

BIO-EFFICACY OF SPIROTETRAMAT 150 OD (W/V) AGAINST SUCKING PESTS OF GRAPEVINE AND ITS PHYTOTOXICITY

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KEY WORDS

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ABSTRACT Three sprays of Spirotetramat 150 OD @ 93.75 g a.i./ha afforded highest protection against thrips with 95.9 per cent over untreated check followed by Spirotetramat 150 OD @ 75 g a.i./ha, Spirotetramat 150 OD @ 60 g a.i./ha, Thiamethoxam 25 WG @ 62.5 g a.i./ha, Phosalone 35 EC @ 700 g a.i./ha, Malathion 50 EC @ 1000 g a.i./ha and Dicofol 18.5 EC @ 185 g a.i./ha with 94.2, 93.4, 91.7, 90.9, 88.4 and 88.4 per cent protection, respectively. Similarly, sprays of Spirotetramat 150 OD @ 93.75 g a.i./ha afforded highest protection against mites with 89.9 per cent over untreated check followed by Thiamethoxam 25 WG @ 62.5 g a.i./ha, Dicofol 18.5 EC @ 185 g a.i./ha, Spirotetramat 150 OD @ 75 g a.i./ha and Spirotetramat 150 OD @ 60 g a.i./ha with 86.5, 85.4, 84.3 and 78.9 per cent protection, respectively. Again, three sprays of Spirotetramat 150 OD @ 93.75 g a.i./ha afforded highest protection against grape mealy bugs with 84.8 per cent over untreated check followed by Thiamethoxam 25 WG @ 62.5 g a.i./ha, Spirotetramat 150 OD @ 75 g a.i./ha and Malathion 50 EC @ 1000 g a.i./ha with 84.5, 75.4 and 74.7 per cent protection, respectively.

Spirotetramat 150 OD @ 93.75 g a.i./ha recorded highest yield of 11.5 kg/vine and did not differ statistically from Spirotetramat 150 OD @ 75 g a.i./ha, Spirotetramat 150 OD @ 60 g a.i./ha, Thiamethoxam 25 WG @ 62.5 g a.i./ha, Phosalone 35 EC @ 700 g a.i./ha, Malathion 50 EC @ 1000 g a.i./ha and Dicofol 18.5 EC @ 185 g a.i./ha with 10.9, 10.6, 10.6, 10.5, 10.3 and 10.3 kg/vine, respectively. None of the insecticidal treatments showed any type of phytotoxic symptoms on grape vines at the dosages tried viz., Spirotetramat 150 OD @ 75 g a.i./ha, Spirotetramat 150 OD @ 93.75 g a.i./ha, Spirotetramat 150 OD @ 187.5 g a.i./ha and Spirotetramat 150 OD @ 375 g a.i./ha.

INTRODUCTION

Grape (*Vitis vinifera* L.) is one of the most important commercial fruit crops of sub-tropical, tropical and temperate regions of the world. The prevailing sub-tropical and tropical climatic condition

of India is well suited for higher sucrose level and berry yield. In India, the major grape growing states include Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Punjab, Madhya Pradesh and Haryana. As per the reports of Butani (1979) over 85 species of

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insect pests are known to occur on grapes in India. Balikai and Kotikal (2003) recorded 26 pests infesting grapevines in northern Karnataka. Among these, two insects viz., flea beetle, *Sceledonta strigicollis* Mots. and mealy bug, *Maconellicoccus hirsutus* (Green) were recorded as major pests on this crop. Lower (1968) described the mealy bug as “hard to kill pest of fruit trees” because mealy bugs are protected by waxy filaments, and almost impossible to be penetrated by insecticidal sprays. In recent years, *M. hirsutus* has become very severe in grape vine yards. In addition, thrips and mites also cause heavy damage affecting berry quality.

Due to continuous and indiscriminate use of synthetic insecticides, there is a development of resistance to insecticides and hence the efficacy has become less reliable. To overcome this problem discovery of novel insecticides with different biochemical targets are needed. Novel molecules are effective at low doses and have less exposure in the environment. The new insecticide spirotetramat 150 OD is a broad spectrum insecticide belonging to Ketoenoles class with “spirotetramat” as active ingredient. It was proved that the bioefficacy of spirotetramat against aphids, cicadas, grapes louse, mealy bug, white fly, scale and also against larvae by ingestion and also proved its efficacy in all types of crops. (www.newsroom.bsyer.vrop.science.com). Spirotetramat is an innovative new insecticide used to control scale insects. It distributes via the phloem and xylem in plants, to eliminate sucking insect pests (Brück *et al.*, 2009).

MATERIALS AND METHODS

A field trial was conducted during *rabi* 2007-08 at the Horticultural Research Station, Bijapur (Tidagundi) in a well established grapevine garden to test the bio-efficacy of spirotetramat 150 OD (W/V) against sucking pests. The experiment consisted of eight treatments (Table 1) replicated thrice in a plot size of 3.03 x 7.57 m (23.94 m²) with seven plants for each treatment. The grapes vines (variety-Thompson seedless) were planted in a telephone system.

Score	Per cent Phytotoxicity
0	No Phytotoxicity
1	1-10
2	11-20
3	21-30
4	31-40
5	41-50
6	51-61
7	61-70
8	71-80
9	81-90
10	91-100

Three insecticidal applications were given at fifteen days interval with the help of knapsack sprayer using spray volume of 1000 litres per hectare. The insecticidal efficacy was assessed by recording observations on sucking pests like thrips, mites and mealy bugs. The number of thrips and mites present on three leaves per vine, from five vines in each treatment was recorded and mean number of thrips and mites per leaf was worked out separately. Similarly, the number of mealy bug colonies per vine from five vines in each treatment was recorded and mean number of mealy bug colonies per vine was worked out. These observations were made a day before first spray as pre-treatment count and on 3, 7 and 14th day after each application as post-treatment counts. The observation recorded on 14th day after first and second sprays served as pre-treatment count for second and third sprays, respectively. The per cent protection against thrips, mites and mealy bugs over untreated check was worked out. The per cent bunches showing scab a symptom due to thrips was also worked out. The fruit yield was harvested separately and fruit yield per vine was calculated.

Three insecticidal applications were given at fifteen days interval with the help of knapsack sprayer using spray volume of 1000 litres per hectare. The treatments included (1) Spirotetramat 150 OD @ 75 g a.i./ha (2) Spirotetramat 150 OD @ 93.75 g a.i./ha (3) Spirotetramat 150 OD 187.5 g a.i./ha (4) Spirotetramat

150 OD @ 375 g a.i./ha and Untreated control (Water spray). The observations on phytotoxicity symptoms (*viz.*, leaf tip and surface injury, wilting, vein clearing, necrosis, epinasty and hyponasty) were recorded on first, third, seventh and tenth day after first, second and third sprays by using the following score.

RESULTS AND DISCUSSION

Bio-efficacy against Thrips, *Thrips palmi* Karny and *Scirtothrips dorsalis* Hood

i) First Spray: At one day before first spray, the thrips population varied from 11.4 to 12.5 per leaf with non-significant differences among various treatments (Table 1). At three days after first spray, all the insecticidal treatments were on par with each other and were significantly superior to untreated check. At seven days after first spray, Spirotetramat 150 OD @ 93.75 g a.i./ha, Spirotetramat 150 OD @ 75 g a.i./ha, Spirotetramat 150 OD @ 60 g a.i./ha and Thiamethoxam 25 WG @ 62.5 g a.i./ha were equally effective in reducing thrips population. At 14 days after first spray, Spirotetramat 150 OD @ 93.75 g a.i./ha, Spirotetramat 150 OD @ 75 g a.i./ha, Spirotetramat 150 OD @ 60 g a.i./ha, Thiamethoxam 25 WG @ 62.5 g a.i./ha and Malathion 50 EC @ 1000 g a.i./ha were equally effective against thrips and did not differ from each other (Table 1).

ii) Second Spray: At three days after second spray, all the dosages of Spirotetramat 150 OD i.e., @ 93.75, 75, 60 g a.i./ha, Thiamethoxam 25 WG @ 62.5 g a.i./ha, Dicofol 18.5 EC @ 185 g a.i./ha and Phosalone 35 EC @ 700 g a.i./ha were on par with each other in reducing thrips population. At seven days after second spray also, all the dosages of Spirotetramat 150 OD (@ 93.75, 75, 60 g a.i./ha) were equally effective in reducing thrips population. At 14 days after second spray, Spirotetramat 150 OD @ 93.75 g a.i./ha was highly effective with 1.5 thrips/leaf followed by Spirotetramat 150 OD @ 75 g a.i./ha (1.8 thrips/leaf) and Spirotetramat 150 OD @ 60 g a.i./ha (2.0 thrips/leaf). The latter two treatments were on par with Thiamethoxam 25 WG @ 62.5 g a.i./ha and

Table 1. Efficacy of Spirotetramat 150 OD against thrips in grapevines at H.R.S. Bijapur (2007-08)

Tr. No.	Treatment	Dosage		Pre-treatment Count (1 DBS)	Post treatment counts (No. of thrips/leaf)											
		(g ai/ha)	Forml./ha (g/ml)		after I spray			after II spray			after III spray					
					3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS			
T ₁	Spirotetramat 150 OD	60	400	11.4 ^a	8.7 ^a	6.0 ^{ab}	4.5 ^{ab}	3.3 ^{ab}	2.5 ^{ac}	2.0 ^{bc}	1.5 ^{ab}	1.2 ^{ac}	0.8 ^{ab}			
T ₂	Spirotetramat 150 OD	75	500	12.3 ^a	8.4 ^a	5.7 ^a	4.2 ^{ab}	3.2 ^{ab}	2.2 ^{ab}	1.8 ^{ab}	1.2 ^a	0.9 ^{ab}	0.7 ^{ab}			
T ₃	Spirotetramat 150 OD	93.75	625	11.7 ^a	8.2 ^a	5.3 ^a	4.0 ^a	3.0 ^a	2.0 ^a	1.5 ^a	1.0 ^a	0.7 ^a	0.5 ^a			
T ₄	Phosalone 35 EC	700	2000	11.4 ^a	9.2 ^a	7.2 ^{bc}	5.2 ^b	4.1 ^{ab}	3.2 ^{cd}	2.5 ^{bc}	1.9 ^{bc}	1.5 ^c	1.1 ^{bc}			
T ₅	Malathion 50 EC	1000	2000	12.5 ^a	9.4 ^a	7.4 ^c	5.1 ^{ab}	4.2 ^b	3.4 ^d	2.6 ^c	2.0 ^{bc}	1.6 ^c	1.4 ^c			
T ₆	Thiamethoxam 25 WG	62.5	250	11.8 ^a	8.5 ^a	6.4 ^{ac}	4.7 ^{ab}	3.7 ^{ab}	2.8 ^{bd}	2.3 ^{bc}	1.8 ^{bc}	1.3 ^{bc}	1.0 ^{ac}			
T ₇	Dicofol 18.5 EC	185	1000	12.2 ^a	9.3 ^a	7.1 ^{bc}	5.2 ^b	4.0 ^{ab}	3.5 ^d	2.7 ^c	2.1 ^c	1.7 ^c	1.4 ^c			
T ₈	Untreated check (Water spray)	-	-	12.4 ^b	12.2 ^b	12.1 ^d	12.0 ^c	12.0 ^c	11.8 ^e	12.1 ^d	12.0 ^d	11.7 ^d	12.1 ^d			
	S.Em±	-	-	0.7	0.6	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2			
	C.D. (0.05)	-	-	N.S.	1.7	1.3	1.2	1.0	0.8	0.8	0.6	0.5	0.6			
	C.V. (%)	-	-	10.8	10.5	10.2	11.9	12.7	11.1	12.5	12.6	10.8	13.4			

Note: DBS= Day Before Spray, DAS= Days After Spray
In the vertical columns means followed by same alphabets are not different statistically (P= 0.05) by DMRT



Phosalone 35 EC @ 700 g a.i./ha with 2.3 and 2.5 thrips per leaf (Table 1).

ii) Third Spray: At three days after third spray, Spirotetramat 150 OD @ 93.75 g a.i./ha and Spirotetramat 150 OD @ 75 g a.i./ha recorded minimum population of 1.0 and 1.2 thrips per leaf and were on par with Spirotetramat 150 OD @ 60 g a.i./ha (1.5 thrips/leaf). The latter treatment in turn was on par with Thiamethoxam 25 WG @ 62.5 g a.i./ha (1.8 thrips/leaf), Phosalone 35 EC @ 700 g a.i./ha (1.9 thrips/leaf) and Malathion 50 EC @ 1000 g a.i./ha (2.0 thrips/leaf). At seven days after third spray also, Spirotetramat 150 OD @ 93.75 g a.i./ha recorded significantly minimum population of 0.7 thrips/leaf and was on par with Spirotetramat 150 OD @ 75 g a.i./ha and Spirotetramat 150 OD @ 60 g a.i./ha with 9.0 and 1.2 thrips/leaf, respectively. The other insecticides viz., Thiamethoxam 25 WG @ 62.5 g a.i./ha, Phosalone 35 EC @ 700 g a.i./ha, Malathion 50 EC @ 1000 g a.i./ha and Dicofol 18.5 EC @ 185 g a.i./ha with 1.3, 1.5, 1.6 and 1.7 thrips/leaf, respectively were on par with lowest dosage of Spirotetramat 150 OD @ 60 g a.i./ha. At 14 days after third spray, Spirotetramat 150 OD @ 93.75 g a.i./ha recorded significantly lowest population of 0.5 thrips/leaf and it was on par with Spirotetramat 150 OD @ 75 g a.i./ha (0.7 thrips/leaf), Spirotetramat 150 OD @ 60 g a.i./ha (0.8 thrips/leaf) and Thiamethoxam 25 WG @ 62.5 g a.i./ha (1.0 thrips/leaf) (Table 1). The results of present investigation are in agreement with Udikeri *et al.* (2009) who reported that the population of thrips, leafhoppers and aphids was brought below ETL with three sprays during 2006 and two sprays in 2007 with spirotetramat 150 OD @ 500 ml/ha. On the other hand, Kumar *et al.* (2009) evaluated that spirotetramat 150 OD as foliar application for its bio-efficacy against cotton whitefly. It was revealed that spirotetramat 75 g a.i./ha reduced the whitefly population up to 89.7% over control.

Bio-efficacy against Mite, *Tetranychus urticae* Koch

i) First Spray: At one day before first spray, the mite population varied from 9.5 to 10.4 per leaf with non-significant differences among various treatments (Table 2). At three days after first spray, Spirotetramat

Table 2. Efficacy of Spirotetramat 150 OD against mites in grapevines at H.R.S. Bijapur (2007-08)

Tr. No.	Treatment	Dosage		Pre-treatment Count (1 DBS)	Post treatment counts (No. of mites/leaf)								
		(g ai/ha)	Forml./ha (g/ml)		after I spray			after II spray			after III spray		
					3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T ₁	Spirotetramat 150 OD	60	400	10.2 ^a	6.0 ^a	5.3 ^a	5.0 ^b	4.5 ^b	4.1 ^b	3.5 ^b	2.9 ^c	2.4 ^b	1.8 ^b
T ₂	Spirotetramat 150 OD	75	500	9.6 ^a	5.4 ^a	5.0 ^a	4.6 ^b	4.2 ^{ab}	3.8 ^{ab}	3.1 ^{ab}	2.5 ^{bc}	2.0 ^{ab}	1.4 ^{ab}
T ₃	Spirotetramat 150 OD	93.75	625	9.8 ^a	4.8 ^a	4.2 ^a	3.7 ^a	3.5 ^a	3.0 ^a	2.6 ^a	2.0 ^a	1.5 ^a	0.9 ^a
T ₄	Phosalone 35 EC	700	2000	10.1 ^a	8.3 ^b	7.8 ^b	7.5 ^c	7.0 ^c	6.4 ^c	6.0 ^c	5.3 ^d	5.0 ^c	4.0 ^c
T ₅	Malathion 50 EC	1000	2000	9.9 ^a	8.4 ^{bc}	8.0 ^b	7.6 ^c	7.2 ^c	6.5 ^c	6.2 ^c	5.2 ^d	4.7 ^c	4.1 ^c
T ₆	Thiamethoxam 25 WG	62.5	250	10.4 ^a	5.3 ^a	4.7 ^a	4.3 ^{ab}	4.0 ^{ab}	3.3 ^{ab}	2.7 ^{ab}	2.4 ^{ab}	1.7 ^{ab}	1.2 ^a
T ₇	Dicofol 18.5 EC	185	1000	9.5 ^a	5.2 ^a	4.5 ^a	4.2 ^{ab}	3.8 ^{ab}	3.1 ^a	2.5 ^a	2.2 ^{ab}	1.4 ^a	1.3 ^{ab}
T ₈	Untreated check (Water spray)	-	-	10.0 ^a	9.8 ^c	9.7 ^c	9.5 ^d	9.3 ^d	9.3 ^d	9.0 ^d	9.0 ^c	8.9 ^d	8.9 ^d
	S.Em.±	-	-	0.8	0.5	0.5	0.3	0.3	0.3	0.3	0.2	0.3	0.2
	C.D. (0.05)	-	-	N.S.	1.4	1.5	0.8	0.9	0.9	0.9	0.5	0.8	0.6
	C.V. (%)	-	-	14.2	12.1	14.2	8.0	9.8	10.3	11.0	7.2	14.0	10.6

Note: DBS= Day Before Spray, DAS= Days After Spray

In the vertical columns means followed by same alphabets are not different statistically (P= 0.05) by DMRT

150 OD @ 93.75 g a.i./ha, Dicofol 18.5 EC 185 g a.i./ha, Thiamethoxam 25 WG @ 62.5 g a.i./ha, Spirotetramat 150 OD @ 75 g a.i./ha and Spirotetramat 150 OD @ 60 g a.i./ha were on par with each other and were significantly superior to remaining insecticides and untreated check. At seven days after first spray also, similar trend was continued. At 14 days after first spray, Spirotetramat 150 OD @ 93.75 g a.i./ha, recorded lowest mite population followed by Dicofol 18.5 EC @ 185 g a.i./ha and Thiamethoxam 25 WG @ 62.5 g a.i./ha which in turn were on par with Spirotetramat 150 OD @ 75 g a.i./ha and Spirotetramat 150 OD @ 60 g a.i./ha (Table 2).

ii) Second Spray: At three days after second spray, Spirotetramat 150 OD @ 93.75 g a.i./ha, Dicofol 18.5 EC @ 185 g a.i./ha, Thiamethoxam 25 WG @ 62.5 g a.i./ha and Spirotetramat 150 OD @ 75 g a.i./ha were on par with each other in reducing mites population. The latter two treatments were on par with Spirotetramat 150 OD @ 60 g a.i./ha. The insecticides viz., Phosalone 35 EC @ 700 g a.i./ha and Malathion 50 EC @ 1000 g a.i./ha were inferior to all above treatments in managing the mites. Exactly similar trend was continued even at 7 and 14 days after second spray also (Table 2).

ii) Third Spray: At three days after third spray, Spirotetramat 150 OD @ 93.75 g a.i./ha recorded minimum population of 2.0 mites per leaf followed by Dicofol 18.5 EC @ 185 g a.i./ha and Thiamethoxam 25 WG @ 62.5 g a.i./ha (2.2 and 2.4 mites/leaf, respectively). The latter two treatments were on par with Spirotetramat 150 OD @ 75 g a.i./ha (2.5 mites/leaf). At seven days after third spray, Spirotetramat 150 OD @ 93.75 g a.i./ha and Dicofol 18.5 EC @ 185 g a.i./ha recorded significantly minimum population of 1.5 and 1.4 mites/leaf, respectively and were on par with Thiamethoxam 25 WG @ 62.5 g a.i./ha and Spirotetramat 150 OD @ 75 g a.i./ha (1.7 and 2.0 mites/leaf, respectively). The latter two treatments were on par with Spirotetramat 150 OD @ 60 g a.i./ha with 2.4 mites per leaf. At 14 days after third spray, Spirotetramat 150 OD @ 93.75 g a.i./ha and Thiamethoxam 25 WG @ 62.5 g a.i./ha recorded significantly minimum population of 0.9 and 1.2 mites/

leaf, respectively and were on par with Dicofol 18.5 EC @ 185 g a.i./ha and Spirotetramat 150 OD @ 75 g a.i./ha (1.3 and 1.4 mites/leaf, respectively). The latter two treatments were on par with Spirotetramat 150 OD @ 60 g a.i./ha (1.8 mites/leaf). Phosalone 35 EC @ 700 g a.i./ha and Malathion 50 EC @ 1000 g a.i./ha were inferior to all above treatments in managing the mites (Table 2).

Bio-efficacy against grape mealy bug, *Maconellicoccus hirsutus* (Green)

i) First Spray: At one day before first spray, the grape mealy bug population varied from 22.7 to 26.1 colonies per vine with non-significant differences among various treatments (Table 3). At three days after first spray, all the insecticidal treatments were on par with each other except Malathion 50 EC @ 1000 g a.i./ha. At seven days after first spray, the lowest population was recorded in Spirotetramat 150 OD @ 93.75 g a.i./ha and Dicofol 18.5 EC @ 185 g a.i./ha followed by Thiamethoxam 25 WG @ 62.5 g a.i./ha, Malathion 50 EC @ 1000 g a.i./ha and Spirotetramat 150 OD @ 75 g a.i./ha which were on par with each other. At 14 days after first spray, Thiamethoxam 25 WG @ 62.5 g a.i./ha and Spirotetramat 150 OD @ 93.75 g a.i./ha recorded lowest population of mealy bugs followed by Dicofol 18.5 EC @ 185 g a.i./ha, Spirotetramat 150 OD @ 75 g a.i./ha and Malathion 50 EC @ 1000 g a.i./ha which were equally effective against mealy bugs and did not differ from each other (Table 3).

ii) Second Spray: At three days after second spray, Thiamethoxam 25 WG @ 62.5 g a.i./ha recorded lowest mealy bug colonies per vine followed by Spirotetramat 150 OD @ 93.75 g a.i./ha, Malathion 50 EC @ 1000 g a.i./ha and Dicofol 18.5 EC @ 185 g a.i./ha. At seven days after second spray, Thiamethoxam 25 WG @ 62.5 g a.i./ha recorded lowest mealy bug colonies per vine followed by Spirotetramat 150 OD @ 93.75 g a.i./ha and Malathion 50 EC @ 1000 g a.i./ha which were equally effective against mealy bugs. At 14 days after second spray, Spirotetramat 150 OD @ 93.75 g a.i./ha was highly effective with 12.2 mealy bug colonies per vine followed by Thiamethoxam 25 WG @ 62.5 g a.i./ha and Malathion 50 EC @ 1000 g

Table 3. Efficacy of Spirotetramat 150 OD against mealy bugs in grapevines at H.R.S. Bijapur (2007-08)

Tr.No.	Treatment	Dosage		Pre-treatment Count (1 DBS)	Post treatment counts (No. of mealy bug colonies/vine)								
		(g ai/ha)	Forml./ha (g/ml)		after I spray			after II spray			after III spray		
					3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS	3 DAS	7 DAS	14 DAS
T1	Spirotetramat 150 OD	60	400	25.8 a	24.2 a-c	23.8 c	22.7 b	21.5 d	20.4 c	19.7 e	18.2 c	15.3 c	12.8 bc
T2	Spirotetramat 150 OD	75	500	23.4 a	22.1 ab	21.4 a-c	20.3 ab	19.8 b-d	17.2 b	15.3 b-d	13.5 b	11.2 b	10.0 b
T3	Spirotetramat 150 OD	93.75	625	22.7 a	21.2 a	20.3 a	19.2 a	17.4 ab	15.3 ab	12.2 a	10.1 a	7.6 a	6.2 a
T4	Phosalone 35 EC	700	2000	24.9 a	24.1 ab	23.2 bc	22.5 b	20.7 cd	17.4 b	16.2 cd	14.3 b	13.1 b	12.7 b
T5	Malathion 50 EC	1000	2000	26.1 a	24.3 bc	22.1 a-c	20.4 ab	18.7 a-c	15.3 ab	14.1 a-c	12.1 ab	11.4 b	10.3 b
T6	Thiamethoxam 25 WG	62.5	250	24.8 a	22.1 ab	20.7 ab	18.5 a	17.2 a	14.4 a	12.7 ab	10.3 a	7.5 a	6.3 a
T7	Dicofol 18.5 EC	185	1000	22.9 a	21.4 ab	20.3 a	20.1 ab	19.4 a-d	17.3 b	17.1 de	17.0 c	16.4 c	16.2 c
T8	Untreated check (Water spray)	-	-	25.0 a	27.2 c	28.3 d	31.4 c	34.7 e	35.1 d	37.8 f	38.1 d	38.9 d	40.7 d
	S.Em.±	-	-	1.4	1.0	0.9	1.0	0.8	0.9	0.9	0.8	0.7	1.1
	C.D. (0.05)	-	-	N.S.	3.1	2.6	3.1	2.5	2.6	2.8	2.4	2.0	3.5
	C.V. (%)	-	-	9.7	7.6	6.7	8.1	6.9	7.8	8.8	8.1	7.4	13.7

Note: DBS= Day Before Spray, DAS= Days After Spray

In the vertical columns means followed by same alphabets are not different statistically ($P=0.05$) by DMRT

a.i./ha (12.7 and 14.1 mealy bug colonies/vine). The latter two treatments were on par with Spirotetramat 150 OD @ 75 g a.i./ha (15.3 colonies/vine) (Table 3).

ii) Third Spray: At three days after third spray, Spirotetramat 150 OD @ 93.75 g a.i./ha and Thiamethoxam 25 WG @ 62.5 g a.i./ha were highly effective with 10.1 and 10.3 mealy bug colonies per vine, respectively followed by Malathion 50 EC @ 1000 g a.i./ha (12.1 mealy bug colonies/vine). The next best treatments included Spirotetramat 150 OD @ 75 g a.i./ha and Phosalone 35 EC @ 700 g a.i./ha (13.5 and 14.3 mealy bug colonies/vine, respectively). At seven days after third spray, Spirotetramat 150 OD @ 93.75 g a.i./ha and Thiamethoxam 25 WG @ 62.5 g a.i./ha were highly effective with 7.6 and 7.5 mealy bug colonies per vine, respectively). The next best treatments included Spirotetramat 150 OD @ 75 g a.i./ha, Malathion 50 EC @ 1000 g a.i./ha and Phosalone 35 EC @ 700 g a.i./ha (11.2, 11.4 and 13.1 mealy bug colonies/vine, respectively). At 14 days after third spray, Spirotetramat 150 OD @ 93.75 g a.i./ha and Thiamethoxam 25 WG @ 62.5 g a.i./ha (6.2 and 6.3 colonies/vine, respectively) retained their effectiveness and were significantly superior to any of the treatments. The next best treatments in this respect included Spirotetramat 150 OD @ 75 g a.i./ha, Malathion 50 EC @ 1000 g a.i./ha, Phosalone 35 EC @ 700 g a.i./ha and Spirotetramat 150 OD @ 60 g a.i./ha (10.0, 10.3, 12.7 and 12.8 mealy bug colonies/vine, respectively). The treatment Dicofol 18.5 EC @ 185 g a.i./ha was the least effective with 16.2 mealy bug colonies per vine (Table 3).

Overall efficacy of insecticides and their effect on fruit yield

All the insecticidal treatments exhibited more than 85 per cent protection against thrips. Three sprays of Spirotetramat 150 OD @ 93.75 g a.i./ha afforded highest protection against thrips with 95.9 per cent over untreated check followed by Spirotetramat 150 OD @ 75 g a.i./ha, Spirotetramat 150 OD @ 60 g a.i./ha, Thiamethoxam 25 WG @ 62.5 g a.i./ha, Phosalone 35 EC @ 700 g a.i./ha, Malathion 50 EC @ 1000 g a.i./ha and Dicofol 18.5 EC @ 185 g

a.i./ha with 94.2, 93.4, 91.7, 90.9, 88.4 and 88.4 per cent protection, respectively (Table 4).

Three sprays of Spirotetramat 150 OD @ 93.75 g a.i./ha afforded highest protection against mites with 89.9 per cent over untreated check followed by Thiamethoxam 25 WG @ 62.5 g a.i./ha, Dicofol 18.5 EC @ 185 g a.i./ha, Spirotetramat 150 OD @ 75 g a.i./ha and Spirotetramat 150 OD @ 60 g a.i./ha with 86.5, 85.4, 84.3 and 78.9 per cent protection, respectively. The insecticides Malathion 50 EC @ 1000 g a.i./ha and Phosalone 35 EC @ 700 g a.i./ha were ineffective with 53.9 and 55.1 percent protection, respectively (Table 4).

Three sprays of Spirotetramat 150 OD @ 93.75 g a.i./ha afforded highest protection against grape mealy bugs with 84.8 per cent over untreated check followed by Thiamethoxam 25 WG @ 62.5 g a.i./ha, Spirotetramat 150 OD @ 75 g a.i./ha and Malathion 50 EC @ 1000 g a.i./ha with 84.5, 75.4 and 74.7 per cent protection, respectively (Table 4).

The insecticidal treatments viz., Spirotetramat 150 OD @ 93.75 g a.i./ha, Spirotetramat 150 OD @ 75 g a.i./ha, Spirotetramat 150 OD @ 60 g a.i./ha and Thiamethoxam 25 WG @ 62.5 g a.i./ha recorded lowest percentage of bunches having scab symptoms (11.0, 12.4, 15.2 and 15.8 %, respectively) due to thrips and were at par with each other (Table 4).

The results of present investigation are in line with Kumar *et al.* (2009) who reported that, spirotetramat @ 75 g a.i./ha reduced the whitefly population up to 89.7% over control Similarly, Kumar *et al.*, (2007) reported that, spirotetramat 150 OD @ 75 g a.i./ha as most effective in reducing aphid population in cotton crop.

Spirotetramat 150 OD @ 93.75 g a.i./ha recorded highest yield of 11.5 kg/vine and did not differ statistically from Spirotetramat 150 OD @ 75 g a.i./ha, Spirotetramat 150 OD @ 60 g a.i./ha, Thiamethoxam 25 WG @ 62.5 g a.i./ha, Phosalone 35 EC @ 700 g a.i./ha, Malathion 50 EC @ 1000 g a.i./ha and Dicofol 18.5 EC @ 185 g a.i./ha with 10.9, 10.6, 10.5, 10.3 and 10.3 kg/vine, respectively (Table 4).

Table 4. Effect of Spirotetramat 150 OD against grape pests and on grape yield at H.R.S. Bijapur (2007-08)

Ti No.	Treatment	Dose/ha (ml/g)	Dose/ha(g/ml)	% Protection over untreated check against			% Bunches showing scab symptoms	Yield (kg/vine)
				Thrips	Mites	Mealy bugs		
T ₁	Spirotetramat 150 OD	60	400	93.4	78.9	68.6	15.2 (22.9) ^{*bc}	10.6 ^b
T ₂	Spirotetramat 150 OD	75	500	94.2	84.3	75.4	12.4 (20.6) ^{ab}	10.9 ^b
T ₃	Spirotetramat 150 OD	93.75	625	95.9	89.9	84.8	11.0 (19.4) ^a	11.5 ^b
T ₄	Phosalone 35 EC	700	2000	90.9	55.1	68.8	17.2 (24.3) ^{bc}	10.5 ^b
T ₅	Malathion 50 EC	1000	2000	88.4	53.9	74.7	18.5 (25.4) ^c	10.3 ^b
T ₆	Thiamethoxam 25 WG	62.5	250	91.7	86.5	84.5	15.8 (23.4) ^{bc}	10.6 ^b
T ₇	Dicofol 18.5 EC	185	1000	88.4	85.4	60.2	18.7 (25.6) ^c	10.3 ^b
T ₈	Untreated check (Water spray)	-	-	-	-	-	87.4 (69.3) ^d	8.4 ^a
	S.E.m. _±	-	-	-	-	-	1.4	0.6
	C.D. (0.05)	-	-	-	-	-	4.1	1.9
	C.V. (%)	-	-	-	-	-	8.1	10.2

Note: In the vertical columns means followed by same alphabets are not different statistically (P= 0.05) by DMRT
 Figures in the parentheses are arcsin transformed values



Table 5. Phytotoxic effect due to Spirotetramat 150 OD recorded at 1, 3, 7 and 10 days after spray at H.R.S. Bijapur (2007-08)

Tr. Treatment No.	Dose/ha (ml/g)	Dose/ha (g/ml)	(Mean of three sprays)																			
			Per cent Leaf tip & surface injury				Per cent Wilting				Per cent Vein clearing				Per cent Necrosis				Per cent Epinasty & Hyponasty			
			1*	3	7	10	1	3	7	10	1	3	7	10	1	3	7	10	1	3	7	10
T ₁ Spirotetramat 150 OD		500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T ₂ Spirotetramat 150 OD	75	62.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T ₃ Spirotetramat 150 OD		1250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T ₄ Spirotetramat 150 OD		2500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T ₅ Untreated check (Water spray)		-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

* 1, 3, 7, 10 Days after spray

Phytotoxicity: The data pertaining to phytotoxicity are presented in Table 5. None of the insecticidal treatments showed any type of phytotoxic symptoms on grape vines at the dosages tried viz., Spirotetramat 150 OD @ 75 g a.i./ha, Spirotetramat 150 OD @ 93.75 g a.i./ha, Spirotetramat 150 OD @ 187.5 g a.i./ha and Spirotetramat 150 OD @ 375 g a.i./ha.

Results of two field trials revealed that after two consecutive applications of spirotetramat 150 OD @ 75 g a.i./ha in combination with imidacloprid 200 SL @ 25 g a.i./ha at 15 days interval brought down the aphids, thrips and whitefly population by 94.42, 79.31 and 91.38 per cent, respectively over control. Further, all the combinations were effective and significantly reduced the sucking pest population without causing any phytotoxicity to cotton plant (Kumar and Kuttalam, 2011).

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