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Novel acaricide toxicities on *Tetranychus urticae* infesting *Piper betle*

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ABSTRACT

Laboratory and field experiments were conducted to test novel acaricide efficacies for the management of two-spotted spider mite, *Tetranychus urticae* (Koch) on betelvine (*Piper betle* L.). The treatments were abamectin 1.9EC @ 0.3ml, 0.5ml and 0.7ml/l, propargite 57EC @ 2.5 and 3.0ml/l, fenazaquin 10EC @ 1.7ml/l, fenpyroximate 5EC @ 1.25ml/l, spiromesifen 22.9SC @ 0.8ml/l, and compared with conventional compounds, sulphur 80WDG @ 3g/l and dicofol 18.5EC @ 2.5ml/l. In laboratory studies, all the acaricides resulted in 14.47 to 85.53% mortality with highest in abamectin @ 0.7ml/l during I season and lowest in dicofol, whereas in II season lowest per cent mortality of 21.80 was recorded in sulphur and highest mortality of mites (83.40%) was noted in abamectin @ 0.7ml/l at 72h after treatment. The acaricides caused mortality of mites in the range of 16.27 of 90.98% during 10 day observation period in the field studies with highest in abamectin (0.7ml/l) treated plots followed by fenazaquin (59.44% at 10th day) and least mortality was showed by dicofol, i.e. less than 20% in first season but spiromesifen, fenpyroximate and propargite @ 3.0ml/l showed good efficacy, i.e. 51.40%, 46.37% and 40.37% mites mortality, respectively, at 10th day during I season trial. In II season, lower mortality of mites was recorded in dicofol (34.41%–16.99%) and sulphur (38.03% – 19.57%) on 1st and 10th day, respectively indicating that these acaricides lost their efficacy over a period of time but abamectin @ 0.7ml/l (90.35–70.39%) and 0.5ml/l (85.65–65.71%) throughout the observation period showed higher efficacy followed by fenazaquin (72.24–56.86%), spiromesifen (69.13–48.60), propargite @ 3ml/l (60.80–39.76%) and fenpyroximate (48.84–28.43%) at 1 and 10th day after spray observations. Abamectin and fenazaquin were superior over other acaricides tested under both conditions followed by spiromesifen, fenpyroximate and propargite.

Key words : Acaricides, Betelvine, Tetranychus urticae

Two spotted spider mite (TSSM) [*Tetranychus urticae* (Koch)] is the major pest species on agricultural crops worldwide (Wu *et al.* 1990, Ho 2000, Takafuji *et al.* 2000), widely distributed and a common pest of many plant species in greenhouses, nurseries and field crops. A population of TSSM can increase rapidly especially during hot and dry periods and in general, the incidence of red spider mites was observed during summer months, i.e. February to May in betelvine (*Piper betle* L.) gardens, however, Sireesha *et al.* (2009) observed severe incidence of red spider mites on betelvine and wide variations in infestation levels, i.e. peak infestation levels recorded from august second fortnight and steadily increased till december first fortnight whereas, Subbarao *et al.* (2000) observed peak incidence of red spider mites from February to May in Andhra Pradesh. The infested tender leaves cause a minute depression on the leaves resulting in roughened leaf surface and such leaves are not accepted for market resulting in direct loss to the growers. Symptoms observed in the mite infested plots and the infestation also turns leaf lamina into brick red and it becomes unfit for consumption.

Spraying regular chemical acaricides, viz. dicofol and sulphur too has failed to control the attacks causing loss in productivity. So, careful selection and use of acaricides early in the season can potentially reduce the number of miticide applications. Hence, a systematic investigation was conducted on evaluation of novel acaricides namely, Abamectin, Fenazaquin, Fenpyroximate, Propargite and Spiromesifen to ascertain the efficacy on spidermites, *Tetranychus urticae* infesting betelvine in both laboratory and field conditions. The commonly used and recommended acaricides as per the university package of practices in betelvine crop were dicofol and sulphur that are used as standards and water spray as control. The acaricides were tested against two spotted red spider mite on Kapoori variety, a popular cultivar cultivated in Kadapa District. The reasons for selecting these acaricides are they have novel mode of action unlike conventional acaricides, easily available in Indian market, effectively being used to control mites in vegetables and ornamentals and studies on betelvine mites management is meager. The other scientific reason being that two spotted spider mites have a history of rapidly developing resistance to miticides, when a miticide is

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repeatedly applied to the same population and alternating miticides that have different modes of action may reduce development of resistance to a specific miticide.

MATERIALS AND METHODS

The toxicity of novel acaricides to the spider mite was tested in the laboratory in 2012 (First crop season) and 2013 (Second crop season) as per the method of Sikha Deka *et al*. (2011). Leaves with actively feeding mites along with petioles collected from the betelvine field were considered for bioassay studies and to keep the leaves turgescent, petioles were covered with wet cotton. These leaves were sprayed with each of the concentration of acaricide and spray of distilled water served as control. After spraying, they were air dried for approximately 2 hr and placed at the bottom of petriplates (90 mm diameter), that were lined with wet cotton and covered with lid. The number of live and dead mites in each replicate was counted under a stereo microscope before the treatment and 24, 48 and 72 hr after the treatment. From each treated leaf, population count was made randomly from 2 cm^2 leaf area and mites were considered dead if their appendages did not move when prodded with a fine hair brush. The data were subjected to ANOVA tests.

Field trials were conducted on evaluation of novel acaricides against two spotted spider mite, *T. urticae* for 2 consecutive seasons during 2012 and 2013 on betelvine (variety: Kapoori) at farmers field in Pullampeta Mandal of Kadapa District. The trials were laid out in a RBD with 10 treatments, i.e. Abamectin, Dicofol, Fenazaquin, Fenpyroximate, Propargite, Spiromesifen and Sulphur, and an untreated control replicated thrice. The plot size was 20m^2 and two sprays of acaricides were given at 15 days interval starting with the initiation of mite infestation by using knapsack sprayer at 300 litres of spray solution per acre.

Five vines were randomly selected from each plot and tagged and from each tagged plant, population count was made from 1 sq. inch leaf area of three leaves (top, middle and bottom) and average population was recorded. The observations were recorded before the spray as well as 1, 3, 5, 7, and 10 days after each spray. Mites not showing any moment when lightly touched with a brush were considered dead. Results were expressed as per cent mortality with correction for untreated mortality using Abbott's formula (Abbott 1925) and values were transformed to arcsine to homogenize the variances. The data were subjected to ANOVA tests.

RESULTS AND DISCUSSION

Five novel acaricides, viz. Abamectin, Fenazaquin, Fenpyroximate, Propargite, Spiromesifen, and two conventional, i.e. Dicofol, Sulphur were evaluated against mites. Analysis of variance shows that the acaricide application had significant effect on the mortality of *T. urticae* proving thereby that their application of acaricides on an average was more effective in reducing the mite population as compared to control. (Tables 1, 2, 3 and 4). The trend of relative efficacy of various treatments has been described below:

Effect of new acaricides on mites in the laboratory

The efficacy of acaricides was observed in the laboratory. After 24 hr of treatment, abamectin 1.9EC at highest dose (0.7 ml/l) was found to inflict highest mite mortality (78.31%), compared to lower dose at 0.5 ml/l causing 74.69% followed by fenazaquin 10EC that caused 63.86% mortality and abamectin @ 0.3ml/l showed 60.24% mortality. Abamectin is reported to be active even at lower concentrations (Croft *et al*. 1987). A tetranic acid derivative acaricide, spiromesifen recorded 42.17% mortality whereas another novel acaricide, fenpyroximate showed mortality of 21.05%. The propargite treated betelvine leaves caused 18.43% mortality, at lower dose (2.5 ml/l) compared to higher dose of 3.0ml/l which recorded 51.80% mortality, but with the conventional acaricides, mortality was less than 30%, i.e. 24.09 and 27.71% in dicofol and sulphur treatments, respectively. The mite mortality increased in all the acaricide treated leaves except in abamectin at lower doses (55.71%)

Table 1 Novel acaricides effect on *Tetranychus urticae* in laboratory (First crop season)

Treatment		Dose/ litre	Per cent mortality of mite population after treatment		
			24 hr	48 hr	72 hr
Abamectin	1.9EC	0.3ml	60.24 (50.91)g	55.71 (48.28)d	32.89 (34.99)c
Abamectin	1.9EC	0.5ml	74.69 (59.80)i	63.16 (52.63)e	62.86 (52.45)e
Abamectin	1.9EC	0.7ml	78.31 (62.24)j	81.43 (64.48)g	85.53 (67.65)h
Fenazaquin	10EC	1.7ml	63.86 (53.05)h	67.11 (55.01)f	77.14 (61.44)g
Fenpyroximate	5EC	1.25ml	21.05 (27.30)b	44.58 (41.89)c	62.86 (52.45)e
Propargite	57EC	2.5ml	18.43 (25.42)a	21.43 (27.57)a	16.58 (24.02)b
Propargite	57EC	3.0ml	51.80 (46.03)f	63.16 (52.63)e	52.86 (46.64)d
Spiromesifen	22.9SC	0.8ml	42.17 (40.50)e	67.14 (55.03)f	73.68 (59.14)f
Dicofol	18.5EC	2.5ml	24.09 (29.39)c	28.57 (32.31)b	14.47 (25.27)a
Sulphur	80WDG	3.0g	27.71 (31.76)d	27.14 (31.39)b	17.11 (24.43)b
Control			0.00 (0.00)k	0.00 (0.00)h	0.00 (0.00) i
CD (P=0.05)			1.31	3.40	1.58
SE(m)±			0.62	1.62	0.75

P=0.05, Mean of three replicates; Figures in parentheses are arcsine transformed values. In a column, 'means' followed by a common letter do not differ significantly at P≤0.05 by Duncan's multiple range test.

Table 2 Novel acaricides effect on *Tetranychus urticae* in laboratory (Second crop season)

Treatment		Dose/ litre	Per cent mortality of mite population after treatment		
			24 hr	48 hr	72 hr
Abamectin	1.9EC	0.3ml	54.25 (47.44)[d]	33.92 (35.61)[c]	36.71 (37.29)[d]
Abamectin	1.9EC	0.5ml	77.10 (61.42)[g]	77.02 (61.37)[g]	66.10 (54.40)[f]
Abamectin	1.9EC	0.7ml	73.50 (59.02)[f]	79.49 (63.27)[h]	83.40 (65.96)[j]
Fenazaquin	10EC	1.7ml	59.10 (50.24)[e]	64.29 (53.31)[f]	74.51 (59.68)[h]
Fenpyroximate	5EC	1.25ml	46.23 (42.84)[c]	61.14 (51.44)[e]	65.65 (54.12)[f]
Propargite	57EC	2.5ml	24.90 (29.93)[a]	38.15 (38.14)[d]	27.29 (31. 48)[c]
Propargite	57EC	3.0ml	57.60 (49.37)[e]	60.73 (51.20)[e]	59.23 (50.32)[e]
Spiromesifen	22.9SC	0.8ml	48.44 (44.10)[c]	66.76 (54.79)[f]	71.03 (57.44)[g]
Dicofol	18.5EC	2.5ml	26.07 (30.69)[a]	23.36 (28.90)[a]	23.90 (29.25)[b]
Sulphur	80WDG	3.0g	33.05 (35.09)[b]	28.82 (32.47)[b]	21.80 (27.82)[a]
Control			0.00 (0.00)[h]	0.00 (0.00)[i]	0.00 (0.00)[j]
CD (P=0.05)			1.73	1.67	1.69
SE(m)±			0.82	0.79	0.80

P=0.05, Mean of three replicates; Figures in parentheses are arcsine transformed values. In a column, 'means' followed by a common letter do not differ significantly at P≤0.05 by Duncan's multiple range test.

at 48h after treatment followed by fenazaquin (67.11%), spiromesifen, propargite, fenpyroximate, dicofol and sulphur. Least mortality of mites was observed in propargite treatment that caused only 21.43% mortality. The decrease in efficacy was observed in dicofol, sulphur, propargite (2.5 ml/l) and abamectin (0.3 ml and 0.5 ml/l) as compared to other miticides at 72 hr after treatment but 85.53% mortality was observed in abamectin at dose of 0.7 ml/l indicating that there is increase in the efficacy with increase in dose and period. Our findings are in support of Sheeba Joyle Roseleen *et al.* (2011) evaluated profenofos 50EC and abamectin 1.8EC with different doses against coconut eriophyid mite through button dip and bunch peduncle dip methods in the laboratory and showed abamectin @ 0.0144% caused 99.6% and 80.06% reduction, respectively, of mite population over control as compared to profenofos and monocrotophos. Spiromesifen and fenazaquin caused more than 70% mortality even 72 hr after observation followed by fenpyroximate (62.86%) which was on par with abamectin at 0.5 ml/l.

In support, Al-Antary *et al.* (2012) conducted laboratory bioassays to evaluate the toxicity of spiromesifen against seven population of adult females of two spotted spider mite and reported spiromesifen induced 74% mortality to all populations tested. In the second crop season (Table 2), the trend of efficacy with relation to mites mortality was similar to first crop season where abamectin 1.9EC @ 0.7ml/l caused higher mortality of 73.50, 79.49 and 83.40% in 24, 48 and 72hr, respectively, after treatment as compared to other acaricides. In conformity of our findings, Akashe *et al.* (2003) evaluated miticides for their toxicity against *T. urticae* under laboratory conditions and from his findings it was evident that abamectin was more toxic causing 100% mortality followed by clofentazine and amitraz and least effective miticide was sulphur. There was increase in the

Table 3 Novel acaricides effect on *Tetranychus urticae* in field (First crop season)

Treatment		Dose/litre	Per cent mortality of mite population after treatment				
			1 day	3 day	5 day	7 day	10 day
Abamectin	1.9EC	0.3ml	69.51 (56.48)[g]	65.19 (53.84)[g]	59.30 (50.36)[g]	49.67 (44.77)[g]	45.84(42.61)[g]
Abamectin	1.9EC	0.5ml	83.81 (66.27)[i]	79.09 (62.79)[i]	72.83(58.58)[i]	69.79 (56.65)[i]	64.96 (53.70)[i]
Abamectin	1.9EC	0.7ml	90.98 (72.52)[j]	85.01 (67.22)[j]	81.23(64.32)[j]	76.31 (60.87)[j]	72.32 (58.25)[j]
Fenazaquin	10EC	1.7ml	76.12 (60.74)[h]	70.63 (57.18)[h]	68.21 (55.68)[h]	62.15 (52.03)[h]	59.44 (50.44)[h]
Fenpyroximate	5EC	1.25ml	50.92 (45.52)[e]	51.18 (45.69)[e]	48.61 (44.20)[e]	42.38 (40.61)[e]	40.37 (39.44)[e]
Propargite	57EC	2.5ml	30.25 (33.36)[b]	25.11(30.07)[b]	21.79 (27.82)[b]	19.52 (26.22)[b]	17.48 (24.71)[b]
Propargite	57EC	3.0ml	59.80 (50.65)[f]	55.80 (48.33)[f]	50.91 (45.52)[f]	48.61 (44.20)[f]	46.37 (42.91)[f]
Spiromesifen	22.9SC	0.8ml	67.89 (55.48)[d]	62.89 (52.54)[d]	59.59 (50.53)[d]	56.29 (48.61)[d]	51.40 (45.80)[d]
Dicofol	18.5EC	2.5ml	28.19 (32.70)[a]	24.73 (29.82)[a]	20.71 (27.71)[a]	18.90 (25.76)[a]	16.27 (23.78)[a]
Sulphur	80WDG	3.0g	35.18 (36.38)[c]	33.68 (35.47)[c]	31.03(33.85)[c]	29.57 (32.94)[c]	25.84 (30.55)[c]
Control			0.00 (0.00)[k]	0.00 (0.00)[k]	0.00 (0.00)[k]	0.00 (0.00)[k]	0.00 (0.00)[k]
CD (P=0.05)			0.65	0.12	0.10	0.10	0.12
SE(m)±			0.30	0.05	0.04	0.04	0.06

P=0.05, Mean of three replicates; Figures in parentheses are arcsine transformed values. In a column, 'means' followed by a common letter do not differ significantly at P≤0.05 by Duncan's multiple range test.

Table 4 Novel acaricides effect on *Tetranychus urticae* in field (Second crop season)

Treatment		Dose/litre	Per cent mortality of mite population after treatment				
			1 day	3 day	5 day	7 day	10 day
Abamectin	1.9EC	0.3ml	55.28 (48.03)[e]	50.14 (45.08)[e]	46.47 (42.97)[e]	43.39 (41.20)[g]	41.30 (39.99)[f]
Abamectin	1.9EC	0.5ml	85.65 (67.74)[i]	79.20 (62.86)[i]	71.14 (57.50)[i]	68.16 (55.65)[i]	65.71 (54.15)[h]
Abamectin	1.9EC	0.7ml	90.35 (71.90)[j]	86.90 (68.78)[j]	81.85 (64.78)[j]	75.24 (60.16)[j]	70.39 (57.03)[i]
Fenazaquin	10EC	1.7ml	72.74 (58.52)[h]	69.31 (56.36)[h]	62.17 (52.04)[h]	59.63 (50.55)[h]	56.86 (48.94)[g]
Fenpyroximate	5EC	1.25ml	48.84 (44.33)[d]	42.44 (40.65)[d]	36.02 (36.88)[c]	31.27 (34.00)[d]	28.43 (32.22)[c]
Propargite	57EC	2.5ml	30.91 (33.77)[a]	28.61 (32.33)[a]	25.28 (30.18)[a]	20.56 (26.96)[a]	17.04 (24.38)[a]
Propargite	57EC	3.0ml	60.80 (51.23)[g]	52.05 (46.17)[g]	49.86 (44.57)[g]	42.79 (40.85)[f]	39.76 (39.09)[d]
Spiromesifen	22.9SC	0.8ml	69.13 (56.27)[f]	67.28 (55.11)[f]	57.10 (49.02)[f]	51.96 (46.12)[e]	48.60 (44.20)[e]
Dicofol	18.5EC	2.5ml	34.41 (35.91)[b]	30.37 (33.44)[b]	26.57 (31.02)[b]	21.96 (27.94)[b]	16.99 (24.34)[a]
Sulphur	80WDG	3.0g	38.03 (38.07)[c]	35.09 (36.32)[c]	39.86 (39.15)[d]	24.01 (29.34)[c]	19.57 (26.25)[b]
Control			0.00 (0.00)[k]	0.00 (0.00)[k]	0.00 (0.00)[k]	0.00 (0.00)[k]	0.00 (0.00)[j]
CD (P=0.05)			0.22	0.14	0.33	0.08	0.12
SE (m)±			0.10	0.07	0.15	0.04	0.06

P=0.05, Mean of three replicates; Figures in parentheses are arcsine transformed values. In a column, 'means' followed by a common letter do not differ significantly at P≤0.05 by Duncan's multiple range test.

mortality of mites in fenazaquin, spiromesifen, fenpyroximate and propargite (3.0 ml/l) as the observation period increased and in contrary decrease in mortality was observed in dicofol, sulphur, propargite (2.5 ml/l) and abamectin treatment at lower doses.

Similarly, Pushpa and Nandihalli (2010) reported fenazaquin 10EC reduced the population of coconut mite by 31% under laboratory conditions, from all these observations, the result of laboratory experiments indicated that abamectin @ 0.7 ml/l and fenzaquin were most effective closely followed by spiromesifen, fenpyroximate due to unique mode of action of these new acaricides as compared to conventional acaricides. The acaricides dicofol and sulphur showed least mortality in both the seasons may be due to their continuous use by farmers in the betelvine field for control of spider which might have lead to development of resistance in these mites population.

Efficacy of acaricides on mites in the field

The acaricide treatments are effective in causing mite mortality in the laboratory, so an experiment was set to determine the toxicity of these acaricides in the field. The results indicated a significant reduction in the mite population (Table 3 and 4). All the treatments recorded mite mortality (28-90%) which proved significantly superior over control after 1 day of treatment in both the seasons. A day after application, among the treatments in first crop season (Table 3), abamectin @ 0.7ml inflicted highest per cent mortality (90.98%) of the mites followed by abamectin @ 0.5 ml (83.81%) and fenazaquin (76.12%). Longhurst *et al.* (1992) reported fenazaquin a novel acaricide for the management of spider mites in variety of crops. In second crop season also abamectin @ 0.7 ml/l inflicted highest percent mortality (90.35%) of the mites followed by abamectin @ 0.5 ml/l (85.65%) and fenazaquin @ 1.7 ml/l (72.74%) (Table 4).

Similarly, 3 days after application, abamectin caused higher mortality of mites in both the seasons (85.01;79.09; and 86.90; 79.20 at 0.7 ml/l and 0.5 ml/l, respectively) followed by fenazaquin and abamectin @ 0.3 ml recorded mortality of mites in the range of 50.0-69% in both the seasons on 1 and 3 day after treatment indicating that it is effective even at lower dose. The greater efficacy of abamectin in reducing the mite population population were recorded in all doses and this may be due to its mode of action (GABA-agonist) and the translaminar activity which provides residual activity against the feeding mites. The treatment, dicofol (3 days after application) showed least mite mortality of 24.73% mortality in first season as compared to propargite @ 2.5 ml (25.11%) and sulphur (33.68%), but in second season, propargite (28.61%) caused least mortality as compared to dicofol and sulphur. Bhardwaj and Sharma (2010) found that out of seven acaricides evaluated against two spotted spider mite, abamectin @ 0.01%, fenazaquin @ 0.001%, hexythiazox @ 0.0025% and propargite @ 0.05% provided excellent control in apple. In 1, 3, 5, 7 and 10 days after treatment, the mite mortality was 16.27-34.41%, and 17.04-30.91% in dicofol and propargite treatments, respectively, in both the seasons indicating that these acaricides doesn't show longer residual control compared to newer acaricides, viz. fenpyroximate (28.43-50.92%), and spiromesifen (31.10-56.19%). Though spiromesifen caused low mortality on 1 and 3 day of observation, but the efficacy remained for longer period i.e. it was significantly superior over dicofol and propargite during 10 days observational period and in support of our results, propargite and fenpyroximate were found to be effective in reducing mites population and remained effective till 15 days after spray as reported by Tomar and Singh (2011).

The results of both seasons after 5, 7 and 10 days of treatment indicated that abamectin 1.9EC doses of 0.7 ml/l and 0.5 ml/l and fenazaquin inflicted higher mortality of mites throughout the observational period as compared to other treatments, followed by spiromesifen and abamectin @ 0.3 ml. The higher efficacy of these acaricides in our study were also supported by observations of Sahoo *et al*. (2003) that fenazaquin was second to abamectin in terms of toxicity to adult females of red spider mite, *Oligonychus coffeae* infesting tea. Similarly, Senapati *et al*. (2010) reported that fenazaquin gave best control of yellow mite up to 14 days in chilli. The higher efficacy of spiromesifen was also reported by Sekh *et al.* (2007) that it gave excellent control of red spider mites, on brinjal along with significance increase in yield Al-Antary *et al*. (2012) evaluated residual effective of six acaricides on two spotted spider mite (*T. urticae*) female populations in Jordan on cucumber under plastic house conditions and stated that bifenazone, chlorfenapyr and spiromesifen induced 90%, 78% and 76% mortality, respectively, to all populations and toxicity persisted for 9 days.

In conclusion, the present study showed that novel acaricides, viz. abamectin (0.3 ml, 0.5 ml and 0.7 ml/l), fenazaquin and spiromesifen can be recommended along with other acaricides namely fenpyroximate and propargite (3 ml/l) on rotation basis under high infestation for effective management, longer residual control and to delay resistance development of red spider mites, *Tetranychus urticae* in betelvine gardens.

Phytotoxicity: The acaricides tested in the present experiment did not exhibit any phytotoxic symptom on betelvine crop.

REFERENCES

Abbott W S. 1925. A method of computing effectiveness of an insecticide. *Journal of Economic Entomology* **18**: 265–7.

Akashe V B, Darekar K S and Kharbade S B. 2003. Toxicity of selective miticides against *Tetranychus urticae* (Koch) on roses. *Pestology* **27**: 30–1.

Al-Antary T M, Al-Lala M R K L and Abdel-Wali M I. 2012. Residual effect of six acaricides on the two spotted spider mite (*Tetranychus urticae* Koch) females on cucumber under plastic houses conditions in three upper lands regions in Jordan. *Advances in Environment Biology* **6**: 2 992–7.

Alzoubi S and Cobonoglu S. 2008. Toxicity of some pesticides against *Tetranychus urticae* and its predatory mites under laboratory conditions. *American Eurasian Journal of Agricultural and Environmental Science* **3**: 30–7.

Babuji Rao V, Nagalingam B and Subba Rao D V. 2000. Effect of some betelvine cultivars on development of tobacco caterpillar, *Spodoptera litura* (Fab.). *Pest Management Ecosystem Zoology* **8**: 167–70.

Bari G, Vernile P, Panzarino O and Lillo E. 2013. Efficacy of Oberon against red spider mite on cucumber. *Colture Protette* **42**: 54–56, 58–60.

Bharadwaj S and Sharma S. 2010. Response of two spotted mite, *Tetranychus urticae* Koch. (Fam : Tetranychidae) to new acaricides in apple orchards of Himachal Pradesh. *Abstract of International Symposium-cum-Workshop in Acarology.* 81–83.

Croft B A, Hoyt S C and Westigard P H. 1987. Spider mite management on pome fruits, revisited: Organotin and Acaricide Resistance Management. *Journal of Economic Entomology* **80**: 304–11.

Dejan Marcic, Pantelija Peric and Slobodan Milenkovic. 2011. Acaricides-Biological profiles, effects and uses in modern crop protection. (*In*) *Pesticides-Formulations, Effects Fate*, pp 37–62. Margarita Stoytcheva (Ed). In Tech, Europe.

Dekeyser M A. 2005. Acaricide mode of action. *Pest Management Science* **61**(2): 103–10.

Helle W and Sabelis M W. 1985a. *Spider mites*: *Their Biology, Natural Enemies and Control,* 1A, Elsevier, Amsterdam, the Netherlands.

Helle W and Sabelis M W. 1985b. *Spider mites*: *Their Biology, Natural Enemies and Control,* 1B. Elsevier, Amsterdam, the Netherlands.

Jeppson L R, Keifer H H and Baker E W. 1975. *Mites Injurious to Economic Plants,* pp 370–6. Berkeley University of California Press. CA.

John B and Dorie. 1997. Mite Counting and Pyramite Trial Project entitled on farm research evaluation of pyramite for spider mite control on apples funded by Environmental Protection Agency. (email: http://whatcomwsuedu/ag/comhort/nooksack/pyramitehtm)

Lindquist E E, Sabelis M W and Bruin J. 1996. *Eriophyoid Mites*: *Their Biology, Natural Enemies and Control*. Elsevier, Amsterdam, the Netherlands.

Longhurst C, Bacci L, Buendia J, Hatton C J, Petitprez J and Tsakonas P. 1992. Fenazaquin – A novel acaricide for the management of spider mites in variety of crops. *Proceedings of The Brighton Crop Protection Conference*, *Pest and Diseases*, Brighton **23**: 51–8.

Negi M.L and Gupta P R. 2007. Evaluation of horticultural mineral oils for the control of the two spotted spider mite *Tetranychus urticae* (koch) on apples. *Bioscan* **2**(3): 177–81.

Pranab Barma and Shantanujha. 2013. Insect and non- insect pests infesting pointed gourd (*Trichosanthes dioica* Roxb.) in West Bengal. *The Bioscan* **8**(2): 537–43.

Prasad R. 2006. Occurrence and pest status of phytophagous mites infesting common vegetables. *Indian Journal of Entomology* **68**(3): 235–9.

Pushpa V and Nandihalli B S. 2010. Evaluation of pesticides and biopesticides against the coconut eriophyid mite, *Aceria guerreronis* Keifer under Laboratory conditions. *Karnataka Journal of Agricultural Sciences* **23**: 178–9.

Rachna G. 2004. Incidence of *Tetranychus unnabarinus* (Boisd) infestation in different varieties of *Abelmoschus esculentus* (L). *Annals of Plant Protection Sciences* **12**: 45–7.

Reghupathy A, Palanisamy S, Chandramohan N and Gunathilagaraj K. 1997. A guide on crop pests. Sooriya Desktop Publishers, Coimbatore, p 170.

Sahoo B, Sahoo S K and Somchaudhury A K. 2003. Studies on the toxicity of newer molecules against tea red spider mite. *Proceedings of the National Symposium on Frontier Areas of Entomological Research,* pp 301–2.

Sekh K, Nair N, Bag V and Somchoudhury A K. 2007. Bioefficacy of Spiromesifen 240SC (Oberon) against red spider mite of brinjal and effect on its natural enemies. *Pestology* **31**: 25–8.

Senapati A K, Maity A K and Chatterjee M L. 2010. Effect of new acaricides against yellow mite of chilli. *Abstracts of International Symposium-cum-workshop in Acarology,* p 95.

Sheeba Joyce Roseleen S, Ramaraju K and Suresh S. 2011.

Laboratory Evaluation of Profenofos 50EC and Abamectin 1.8 EC against Cocount Eriophyid Mite. *Madras Agriculture Journal* **98**: 263–5.

Sikha Deka, Tanwar R K, Sumitha R, Naved Sabir, Bambawale O M and Balraj Singh. 2011. Relative efficacy of agricultural spray oil and azadirachtin against two-spotted spider mite (*Tetranychus urticae*) on cucumber (*Cucumis sativus*) under greenhouse and laboratory conditions. *Indian Journal of Agricultural Sciences* **81**: 158–62.

Sireesha K, Ramadevi P and Tanuja Priya B. 2009. Biodiversity of insect pests and their natural enemies in betelvine ecosystem in Andhra Pradesh. *Karnataka Journal of Agricultural Science* **22** (3- spl. Issue): 727–8.

Subba Rao D V, Babu M K, Rosaiah K and Subbaratnam GV. 2000. Pests of betelvine and its prop crop, sesbania and their management. (*In*) *Pests Associated with Major Crops of India*. SV Agricultural College, Tirupathi.

Tomar A S and Singh S P. 2011. Efficacy of selected acaricides against mite, *Tetranychus urticae* Koch (Acarina: Tetranychidae) on okra. *Pestology* **35**: 27–9.

Van Leeuwen T, Witters J, Nauen R, Duso C and Tirry L. 2010. The control of eriophyoid mites: state of the art and future challenges. *Experimental and Applied Acarology* **51**: 205–24.

Whalon M E, Mota-Sanchez D and Hollingworth R M. 2008. *Global Pesticide Resistance in Arthropods*. CAB International, Wallingford, UK.

Zhang Z O. 2003. *Mites of Greenhouses, Identification, Biology and Control*. CAB International, Wallingford, UK.