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Bio-Efficacy, Yield Loss and Economics of Two Spotted Spider Mite *Tetranychus urticae* Koch (Acarina: Tetranychidae) Management through Synthetic Acaricides and Biorationals in Grape Vineyards

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Abstract

Mites especially the *Tetranychus urticae* Koch have become a serious arthropod pest of grapes in Maharastra, Karnataka and Telangana states of India since recent past. The suitable management strategies for this pests are to be updated for the benefit farmers and related industry. A study on the bioefficacy of synthetic acaricides and selected biorationals was conducted in Karnataka (India) for management of *Tetranychus urticae* infesting grapes. Among different classical as well new chemistry acaricides hexythiazox 5.45 EC (1.5 mL/ L), abamectin 1.9 EC (0.5 mL /L) and propargite 57 EC (2.0 mL /L) appeared to be highly effective in containing the incidence of grape mites. With three sprays the mite incidence could be reduced from 185.21 per four leaves to 3.67 through hexythiazox application. This treatment rendered 355.81 quintal per hectare grape berry yield in cv Thomson seedless. From abamectin spray the population was from 184.50 to 8.00 per four leaves where in the yield was 337.81 quintal per hectare. The avoidable yield loss and C: B ratio in hexythiazox treatment was 47.20 % and 1: 7.13 respectively.

Keywords

Economics

Grape infestation

Mite management

Tetranychus urticae

Introduction

Grape (*Vitis vinifera* L.) is one of the commercially important fruit crops of the world and is fairly good source of minerals like calcium, phosphorous, iron and vitamins like B_1 and B_2. Its juice is mild laxative and acts as stimulant for kidneys. Fruits are used for table purpose, wine preparation, juice, resins and canning. Fresh and dried fruits have various uses in ayurvedic and unani medicine. The primary centre of origin for grape is suppose to be Armenia near the Black and Caspian seas in Russia, and is widely grown in temperate zone. However it has acclimatized to sub tropical and tropical agro climatic conditions prevailing as in the Indian sub-continent. It is extensively grown in France, Italy, America, Africa, Australia, Algeria and India. In the year 2010-11, major grape growing states in India are Maharashtra (62.7%), Karnataka (26.8%), Andhra Pradesh (2.2%), Mizoram (1.7%) and Tamil Nadu (4.3%), others

(2.4%) amounting to nearly 90 per cent of the total production (Anon 2011). India is the 13th largest producer of grapes appropriating 2.00 per cent of the global production. The area under grapes in India was 1.17 lakh hectares during 2013 with the production of 24.83 lakh t of fresh grapes with an average productivity of 21.1 t / ha (Anon., 2013).

In India, Karnataka occupies second position in cultivation and production of grapes next to Maharashtra. In 2010-11, Karnataka contributed to about 14.3 per cent of the total Indian grape area (18,100ha) with production of 3.30 lakh tonnes with productivity of 18.3 t/ha (Anon., 2011). In Karnataka major grape growing districts are Bangalore, Chikkaballapur, Kolar, Bijapur, Belgaum, Koppal, Bagalkot and Gulbarga. In 2010-11, Bijapur district contributed an area of 6,137 ha, production of 97,592 tons, with average productivity 15 t/ha. Large acreages of grape cultivation is quite evident in Basavana Bagewadi, Bijapur, Indi, Muddebihal and Sindagi talukas of Vijayapur.

Commercial cultivation of grapes tends to attract various kinds of pests to the vineyards (Alexandri, 1973). As many as 132 insects have been (Bournier, 1977) known to attack grape vine in the world wide. In India as many as 60 species of insects and a few mites have been found damaging vines (Wadhi and Batra, 1964). However, acarine pests have been considered to be most dreaded very recently in Indian scenario. Six species of mites *viz*., *Tetranychus urticae* Koch, *T. cinnabarinus* Boisdual, *T.neocoledonicus* Andre, *Oligonicus mangiferus* Rahmen and Sapra, *O. punicae* Baker and *Eutetranychus orientalis* Klein are found causing damage to grapevine in India (Anon., 2008). Out of these the infestation of *Tetarnychus urticae* is reported to be quite considerable in abundance and damage designating it as an emerging sucking pests of grape these days (Chandra Sekhar et al., 2008). It has been confirmed recently (Veerendra et al., 2014) that *Tetarnychus urticae* relish the grapes in terms of their bionomics supporting continued pestiferousness. Now, it is known to cause severe yield loss both qualitatively and quantitatively through direct effects like loss of chlorophyll, stunting of growth, stippling, webbing, leaf yellowing, defoliation, leaf burning, reduction in size and quality of fruits and appearance of various types of plant deformities. However, the studies with respect to mites in grapes are limited. In the present investigation the chemical and bio-rational approaches have been addressed to manage the mite incidence in grapes economically.

Materials and methods

A field experiment was carried out in a commercial Thompson seedless vineyard from December 2012 to March 2013 at Toravi (Tq/Dt: Vijayapur, Karnataka: India) to evaluate the efficacy of different acaricides and biorationals against grape mites. Toravi is situated at 16^{0}49'50.33" N, 75^{0}41'32.13" E and 611.7 MSL elevations. There were fourteen treatments including a control (Table 1) in the bio-efficacy trail replicated thrice. Totally three applications were targeted against mites (December to March) since the onset of their incidence.

Table 1. Synthetic acaricides and biorationals used in grape mite management experiment.

Sl No.	Treatments	Dosage	Trade names
1	Dicofol 18.5 EC	2.50 mL/L	Kelthane
2	Fenpyroximate 5SC	1.00 mL/L	Neon
3	Diafenthiuron 50SC	0.80 mL/L	Polo
4	Sulphur 80WP	2.00 g/L	Sulfex
5	Abamectin 1.9 EC	0.50 mL/L	Abacin
6	Neemazal 3000ppm	2.00 mL/L	Neemark
7	Hexythiazox 5.45EC	1.50 mL/L	Maiden
8	Spiromecifen 240SC	0.50 mL/L	Oberon
9	Propargite 57 EC	2.00 mL/L	Omite
10	Ethion 50EC	2.00 mL/L	Fosmite
11	*Verticillium lecanii* (2.5×10^7 spores/mL)	2.00 g/L	-
12	Fenzaquin 10% EC	1.00 mL/L	Magister
13	*Hirsutella thompsonii*(2.5×10^9 spores/mL)	1.00 g/L	-
14	Untreated control	-	-

The observations were recorded on incidence of mites a day before and after one, five and ten days after each application. The mite population recorded was on per leaf basis and presented as mites / four leaves. The numbers of vines/ treatment were five and cane/ vine were three. The total number of leaves considered for recording mites was nine / cane which were selected randomly. The 7X magnifier hand lens was convenient to count the mites accurately. The berry yield was accounted kg/vine and tons/ha. The per cent avoidable yield loss due to each treatment was extrapolated considering the yield in untreated control as maximum yield loss possible. The fungicides difencanazole (Score 25% EC), propicanazole (Tilt 25% EC), hexaconazole (Contaf 5% EC), pencanazole (Topas 10%), bordaux mixture (farm preparation), mancozeb (Indofil M 45WP),metalaxyl (Ridomyl MZ 72 WP), carbendazim (Bavistin 50 WP) and cymoxanil 8% + mancozeb 64% (Curzate) were used to protect grape garden from diseases *viz.*, powdery mildew, downy mildew and anthracnose etc. The orchard was free from other insect pests and hence there was no interference of any other plant protection operations on the targeted studies. The data on mites was transformed to $\sqrt{(X+0.5)}$ before subjecting to analysis. Both data (mite population and yield) was subjected to ANOVA and F- test.

Results and discussion

It was evident from the present study that protection through acaricides has direct impact on bearing of the grape berries (Fig. 1). Thus, the protection against this pest appeared to be quite essential. In the pretext of emerging insect pest scenario in many crops (Udikeri et al., 2008) due climate change, resistance or resurgence it is essential to address the new pests in each crops critically. This holds very much true where the crops have association with sap feeding arthropods and heavy reliance on neonicotinoides (Patil et al., 2003) is evident.

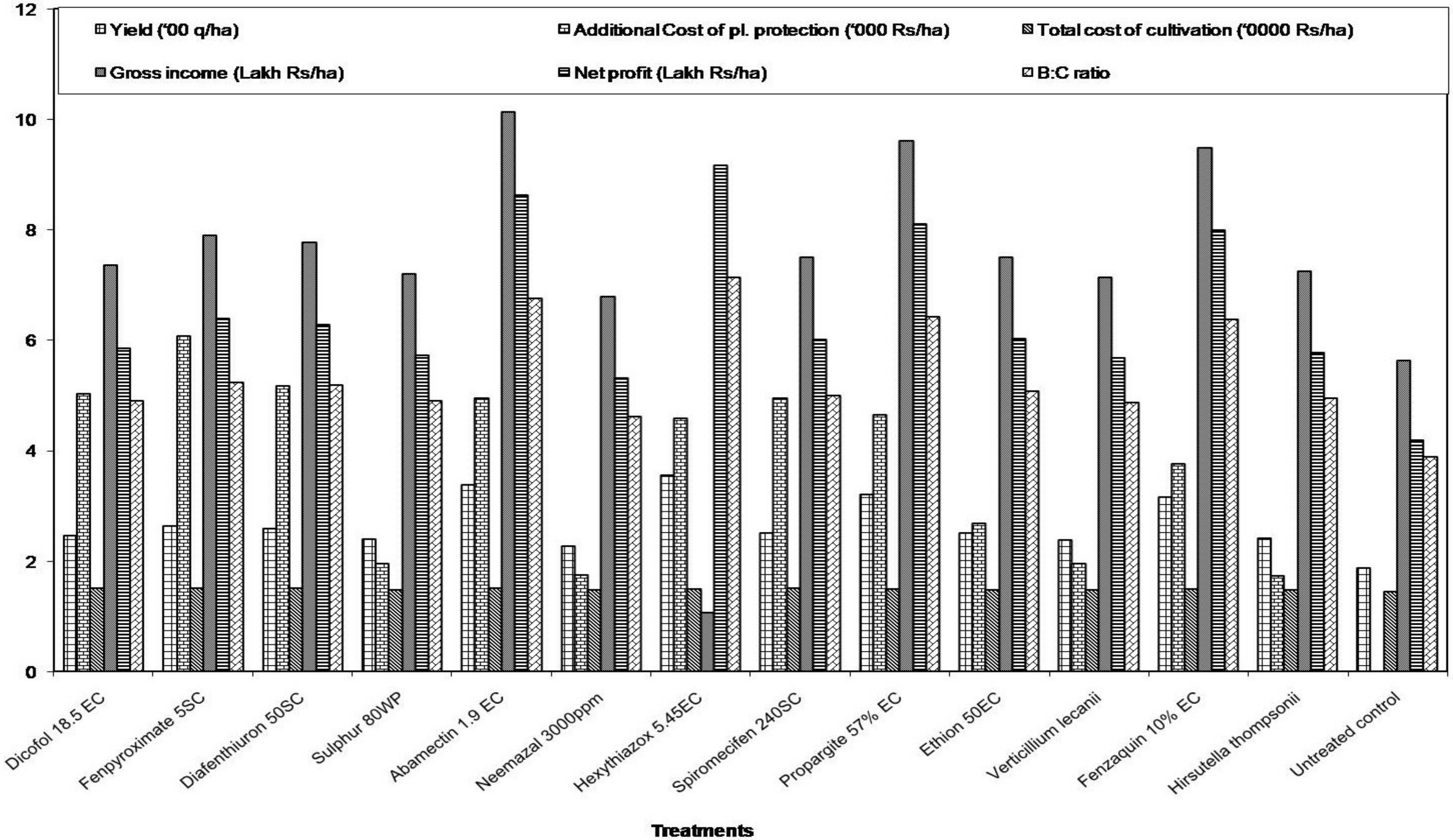
Bio-efficacy against mite population

The insights of study have indicated varied degree of efficacy of each option tried against this mite in grape (Table 2, 3 and 4). Among different treatments hexythiazox 5.45 EC appeared to be the best in containing the *T.urticae* incidence successfully. Though many acaricides were on par with hexythiazox at one DAS, only abamectin and propargite could maintain the comparative efficacy with it in all observations as per first spray efficacy (Table 2). The population was brought down to 56.32 per four leaves from 185.21 in 10 DAS when hexythiazox was applied @ 1.5 mL per liter. Similarly, suppression was from 187.5 to 61.0 in abamectin 1.9 EC treatments @ 0.5 mL per liter. Even after 2nd and 3rd spray (Table 3 and 4) bio-efficacy of these compounds remained superior over the rest. Ultimately the population observed in hexythiazox and abamectin treatments at 10 days of 3rd spray was 3.7 and 8.00 per four leaves respectively. The bio-activity of spiromecifen 240 SC (0.5 mL/Liter) and propargite 57 EC (2.0mL/Liter) were next best treatments with 12.35 and 12.67 mites per four leaves at 10 DAS of 3rd spray. Conventional acaricides *viz.*, dicofol 18.5 EC, ethion 50 EC could not be considered as effective based on the persisting populations of mites in these treatments. This holds good even for sulphur 80 WP a compound known for acaricidal activity since ages.

However, fenazaquin 10 EC had a fairly good effect against grape mites. The efficacy of fungal bio-agents *Hirsutella thompsonii* and *Verticillium lecanii* was on par with efficacy of Dicofol/Ethion/Sulphur in suppressing mite incidence. Thus, reliance on these two bio-agents as sole application was not defendable as per the results of present study. However, the scope for using them at still higher dosages or with strains of better pathogenicity still remains as a choice. Such considerations holds good for neem product (neemazal 3000 ppm) also which had bio-efficacy significantly lower than fungal bio-agents. Dicofol, sulphur and ethion have been considered as effective against *Tetranychus urticae* and other phytophagus mites in grape and different crops by Kumar and Sharma (1991), Rai et al. (1995), Patel et al. (1993). The poor performance of these compounds in the present study may be due to development of resistance in *Tetranychus urticae* as they are being used since long against these mites in different crops.

The superiority of hexythiazox is in confirmation with the investigations of Keena et al. (1991) against *Tetranychus* sp. in laboratory and Ma-Shue et al. (1998) against *T. urticae* on apple. However, its efficacy study in grape is not evident in literature presently. The effectiveness of abamectin in reducing the mite population has been reported by (Karmate and Chandele, 1997) in different crops.

Fig. 1: Yield and economics of management of grape mites through different options.



Economics of management of grape mites

Table 2. Bio-efficacy of acaricides and biorationals against grape mites (after first spray).

No.	Treatments	Dosage	Mean population of mites/ 4 leaves			
			1DBS	1DAS	5DAS	10DAS
T1	Dicofol 18.5 EC	2.50 mL/L	168.33 (12.99)[a]	140.33 (11.87)[cd]	125.33 (11.22)[d]	120.67 (11.01)[f]
T2	Fenpyroximate 5SC	1.00 mL/L	165.33 (12.88)[a]	130.67 (11.45)[ab]	98.67 (9.96)[c]	84.67 (9.23)[cd]
T3	Difenthurion 50SC	0.80 mL/L	178.00 (13.36)[a]	130.33 (11.44)[ab]	115.33 (10.76)[d]	101.67 (10.11)[e]
T4	Sulphur 80WP	2.00 g/L	182.33 (13.52)[a]	164.67 (12.85)[f]	148.00 (12.19)[e]	152.67 (12.38)[h]
T5	Abamectin 1.9 EC	0.50 mL/L	187.50 (13.71)[a]	131.24 (11.48)[ab]	72.12 (8.52)[a]	61.00 (7.84)[a]
T6	Neemazal 3000ppm	2.0mL/L	154.00 (12.43)[a]	141.67 (11.92)[d]	137.67 (11.75)[e]	142.67 (11.97)[g]
T7	Hexythiazox 5.45EC	1.50 mL/L	185.21 (13.63)[a]	130.00 (11.42)[a]	65.67 (8.13)[a]	56.32 (7.54)[a]
T8	Fenazaquin 10EC	1.00 mL/L	181.33 (13.48)[a]	140.33 (11.87)[cd]	117.33 (10.85)[d]	116.31 (10.81)[f]
T9	Propargite 57 EC	2.00 mL/L	178.33 (13.37)[a]	130.33 (11.44)[ab]	88.23 (9.42)[b]	87.67 (9.39)[d]
T10	Ethion 50EC	2.00mL/L	173.67 (13.20)[a]	147.67 (12.17)[e]	140.00 (11.85)[e]	135.67 (11.67)[g]
T11	*Verticillium lecanii* (2.5 × 10^7 spores/mL)	1.00 g/L	171.00 (13.10)[a]	174.00 (13.21)[g]	177.40 (13.34)[f]	175.33 (13.26)[j]
T12	Spiromecifen 240SC	0.50 mL/L	171.67 (13.12)[a]	132.67 (11.54)[b]	86.33 (9.32)[b]	68.00 (8.28)[b]
T13	*Hirsutella thompsonii* (2.5 × 10^9 spores/ mL)	1.00 g/L	176.67 (13.31)[a]	178.33 (13.37)[h]	175.67 (13.27)[f]	165.67 (12.89)[i]
T14	Untreated control	2.50 mL/L	193.33 (13.92)[a]	233.67 (15.30)[i]	236.33 (15.39)[g]	243.67 (15.63)[k]
	CD @ 5.0%		NS	0.09	0.51	0.35
	SEM ±		0.54	0.03	0.17	0.12
	CV (%)		8.58	6.36	8.96	5.69

Figures in the parenthesis are √(X+0.5) transformations; Means with similar alphabets in a column do not differ significantly by DMRT (*p*=0.05); DBS: Day before spray; DAS: Days after spray.

National Research Centre (NRC), Pune, (Anon., 2008) and Indian Horticultural Research Institute(IIHR), Bangalore (both in India) (www.iihr.ernet.in) also have recommended dicofol, fenpyroximate, difenthurion, sulphur, abamectin, azadirachtin for management of grape mites with certain pre-harvest interval for safety in terms of residue. In the present study these chemicals have been used in the dosages recommended by these institutions. (Chandra Sekhar et al., 2008) also considered abamectin as a best treatment against mites in grapes followed by difenthurion, fenazaquin and spiromecifen. Further, propargite 57 EC has been reported as most effective treatment in containing *Tetranychus urticae* incidence in grapes (Thompson seedless) at Vijyapur itself (Karabhantanal et al., 2012) recently. The efficacy of abamectin and poor performance of dicofol is also evident in this report. The bio-efficacy of abamectin, fenazaquin and propargite observed in present study is in agreement with reports of Mani et al. (2003), Anandkumar (2002), Singh et al., (2004) and Roopa (2005) against different phytophagus mites. Thus acaricides of recent origin as well as different chemistry preferably with IGR action have rendered better suppression of *Tetranychus urticae* in grape compared to old and conventional chemicals.

Table 3. Bioefficacy of acaricides and biorationals against grape mites (after second spray).

No.	Treatments	Dosage	Mean population of mites/ 4 leaves			
			1DBS	1DAS	5DAS	10DAS
T1	Dicofol 18.5 EC	2.50 mL/L	144.67 (12.05)[ef]	127.67 (11.32)[e]	120.33 (10.99)[ef]	118.33 (10.90)[f]
T2	Fenpyroximate 5SC	1.00 mL/L	121.14 (11.03)[bcd]	103.1 (10.18)[c]	87.33 (9.37)[c]	81.63 (9.06)[d]
T3	Difenthurion 50SC	0.80 mL/L	135.33 (11.65)[cd]	114.67 (10.73)[d]	101.24 (10.09)[d]	90.83 (9.56)[d]
T4	Sulphur 80WP	2.00 g/l	156.33 (12.52)[f]	142.33 (11.95)[f]	126.33 (11.26)[fg]	124.2 (11.17)[f]
T5	Abamectin 1.9 EC	0.50 mL/L	106.67 (10.35)[b]	95.67 (9.81)[abc]	51.67 (7.22)[a]	38.00 (6.20)[ab]
T6	Neemazal 3000 ppm	2.0 mL /L	146.67 (12.13)[ef]	143.33 (11.99)[f]	138.4 (11.79)[h]	141.2 (11.90)[g]
T7	Hexythiazox 5.45EC	1.50 mL/L	97.67 (9.91)[a]	85.37 (9.27)[a]	45.33 (6.77)[a]	28.33 (5.37)[a]
T8	Fenazaquin 10EC	1.00 mL/L	146.00 (12.10)[ef]	115.67 (10.78)[d]	107.67 (10.40)[d]	110.33 (10.53)[e]
T9	Propargite 57 EC	2.00 mL/L	119.33 (10.95)[bc]	89.00 (9.46)[ab]	57.23 (7.60)[b]	53.33 (7.34)[b]
T10	Ethion 50EC	2.00mL/L	146.33 (12.12)[ef]	119.33 (10.95)[e]	112.33 (10.62)[e]	107.33 (10.38)[e]
T11	*Verticillium lecanii* (2.5 x 10^7 spores/ mL l)	1.00 g/L	168.67 (13.01)[g]	144.67 (12.05)[f]	136.00 (11.68)[gh]	129.33 (11.39)[f]
T12	Spiromecifen 240SC	0.50 mL/L	112.31 (10.62)[bc]	99.36 (9.99)[bc]	59.23 (7.73)[b]	55.33 (7.47)[c]
T13	*Hirsutella thompsonii* (2.5 x 10^9 spores/ mL)	1.00 g/L	151.5 (12.33)[ef]	143.67 (12.01)[f]	128.00 (11.34)[fgh]	112.67 (10.64)[f]
T14	Untreated control	2.50 mL/L	237.67 (15.43)[h]	245.00 (15.67)[g]	253.67 (15.94)[i]	252.66 (15.91)[h]
	CD @ 5.0%		0.73	0.62	0.52	1.25
	SEM ±		0.24	0.21	0.17	0.42
	CV (%)		9.23	6.22	5.75	10.02

Figures in the parenthesis are $\sqrt{(X+0.5)}$ transformations; Means with similar alphabets in a column do not differ significantly by DMRT (*p*=0.05); DBS: Day before spray; DAS: Days after spray.

Table 4. Bioefficacy of acaricides and biorationals against grape mites (third spray).

No.	Treatments	Dosage	Mean population of mites/ 4 leaves			
			1DBS	1DAS	5DAS	10DAS
T1	Dicofol 18.5 EC	2.50 mL/L	112.67 (10.64)[d]	95.36 (9.79)[e]	74.1 (8.64)[d]	78.29 (8.88)[h]
T2	Fenpyroximate 5SC	1.00 mL/L	95.67 (9.81)[c]	55.67 (7.49)[c]	31.67 (5.67)[c]	29.23 (5.45)[d]
T3	Difenthurion 50SC	0.80 mL/L	91.67 (9.60)[c]	68.67 (8.32)[d]	45.67 (6.79)[c]	43.53 (6.64)[e]
T4	Sulphur 80WP	2.00 g/L	121.67 (11.05)[d]	103.33 (10.19)[f]	93.33 (9.69)[e]	104.00 (10.22)[f]
T5	Abamectin 1.9 EC	0.50 mL/L	55.33 (7.47)[a]	21.32 (4.67)[a]	11.00 (3.39)[a]	8.00 (2.92)[b]
T6	Neemazal 3000 ppm	2.0mL/L	131.33 (11.48)[e]	119.00 (10.93)[g]	102.67 (10.16)[e]	98.67 (9.96)[f]
T7	Hexythiazox 5.45EC	1.50 mL/L	45.67 (6.79)[a]	15.67 (4.02)[a]	5.33 (2.41)[a]	3.67 (2.04)[a]
T8	Fenazaquin 10 EC	1.00 mL/L	108.33 (10.43)[d]	75.67 (8.73)[d]	61.24 (7.86)[d]	64.84 (8.08)[f]
T9	Propargite 57 EC	2.00 mL/L	73.00 (8.57)[b]	23.67 (4.92)[b]	15.67 (4.02)[b]	12.67 (3.63)[c]
T10	Ethion 50EC	2.00 mL/L	102.32 (10.14)[c]	85.21 (9.26)[e]	67.21 (8.23)[d]	70.31 (8.41)[g]
T11	*Verticillium lecanii* (2.5×10^7 spores/ mL)	1.00 g/L	107.33 (10.38)[d]	91.53 (9.59)[e]	87.23 (9.37)[e]	78.75 (8.90)[h]
T12	Spiromecifen 240SC	0.50 mL/L	63.26 (7.98)[b]	31.25 (5.63)[b]	15.23 (3.97)[b]	12.35 (3.58)[c]
T13	*Hirsutella thompsonii* (2.5×10^9 spores/ mL)	1.00 g/L	101.33 (10.09)[c]	87.3 (9.37)[e]	78.11 (8.87)[d]	71.2 (8.47)[g]
T14	Untreated control	2.50 mL/L	220.33 (14.86)[f]	223.33 (14.96)[h]	222.33 (14.93)[f]	221.67 (14.91)[i]
	CD @ 5.0%		0.74	0.65	1.25	0.92
	SEM ±		0.25	0.21	0.42	0.32
	CV (%)		8.21	5.87	9.87	6.65

Figures in the parenthesis are $\sqrt{(X+0.5)}$ transformations; Means with similar alphabets in a column do not differ significantly by DMRT (p=0.05); DBS: Day before spray; DAS: Days after spray.

Table 5. Effect of different acaricides and biorationals on grape yield

No.	Treatments	Dosage	Kg vine^{-1}	Q ha^{-1}	Avoidable yield loss (%)
T_1	Dicofol 18.5 EC	2.50 mL/L	11.03 (3.38)^{c}	245.15^{c}	23.38
T_2	Fenpyroximate 5SC	1.00 mL/L	11.85 (3.44)^{bc}	263.39^{bc}	28.69
T_3	Difenthurion 50SC	0.80 mL/L	11.63 (3.41)^{bc}	259.07^{bc}	27.50
T_4	Sulphur 80WP	2.00 g/L	10.81 (3.29)^{c}	240.25^{c}	21.82
T_5	Abamectin 1.9 EC	0.50 mL/L	15.2 (3.96)^{ab}	337.81^{ab}	44.40
T_6	Neemazal 3000ppm	2.0mL/L	10.14 (3.25)^{c}	226.09^{c}	16.93
T_7	Hexythiazox 5.45EC	1.50 mL/L	16.01 (1.06)^{a}	355.71^{a}	47.20
T_8	Fenazaquin 10EC	1.00 mL/L	11.23 (3.35)^{c}	250.05^{c}	24.89
T_9	Propargite 57 EC	2.00 mL/L	14.4 (3.86)^{ab}	320.11^{ab}	41.32
T_{10}	Ethion 50EC	2.00mL/L	11.24 (3.35)^{c}	250.07^{c}	24.89
T_{11}	*Verticillium lecanii* (2.5×10^7 spores/ mL)	1.00 g/L	10.72 (3.34)^{c}	238.25^{c}	21.17
T_{12}	Spiromecifen 240SC	0.50 mL/L	14.21 (3.83)^{ab}	316.15^{ab}	40.59
T_{13}	*Hirsutella thompsonii* (2.5×10^9 spores/ mL)	1.00 g/L	10.85 (3.38)^{c}	241.50^{c}	22.23
T_{14}	Untreated control	2.50 mL/L	8.45 (2.91)^{d}	187.81^{d}	00.00
	CD @ 5.0%		0.42	50.42	
	SEM ±		0.14	20.25	
	CV (%)		6.66	11.5	

Figures in the parenthesis are √(X+0.5) transformations; Means with similar alphabets in a column do not differ significantly by DMRT (P=0.05); DBS: Day before spray; DAS: Days after spray.

Yield advantage through mites control

In grapes the pest management and other treatments are very precise and every vine is taken care accordingly. The mite incidence management in the present study revealed the variable impact of on yield also at individual vine level and whole orchard as well (Table 5). Amongst most promising acaricides significantly highest yield (16.01 Kg/vine and 355.71 q/ha) has been harvested from hexythiazox application. Statistically on par to it, abamectin, propargite and spiromecifen sprayed plots could yield 337.81, 320.11and 316.15 q/ha respectively. Difenthurion and fenpyroximite remained par with abamectin in terms of yield. All other treatments also rendered significant yield advantage over untreated control despite their lower bio-activity. The studies of Chandra Sekhar et al. (2008) and Karabhantal et al. (2012) endorse the present study in terms of yield also. The avoidable yield loss deduced was maximum 47.20% in the most promising treatment hexythiazox application. By this parameter the next best treatments to avoid heavy loss were abamectin and propargite with 44 and 41.32% avoidance.

Table 6. Economics analyses of grape mites management through synthetic acaricides and biorationals.

Sl No	Treatments	Dosage	Yield ('00 q/ha)	Additional Cost of plant protection ('000 Rs/ha)	Other cost of cultivation (Lakh Rs/ha)	Total cost of cultivation ('0000 Rs/ha)	Gross income (Lakh Rs/ha)	Net profit (Lakh Rs/ha)	B : C ratio
1.	Dicofol 18.5 EC	2.50 mL/L	2.45	5.025	1.45	1.505	7.35	5.85	4.90
2.	Fenpyroximate 5SC	1.00 mL/L	2.63	6.075	1.45	1.510	7.90	6.39	5.23
3.	Diafenthiuron 50SC	0.80 mL/L	2.59	5.160	1.45	1.501	7.77	6.27	5.18
4.	Sulphur 80WP	2.00 g/L	2.40	1.950	1.45	1.469	7.20	5.73	4.90
5.	Abamectin 1.9 EC	0.50 mL/L	3.37	4.950	1.45	1.499	10.13	8.63	6.76
6.	Neemazal 3000ppm	2.00 mL/L	2.26	1.740	1.45	1.467	6.78	5.31	4.62
7.	Hexythiazox 5.45EC	1.50 mL/L	3.55	4.575	1.45	1.495	1.06	9.17	7.13
8.	Spiromecifen 240SC	0.50 mL/L	2.50	4.950	1.45	1.499	7.50	6.00	5.00
9.	Propargite 57% EC	2.00 mL/L	3.20	4.650	1.45	1.496	9.60	8.10	6.42
10.	Ethion 50EC	2.00 mL/L	2.50	2.675	1.45	1.476	7.50	6.02	5.08
11.	*Verticillium lecanii*	2.00 g/L	2.38	1.950	1.45	1.469	7.14	5.67	4.86
12	Fenzaquin 10% EC	1.00 mL/L	3.16	3.750	1.45	1.487	9.48	7.99	6.38
13	*Hirsutella thompsonii*	1.00 g/L	2.41	1.725	1.45	1.467	7.24	5.77	4.94
14	Untreated control	-	1.87	0	1.45	1.450	5.63	4.18	3.89

Economics of mites management

Plant protection against mites involved varied amount of additional cost (Table 6 and graph). Synthetic acaricides had higher cost involvement than biorationals. However the better bioefficacy and yield advantage has resulted into better net profit also. The results on the cost economics of grape mite management revealed that, the highest net profit of ₹.37625 per ha/year was recorded in hexythiazox 5.45EC followed by abamectin 1.9 EC, propargite 57 EC, fenazaquin 10EC, fenpyroximate 5SC, difenthurion 50SC, ethion 50 EC spiromecifen 240SC, dicofol 18.5 EC, *Hirsutella thompsonii* and sulphur 80WP which recorded the net profit of ₹. 917555, 863480, 810680, 799700, 639095, 627050, 602535, 600200, 585425, 577775 and 573800/ha/year, respectively through table purpose harvest. Whereas, *Verticillium lecanii, and* neemazal 3000ppm recorded the minimum net profit of ₹. 567800 and 531530/ha/year, respectively. The cost: benefit was highest (1: 7.13) in hexythiazox treatment. Abamectin, fenazaquin and propargite had B : C > 6.0. The economic analyses mites management indicated that protection by any means would be profitable. Thus for organic grape cultivation the biorational options *viz*., could also be relied upon as *Hirsutella thompsonii*, *Verticillium lecanii*, and neem based products reveled C:B > 4.0 and equal to some of acaricides like dicofol and sulphur. Thus the management of mites infesting grapes is significant in terms of economic advantage also.

Conclusion

It was quite appealing from present study that mites have considerable economical significance on grapes as emerging pests and the management options significant in terms of bio-efficacy and economics. However, the attention has to be given to residue issue also while adopting the results in commercial orchards as grape is harvested for table purpose, resin making and vine preparation.

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