. Among the tested plants, the fruits of *Solanum virginianum* caused 88.89% adult mortality of *T. urticae* at 10 per cent concentration on 72 hours after treatment (HAT) with LC_{50} value 2.56% which was statistically superior to all other treatments. Next to *S. virginianum*, *Polyalthia longifolia*, *Bougainvillea glabra*, *Datura stramonium*, *Tecoma stans*, *Lawsonia inermis* leaves and *Carica papaya* seeds showed mite mortality of 68.89, 66.67, 64.44, 62.22, 61.11 and 60.00%, respectively which were statistically on par. Further, the aqueous extracts of *Argemone mexicana*, *Lawsonia inerm*is seeds, *Limonia acidissima* and *Piper betle* caused mortality of 55.56, 42.22, 40.00, 40.00%, respectively. Whereas aqueous extracts of *Aristolochia bracteata*, *Eichornea crassipes*, *Albizia amara* and *Ziziphus jujuba* recorded 36.67, 35.56, 32.22 and 28.89% mortality, respectively. The repellent, oviposition deterrence and ovicidal properties were evaluated and *S. virginianum* was found to be superior among the screened products with 56.18% repellency, 55.69% oviposition deterrence and 48.89% ovicidal activity.

Keywords: *T. urticae*, botanicals, tuberose, aqueous extracts, LC_{50}

1. Introduction
Tuberose (*Polianthes tuberosa* L.) is an important flower crop grown in tropical regions for the production of loose flowers and long lasting flower spikes. Loose flower production is mainly for making garlands and essential oil preparation. Farmers highly prefer tuberose cultivation due to their sustained economic returns throughout the year. In India, total area under tuberose cultivation is about 7.95 lakh hectares with annual production of 27.71 MT as per National Horticultural Mission Statistics (2013) [1]. In Tamil Nadu, this crop is cultivated in Dindigul, Erode, Coimbatore, Madurai, Trichy and Ariyalur districts.

The yield of tuberose is affected by insect pests and diseases like mealy bug, bud borer, bud rot etc., Among them, two spotted spider mite, *Tetranychus urticae* Koch is the important phytophagous non-insect pest causing considerable yield loss due to reduction in the area of photosynthesis [9]. The symptoms of mite damage in tuberose include yellowing and bronzing of leaf folds where the mites are particularly localized. Over the period of time, leaf gets dried up affecting the yield. As loose flower producing tuberose crop is maintained for nearly 3-5 years, farmers are in need to save them for gaining continuous yield.

Farmers usually resort to insecticides which results in development of resistance in mites over a period of time. Therefore it is essential to develop an alternative to synthetic insecticide control by way of exploiting botanicals. Biopesticides (botanicals) are relatively safe and ecofriendly. The plants produce numerous secondary metabolites that can be extracted from various plant tissues like leaves, seeds, fruits, roots, bark etc., which are documented for inhibition of acute toxicity, antifeedant and ovipositional deterrent effects against agricultural insect pests. Hence plant extracts are considered as potential source of mixture of various bioactive chemicals with different mechanisms of action which can be effectively used as an alternative and environmentally safe management strategy [13].

Recently many researchers have been used plant products or extracts against *T. urticae* [14, 23]. Extracts of *Glyricidia sepium* against *T. cannabarinus* [21]; *Sesbania grandiflora* [14]; *Tagetes minuta* and *Tephrosia vogelli* [10] against *T. urticae*, *Cassia alata* against *T. neocaledonicus* [18] and *Allamanta catharitica* against *Oligonychus coffeae* [16]. In addition, many works have been carried out to study the properties for the management of mite like repellency, oviposition deterrency and ovicidal effects with these aqueous extracts.

The present study was undertaken with the objectives of evaluating aqueous extract of 15 plant parts on repellency, oviposition deterrent and ovicidal effects against *T. urticae* infesting tuberose under laboratory conditions.

2. Materials and methods

The laboratory experiments for testing bioefficacy, repellency, oviposition deterrency and ovicidal activities of various botanical extracts against *T. urticae* infesting tuberose were carried out from October to December, 2018 at the Acarology laboratory, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore.

2.1. Mass culturing of two spotted spider mite in Screen house condition

Tuberose plants were raised in earthen pots with disease and pest free healthy bulbs. These potted plants were kept separately under greenhouse conditions at 25±5 ºC and 60±10% RH so as to avoid infestation from outside sources. The plants were allowed to grow and at the age of 75 days (flushy green foliage stage), *T. urticae* population were collected from tuberose field and were released over the 50 host plants after confirming the identity of the species. The infested mites were allowed for multiplication on the potted plants for further lab studies.

2.2. Collection of botanicals

A quantity of 2 kg of matured, healthy and biologically active plants parts of 14 plants were collected from different areas during morning hours in and around Coimbatore district of Tamil Nadu, India (Table 1). These plant parts were shade dried separately for 5 to 15 days and coarsely grounded using Willey Mill and were passed through 20 mesh sieve and kept in an airtight container.

2.3. Preparation of aqueous extracts

For extraction of active principle compounds from selected plant parts, infusion method was followed. The well homogenised powder (10 g) of each plant parts were separately soaked overnight in distilled water (100 ml) and then filtered using double layered muslin cloth to get desired concentration of 10% (w/v). These filtrates were used for conducting bioassay and associating concordant effects. All the experimental extracts (treatment & control) were mixed with Teepol as a wetting agent at the rate of $1mlL^{-1}$ to facilitate adherence of the extracts to the plant surface.

2.4. Bioassay against *T. urticae*

This bioassay was performed to evaluate the efficacy of the selected aqueous extracts against the arthropod pest, *T. urticae.* The acaricidal effect of aqueous plant extracts were evaluated under laboratory conditions at 25 ± 2 ºC and 75 ± 1% RH by leaf disc method [20]. For this bioassay, the leaf disc of 6 cm diameter was cut from mulberry leaves. The leaf discs were dipped in prepared solutions of aqueous extracts separately for 60 seconds and allowed to air dry. The treated leaf disc was placed with its dorsal surface down over the wet cotton taken in a petriplate (9cm diameter). Thirty adult mites were released on each disc with a brush and allowed to settle in the disc. Three replicates were maintained for each treatment and a water dipped disc served as control. The experimental setup was maintained without disturbance. The mites were assessed for mortality 24, 48 and 72 hours after treatment (HAT) under stereo binocular microscope (Nikon SMZ-5). The mites were considered dead when no leg movements were observed on pricking with a needle.

2.5. Repellency test

Leaf discs of mulberry leaves of 6 cm diameter were used to study the repellency of various plant aqueous extracts. Half of the disc was immersed for 30 seconds into the 10% aqueous extracts and dried, after drying, the other half of the disc was immersed in water as control. A total of 30 adult mites consisting of males and females were released on leaf midrib on each disc and replicated 3 times. The repellency was evaluated 24, 48 and 72 hours after treatment.

2.6. Oviposition deterrence

The oviposition reduction was investigated with 10% aqueous extract containing 0.1% Teepol. The leaf discs were dipped in prepared aqueous extracts for 60 seconds and allowed to air dry. Then it was transferred to petriplate (9 cm diameter) lined with moist cotton. Two pairs of freshly emerged adults of *T. urticae* were released on treated leaf disc using a fine camel hair brush along with control and replicated thrice. The number of eggs oviposited were recorded at 24, 48 and 72 hours after treatment.

2.7. Ovicidal effect

The ovicidal property of the aqueous extracts were observed with 10% concentration by allowing five adult female mites to lay eggs on mulberry leaf for 24 hrs and out of the total eggs, only thirty eggs were kept intact per leaf which were sprayed with 1500 µL of aqueous extracts using glass atomiser. The unhatched eggs were counted and mortality percentage of eggs was worked for a period of 7 days after oviposition.

2.8. Statistical analysis

The experimental data were transformed to arcsine values and subjected to ANOVA
(Analysis of Variance) using AGRES. The mortality data of 24, 48, 72 HAT were corrected after Abbott (1925) [2] and subjected to probit analysis for the calculation of LC_{50} values, confidential limits (upper and lower) and slope. Regression lines of probit against logarithmic transformation of concentration were also obtained.

3. Results

Data on adult mortality of *T. urticae* using various aqueous extracts of 15 different plant parts were summarized in table 2. The 10% aqueous extract of *S. virginianum* caused more than 50 per cent mortality of adult mites after 24 hours of treatment whereas aqueous extracts of *P. longifolia*, *T. stans*, *C. papaya*, *B. glabra*, *L. inermis* leaves and *D. stramonium* exhibited mortality in the range 40 to 46%. The mortality per cent was less than 30% for rest of the aqueous extracts tested against mites. (Table 2)

The adult mortality was assessed on second day (48 hours after treatment) and fruit extracts of *S. virginianum* was found to be 70 per cent against *T.urticae* followed by *P. longifolia* which caused 63.33% mortality, *B. glabra* (54.44%), *C. papaya* and *D. stramonium* (53.33%), and *T. stans* and *L. inermis* leaves caused 50.00% mortality which are statistically on par with each other. It was followed by *A. mexicana* and *P. betle* which had significant acaricidal activity of 43.33 and 35.56%, respectively, Both *L. inermis* seeds, *L. acidissima*

had 32.22% mortality whereas *A. bracteata*, *E. crassipes*, *A. amara* and *Z. jujuba* registered 28.89, 26.67, 24.44 and 21.11% mortality, respectively.

Similar trend was observed on third day (72 hours after treatment), 10% extract of *S. virginianum* caused the mortality from 70 to 88.89% mortality whereas aqueous extracts of *P. longifolia*, *C. papaya* seeds, *L. inermis* leaves, *B. glabra*, *T. stans* and *D. stramonium* showed mite mortality of 68.89, 66.67, 64.44, 62.22, 61.11 and 60.00% respectively which were different from all the other treatments. In addition, *A. mexicana* (55.56%), *L. inerm*is seeds (42.22%), *L. acidissima* and *P. betle* of 40.00% recorded significant acaricidal action. Besides the above mentioned plant extracts, moderate acaricidal action was seen in *A. bracteata* (36.67%), *E. crassipes* (35.56%), *A. amara* (32.22%) and *Z. jujuba* (28.89%).

Table 2 also substantiates the efficiency of different 10% aqueous extracts against two spotted spider mite over negative control. It indicates that efficiency was the highest in *S. virginianum* (86.67%) and for others it ranged between 10 and 65%. Hence to find out the effective dosage of aqueous extract, probit analyses were carried out.

Table 3 and 4 proved that the aqueous fruit extracts of *S. virginianum* represented the most potent acaricidal activity at 72 HAT. The LC_{50} values after 24, 48 and 72 h for adults were 11.58, 7.22 and 3.14%, respectively. The slope values of the regression line were 1.87, 1.56 and 1.61 after one, two and three days respectively. LC_{95} values were 87.30, 80.65 and 36.08% for adults respectively.

Repellency studies (Table 5) showed that its activity in 3 days after treatment was superior in *S. virginianum* fruit aqueous extract of 56.18%. It was followed by *C. papaya* and *D. stramonium* (54.27%), *A. amara* (53.91%), *P. betle* (48.34%), *L. inermis* leaves (44.28%), *Z. jujube* (43.33%), *A. mexicana* (40.39%) and *T. stans* (39.68%). Moderate walk off was observed in *B. glabra* (35.45%), *L. inermis* seeds (35.04%) and *A. bracteata* (35.01%) whereas *L. acidissima*, *P. longifolia*, *E. crassipes* exhibited 25.84, 25.00, 20.02% repellency, respectively

In oviposition deterrence studies (Table 5), in 3 days after treatment, *S. virginianum* fruit aqueous extract was found to be superior with 55.69% followed by *C. papaya* (51.21%), *D. stramonium* (47.55%), *T. stans* (46.14%), *L. inermis* leaves (44.92%), *P. betle* (43.91%), *Z. jujube* (40.67%), *B. glabra* (40.08%) and *L. inermis* seeds (39.97%). Moderate deterrence was observed in *A. bracteata* (36.49%)**,** *A. mexicana* (34.89%) and *A. amara* (33.73%). Least deterrence effects were observed in leaf discs treated with aqueous extracts of *P. longifolia* (29.07%), *L. acidissima* (27.23%) and *E. crassipes* (22.71%).

Egg mortality was studied, when the eggs in mock (water) disc started hatching. Ovicidal effects of all plant extracts were significantly higher than the control at 10% concentration from 4 days after treatment (Figure 1). Upto 7th day, observations were taken by giving a required period for hatching. The highest number of unhatched eggs was observed in fruit extracts of *S. virginianum* at 7 DAT (48.89%), this was followed by *E. crassipes*, *T. stans*, *L. inermis* leaves, *D. stramonium*, *Z. jujube*, *A. bracteata* and *P. betle*, showing mortality from 30 to 45%. Low mortality (<25%) was recorded with *B. glabra*, *A. amara*, *P. longifolia*, *C. papaya*, *A. mexicana*, *L. inermis* seeds and *L. acidissima.*

4. Discussion

In the present study, among the fifteen botanical extracts tested, *S. virginianum* fruits 10% aqueous extract exhibited highest bioefficacy against *T. urticae* with 88.89% mortality at 3 DAT as the results were in consonance with earlier findings of Premalatha *et al*. [15]. LC_{50} values after 24, 48 and 72 h for adults were 9.95, 5.65 and 2.56%, respectively which indicates that the persistence of the extract improves the bioefficacy over the period of time. Traditionally, *S. virginianum* fruits were used for antiasthmatic, hypoglycemic, hepatoprotective, antibacterial and as insect repellent [12].

It is reported that fruits contain more alkaloids than other parts of the plant. Alkaloids (solasodine, solasonine, solamargine, solanocarpine, beta-solamargine, solacarpidine, caffeic acid), coumarins (aesculetin and aesculin), steroids (carpesterol, diosgenin, campesterol, cholesterol, sitosterol glucoside, stigmasterol glucoside, daucosterol), triterpenes (cycloartanol and cycloartenol), volatiles (benzyl benzoate and (*E*,*E*)-geranyl linalool) were reported from the fruits [19]. Gupta *et al.* [6] extracted greenish-yellow oil (19%) from powdered seeds of *S. virginianum* and isolated oleic acid (42.93%), linoleic acid (36.18%), palmitic acid (5.37%), stearic acid (9.77%), arachidic acid (0.35%) and unsaponifiable matter (1.2%). Among the above constituents, palmitic acid was reported to have acaricidal activity [4, 22].

The next best acaricidal activity was present in aqueous extracts of *P. longifolia* Sonn. possessing 68.89% mortality, the acaricidal action may be due to the presence of sesquiterpene hydrocarbons like (E)-β-caryophyllene, α-zingiberene and allo-aromadendrene [11]. Methanol extracts of *P. longifolia* Sonn. showed antifeedancy against *Spodoptera litura* and *Lipaphis erysimi* [5].

Similarly extracts of *D. stramonium* leaves and seeds were used by Kumral *et al*. [8] to evaluate their acaricidal activity were 167.25 and 145.75 mgL^{-1} respectively which caused 98 and 25% of the mortality respectively after 48 hours of application. Likewise Hiremath *et al*. [7] found out that leaf extracts of *B. glabra* at 2500 and 5000 ppm showed the adult mortality against *T. urticae* from 61 to 80%. Both differ from the aqueous mortality as the study was performed with solvent extracts which had more of pesticidal compounds.

Based on Probit analysis, the estimated lethal concentration (LC_{50}) with the aqueous extract showed that 2.56% of *S. virginianum* extract was enough to kill 50% of the 30 mites under laboratory conditions at 72 hours after treatment. Similarly previous studies exhibited that LC_{50} values for aqueous extracts of *Ruta chalepensis*, *Astralagus occephalus* and *Alkanna strigosa* against adults of *T. urticae* were 8.5, 9.9 and 10.8% wt/wt. [3]

Repellency and oviposition deterrent studies showed that their activities are interdependent and almost similar trends were seen in the present study. *S. virginianum* fruit aqueous extract was found to be superior in repelling mites and deterrent for oviposition. Fruit extracts of Solanaceaeous plants like *Capsicum annum*, *C. baccatum*, *C. chinense* and *C. frutescens* were found to have repellent effect on *T. urticae* adult females [4]. Similarly Reddy *et al*. [17] showed that 10 per cent aqueous leaf extracts of *Cinnamomum camphora* caused 47% repellence of *T. urticae* and *Jatropha multifida*, *J. gossypifolia* and *J. curcus* caused 40, 38 and 11 per cent walk-off, respectively, whereas bark extracts of *C. camphora* exhibited 63% repellence and 5 per cent aqueous bark extracts of *J. multifida*, *J. gossypifolia* and *C. tamala* also caused the similar effect. In the oviposition deterrent action, the fruit

extracts of *S. virginianum* had increased effect allowing only 31 eggs to be laid by females at 72 HAT at 10% concentration. Extracts of the *Datura stramonium* leaves, seeds were used by Kumral *et al*. [8] to assess their oviposition hindrance effects on *T. urticae* adults at 167.25 and 145.75 mgL^{-1}.

Ovicidal activity of the present study showed only moderate results from 14 to 48% efficiency whereas in previous works, Pavela [13] reported that 5% aqueous extracts *Ammi visnaga*, *Glycyrrhiza glabra*, *Jateorhiza palmata*, *Leuzea carthamoides*, *Origanum majorana* and *Saponaria officinalis* exhibited an efficacy of 92.6, 94.6, 91.3, 82.6, 96 and 95.3% on eggs respectively. This exempts that ovicidal compounds are different from adulticidal compounds in the experimental aqueous extracts.

Bioefficacy, ovicidal, repellency and oviposition obstacle effects over *T. urticae* adults of the aqueous extracts of *T. stans*, *L. inermis* leaves, *C. papaya* seeds, *A. mexicana*, *L. inerm*is seeds, *L. acidissima*, *P. betle*, *A. bracteata*, *E. crassipes*, *A. amara* and *Z. jujuba* had not been reported earlier.

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

Treatments	Common name	Scientific name	Family	Plant parts used
T1	Krishna Siris	*Albizia amara* (Roxb.) Boiv.	Fabaceae	Leaves
T2	Prickly poppy	*Argemone mexicana* L.	Papaveraceae	Leaves
T3	Worm killer	*Aristolochia bracteata* Lam.	Aristolochiaceae	Leaves
T4	Paper flower	*Bougainvillea glabra* Choisy	Nyctaginaceae	Leaves
T5	Papaya	*Carica papaya* L.	Caricaceae	Seeds
T6	Jimson weed	*Datura stramonium* L.	Solanaceae	Leaves
T7	Water hyacinth	*Eichornea crassipes* (Mart.) Solms	Pontederiaceae	Leaves
T8	Henna	*Lawsonia inermis* L.	Lythraceae	Leaves
T9	Henna	*Lawsonia inermis* L.	Lythraceae	Seeds
T10	Wood Apple	*Limonia acidissima (*L.)	Rutaceae	Leaves
T11	Betel vine	*Piper betle* L.	Piperaceae	Leaves
T12	False Asoka tree	*Polyalthia longifolia* Sonn.	Annonaceae	Leaves
T13	Thorny nightshade	*Solanum virginianum* L.	Solanaceae	Fruits
T14	Yellow trumpet	*Tecoma stans* (L.) Juss.	Bignoniaceae	Leaves
T15	Indian apple	*Ziziphus jujuba* Mill.	Rhamnaceae	Leaves
T16	Control	-	-	-

Table 2: Acaricidal activity of aqueous extracts of different plants against *T. urticae* on tuberose (n=3)

Treatments	Cumulative per cent mortality			Per cent reduction over control (%)		
	24 HAT	48 HAT	72 HAT	1 DAT	2 DAT	3 DAT
T1	15.56(23.03)^{ef}	24.44(29.47)^{fg}	32.22(34.54)^{fg}	9.52	16.05	18.67
T2	36.67(37.25)^{bc}	43.33(41.16)^{cd}	55.56(48.20)^{d}	32.14	37.04	46.67
T3	18.89(25.62)^{def}	28.89(32.45)^{efg}	36.67(37.25)^{efg}	13.10	20.99	24.00
T4	43.33(41.15)^{ab}	54.44(47.56)^{bc}	62.22(52.08)^{bcd}	39.29	49.38	54.67
T5	43.33(41.16)^{ab}	53.33(46.91)^{bc}	66.67(54.75)^{bc}	39.29	48.15	60.00
T6	40.00(39.22)^{b}	53.33(46.91)^{bc}	60.00(50.78)^{cd}	35.71	48.15	52.00
T7	13.33(21.32)^{fg}	26.67(30.97)^{efg}	35.56(36.57)^{efg}	7.14	18.52	22.67
T8	42.22(40.51)^{b}	50.00(45.00)^{c}	64.44(53.41)^{bcd}	38.10	44.44	57.33
T9	23.33(28.85)^{de}	32.22(34.58)^{def}	42.22(40.52)^{ef}	17.86	24.69	30.67
T10	20.00(26.51)^{def}	32.22(34.56)^{def}	40.00(39.22)^{ef}	14.29	24.69	28.00
T11	27.78(31.75)^{cd}	35.56(36.59)^{de}	40.00(39.22)^{ef}	22.62	28.40	28.00
T12	46.67(43.09)^{ab}	63.33(52.75)^{ab}	68.89(56.10)^{b}	42.86	59.26	62.67
T13	55.56(48.20)^{a}	70.00(56.81)^{a}	88.89(70.84)^{a}	52.38	66.67	86.67
T14	45.56(42.37)^{ab}	50.00(45.00)^{c}	61.11(51.56)^{bcd}	41.67	44.44	53.33
T15	14.44(22.14)^{ef}	21.11(27.06)^{g}	28.89(32.35)^{g}	8.33	12.35	14.67
T16	6.67(14.64)^{g}	11.11(19.27)^{h}	15.56(23.20)^{h}	-	-	-
SE	3.62	3.48	2.57	-	-	-
CD (P=0.05)	7.37	7.09	5.23	-	-	-

SE – Standard Error, CD – Critical Difference, HAT – Hours after Treatment
Figures in parentheses are arcsine transformed values.

Table 3: Mortality per cent with the aqueous extracts of *Solanum virginianum* at different concentrations against *T. urticae* adults

Concentration (%)	Mean mortality per cent		
	1 DAT	2 DAT	3 DAT
2	13.33	25.56	46.67
4	23.33	41.11	62.22
8	40.00	57.78	67.78
10	55.56	70.00	88.89
12	68.89	76.67	90.00
16	74.44	78.89	91.11
20	73.33	78.89	92.22
32	74.44	82.22	95.56
Control	6.66	10.00	10.00

Table 4: LC_{50} and LC_{95} of the aqueous extracts of *Solanum virginianum* against *T. urticae* adults

Toxicity parameters	LC_{50}	LC_{50} Fiducial limits		$\chi 2$	LC_{95}	LC_{95} Fiducial limits		Regression equation	Slope	R^2
		Lower	Upper			Lower	Upper			
24 HAT	11.58	8.70	15.42	2.90	87.30	41.09	185.45	y = 1.88x + 2.99	1.87	0.95
48 HAT	7.22	5.24	9.95	1.01	80.65	33.94	191.64	y = 1.56x + 3.65	1.56	0.97
72 HAT	3.14	2.05	4.80	1.88	36.08	16.87	77.12	y = 1.61x + 4.20	1.61	0.95

Table 5: Repellent and oviposition deterrent activity of botanicals against *T. urticae* (n=3)

Treatments	24 HAT		48 HAT		72 HAT	
	Rep.	OD	Rep.	OD	Rep.	OD
T1	68.48 (56.41)^{abc}	47.85 (43.77)^{de}	63.10 (52.86)^{abc}	44.36 (41.75)^{cde}	53.91 (47.27)^{a}	33.73 (35.47)^{efg}
T2	54.44 (47.92)^{c}	54.17 (47.41)^{bcde}	45.36 (42.34)^{defg}	45.99 (42.70)^{cde}	40.39 (39.42)^{cd}	34.89 (36.08)^{efg}
T3	66.55 (54.75)^{abc}	66.35 (56.46)^{ab}	44.29 (41.71)^{defg}	48.15 (43.94)^{cde}	35.01 (38.16)^{d}	36.49 (36.77)^{def}
T4	47.41 (43.16)^{d}	50.09 (45.05)^{cde}	40.21 (39.32)^{efg}	43.43 (41.17)^{cde}	35.45 (36.51)^{d}	40.08 (39.25)^{cde}
T5	68.00 (55.66)^{abc}	66.41 (54.66)^{ab}	64.67 (58.8)^{ab}	59.86 (50.69)^{ab}	54.27 (47.99)^{a}	51.21 (45.70)^{ab}
T6	62.22 (52.43)^{abc}	63.06 (52.63)^{abc}	49.49 (44.70)^{def}	52.03 (46.17)^{bcd}	52.27 (46.31)^{ab}	47.55 (43.54)^{bcd}
T7	71.11 (57.70)^{a}	69.84 (56.84)^{a}	35.56 (36.48)^{g}	41.63 (40.16)^{de}	20.02 (25.10)^{e}	22.71 (28.38)^{de}
T8	67.46 (55.42)^{abc}	62.96 (52.55)^{abc}	53.33 (46.96)^{bcd}	53.33 (46.92)^{abc}	44.28 (41.71)^{bcd}	44.92 (42.06)^{abc}
T9	56.75 (48.89)^{bcd}	59.23 (50.34)^{abcde}	46.11 (42.38)^{defg}	52.83 (46.57)^{abc}	35.04 (36.29)^{d}	39.97 (38.80)^{abc}
T10	46.88 (42.70)^{d}	41.55 (39.96)^{e}	52.59 (46.59)^{cd}	31.07 (33.72)^{f}	39.18 (37.10)^{cd}	27.23 (30.47)^{f}
T11	64.29 (53.97)^{abc}	62.48 (52.25)^{abc}	51.60 (45.94)^{cde}	49.30 (44.59)^{bcde}	48.34 (44.25)^{abc}	43.91 (41.49)^{bcde}
T12	70.33 (57.56)^{ab}	65.74 (54.31)^{ab}	38.52 (38.05)^{fg}	43.48 (41.25)^{cde}	25.00 (29.79)^{e}	29.07 (31.91)^{cde}
T13	72.46 (58.80)^{a}	68.52 (56.00)^{a}	70.71 (57.47)^{a}	62.73 (52.45)^{a}	56.18 (48.95)^{a}	55.69 (48.27)^{a}
T14	60.90 (51.52)^{abcd}	63.62 (53.04)^{abc}	45.40 (42.31)^{defg}	51.69 (46.00)^{bcd}	39.68 (38.89)^{cd}	46.14 (42.78)^{bcd}
T15	62.27 (52.26)^{abc}	64.60 (53.79)^{ab}	54.10 (47.39)^{bcd}	53.18 (39.6)^{cde}	43.33 (41.06)^{cd}	40.67 (39.58)^{ef}
SE_d	4.21	3.91	3.36	3.01	2.68	2.52
CD (P=0.05)	8.60	8.01	6.87	6.14	5.47	5.16

Rep. – Repellency, OD – Oviposition Deterrent, HAT – Hours after treatment
Figures in parentheses are arcsine transformed values.

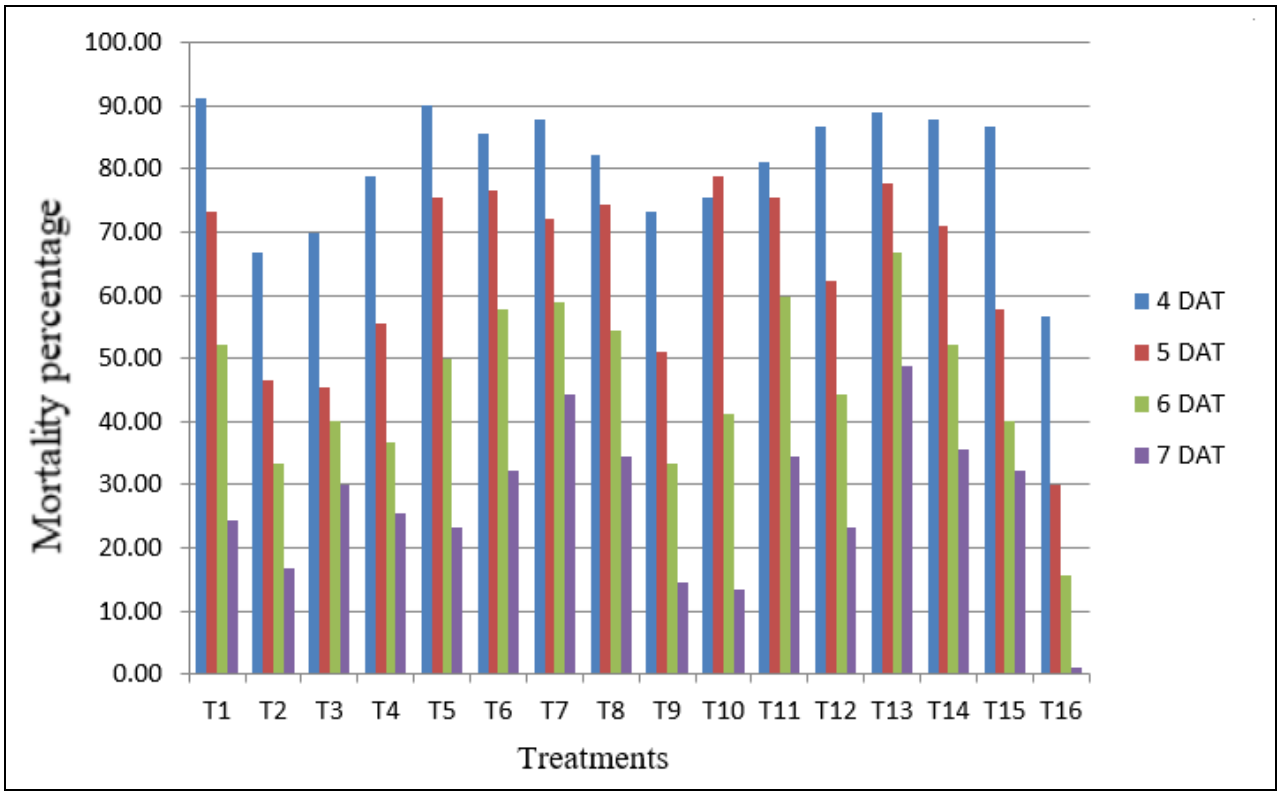

Fig 1: showing ovicidal activity of aqueous extracts against two spotted red spider mite

5. Conclusion

The aqueous extracts of plants used in the present experiment tend to have miticidal effects against *T. urticae* under laboratory conditions. The efficacy varies with species, plant parts used and concentration of extracts. Among the studied botanicals, aqueous extracts of *S. virginianum* exhibited better acaricidal properties with efficiency of 89% at a concentration of 10% compared to other botanicals. Hence *S. virginianum* fruits need to be explored for their acaricidal activity by studying their chemical constituents extracted by different solvents possessing insecticidal making them useful in sustainable crop protection.

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