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Evaluation of the Comparative Efficacy of Spirotetramat 150 OD on the Sucking Insect Pests of *Citrus* and their Impact on Fruit Yield

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ABSTRACT

Field trials were carried out during 2016 and 2017 at Agricultural Research Station, Sriganganagar to find out the efficacy of new insecticide with different dose of spirotetramat 150 OD @ 0.4, 0.5 and 0.6 ml per liter of water along with conventional insecticides (dicofol 18.5% SC @ 2.7 ml/l, quinalphos 25% EC @ 2.8 ml/l and imidacloprid 200 SL @ 0.5 ml/l) againstsucking insect pestsviz., whitefly, *Citrus psylla* and mite in *Citrus*. The results indicated that among different insecticides spirotetramat 150 OD at 0.6 ml per liter of water found as the most effective treatment by recording highest percent reduction of whitefly (74.32, 72.82, 73.47 and 73.36), *Citrus psylla* (80.04, 76.87, 79.16 and 77.08) and mite (75.74, 79.28, 81.01 and 79.33) during 2016-17 and 2017-18 of first and second spray, respectively and at par with spirotetramat 150 OD @ 0.5 ml per liter of water. Significantly highest fruit yield was harvested from the spirotetramat 150 OD @ 0.6 ml/l (417.60 and 439.27 q/ha during 2016 and 2017 respectively) and at par with spirotetramat 150 OD @ 0.5 ml per liter of water. Study revealed that spirotetramat 150 OD @ 0.6 ml/l or spirotetramat 150 OD @ 0.5 ml/l can be suggested to the farmers for the management of sucking pests in kinnow orchard under irrigated north western plain zone.

Keywords Comparative efficacy, Spirotetramat 150 OD, Insecticide, Sucking insect pests, *Citrus.*

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INTRODUCTION

Kinnow is an important horticultural crop, belongs to family Rutaceae and sub-family Aurantioedae, which was developed through hybridization between King mandarin × Willow leaf orange produced by H.B. Frost in 1915 and released in 1935 (Frost 1935) was introduced by Dr JC Bakhshi at Abohar research station during 1954. *Citrus* fruits are rich source of

Table 1. Bio-efficacy of spirotetramat 150 OD and otherconventional insecticides against whitefly, *Dialeurodes citri* (Ashmead) 2016 (first spray). *Figures in parentheses are square root values; **Figures in parentheses are arc sin values; BS - Before Spray; DAS – Days After Spray.

Sl. No.	Treatments	Dose (ml/10 liter water)	White fly/20 leaves BS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	Mean percent reduction
1.	Control	-	48.56 (7.00)*	49.56 (7.07)*	52.83 (7.30)*	53.67 (7.36)*	54.17 (7.39)*	52.56 (7.28)*	0.00
2.	Spirotetramat 150 OD	4.00	49.72 (7.09)	15.83 (4.02)	9.33 (3.12)	14.83 (3.91)	37.00 (6.12)	19.25 (4.29)	63.53 (53.25)**
3.	Spirotetramat 150 OD	5.00	47.78 (6.93)	12.33 (3.37)	5.83 (2.52)	11.50 (3.46)	34.17 (5.88)	15.96 (3.86)	69.91 (57.65)
4.	Spirotetramat 150 OD	6.00	49.33 (7.05)	10.17 (3.26)	3.67 (2.02)	9.17 (3.11)	31.50 (5.65)	13.63 (3.51)	74.32 (60.96)
5.	Dicofol 18.5% SC	27.00	48.67 (7.01)	16.33 (4.10)	19.50 (4.47)	25.67 (5.11)	46.17 (6.83)	26.92 (5.13)	49.31 (44.10)
6.	Quinalphos 25% EC	28.00	49.06 (7.04)	12.83 (3.65)	16.33 (4.09)	22.50 (4.79)	44.83 (6.73)	24.13 (4.82)	54.64 (47.45)
7.	Imidacloprid 200 SL (Imidacloprid 17.8% w/w SL)	5.00	46.44 (6.84)	10.50 (3.31)	14.00 (3.80)	18.33 (4.34)	41.00 (6.44)	20.96 (4.47)	60.56 (51.25)
CV %			10.07	10.73	10.63	9.57	8.44	9.84	6.04
SEm (±)			3.99	1.60	1.51	1.74	2.84	1.92	3.09
CD at 5%			12.29	4.92	4.64	5.36	8.76	5.92	9.26

vitamin C, Citric acid, minerals, carbohydrates and fibers along with some essential nutrients like calcium, copper, folate, potassium, magnesium, niacin and vitamin B6, required for the proper functioning of the body. This is being cultivated throughout North India and even in other *Citrus* growing states. Area under

Table 2. Bio-efficacy of spirotetramat 150 OD and other conventional insecticides against whitefly, *Dialeurodes citri* (Ashmead) 2016 (second spray). *Figures in parentheses are square root values; **Figures in parentheses are arc sin values; BS - Before Spray; DAS – Days After Spray.

Sl. No.	Treatments	Dose (ml/10 liter water)	White fly/20 leaves BS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	Mean percent reduction
1.	Control	-	29.17 (5.44)*	31.83 (5.69)*	33.33 (5.82)*	35.33 (5.99)*	37.83 (6.19)*	34.58 (5.92)*	0.00
2.	Spirotetramat 150 OD	4.00	29.67 (5.49)	11.00 (3.39)	6.50 (2.64)	10.83 (3.36)	26.83 (5.22)	13.79 (3.66)	61.03 (51.59)**
3.	Spirotetramat 150 OD	5.00	31.83 (5.68)	8.33 (2.97)	4.17 (2.15)	8.00 (2.91)	24.33 (4.98)	11.21 (3.25)	68.56 (56.71)
4.	Spirotetramat 150 OD	6.00	28.33 (5.37)	6.96 (2.73)	2.67 (1.76)	6.67 (2.67)	22.67 (4.81)	9.74 (2.99)	72.82 (59.81)
5.	Dicofol 18.5% SC	27.00	30.67 (5.58)	11.17 (3.40)	12.83 (3.65)	17.17 (4.20)	33.17 (5.80)	18.58 (4.26)	47.56 (42.90)
6.	Quinalphos 25% EC	28.00	27.83 (5.32)	9.17 (3.11)	11.00 (3.38)	15.33 (3.97)	31.67 (5.67)	16.79 (4.03)	52.74 (46.24)
7.	Imidacloprid 200 SL (Imidacloprid 17.8% w/w SL)	5.00	30.33 (5.54)	7.83 (2.88)	9.50 (3.16)	13.00 (3.67)	29.67 (5.49)	15.00 (3.80)	57.97 (49.61)
CV %			10.87	10.30	10.98	9.08	8.26	9.66	6.11
SEm (±)			2.63	1.04	1.02	1.13	1.99	1.30	3.05
CD at 5%			8.12	3.19	3.16	3.47	6.12	3.99	9.39

Table 3. Bio-efficacy of spirotetramat 150 OD and other conventional insecticides against whitefly, *Dialeurodes Citri* (Ashmead), 2017(first spray). *Figures in parentheses are square root values; **Figures in parentheses are arc sin values; BS - Before Spray; DAS – Days After Spray.

Sl. No.	Treatments	Dose (ml/10 liter water)	White fly/20 leaves BS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	Mean percent reduction
1.	Control	-	45.17 (6.76)*	46.83 (6.88)*	48.67 (7.01)*	52.83 (7.30)*	55.17 (7.46)*	50.88 (7.16)*	0.00
2.	Spirotetramat 150 OD	4.00	46.83 (6.88)	15.83 (4.04)	10.33 (3.29)	14.17 (3.83)	38.83 (6.26)	19.79 (4.35)	61.91 (52.13)**
3.	Spirotetramat 150 OD	5.00	45.83 (6.80)	12.33 (3.58)	6.17 (2.58)	10.67 (3.33)	35.33 (5.98)	16.13 (3.87)	69.18 (57.10)
4.	Spirotetramat 150 OD	6.00	47.17 (6.90)	10.67 (3.34)	3.67 (2.04)	8.33 (2.97)	33.17 (5.80)	13.96 (3.54)	73.47 (60.33)
5.	Dicofol 18.5% SC	27.00	44.33 (6.69)	16.33 (4.10)	17.33 (4.22)	24.83 (5.03)	47.83 (6.95)	26.58 (5.07)	48.93 (43.70)
6.	Quinalphos 25% EC	28.00	48.17 (6.97)	13.17 (3.69)	14.17 (3.81)	21.83 (4.72)	46.17 (6.82)	23.83 (4.76)	54.48 (47.22)
7.	Imidacloprid 200 SL (Imidacloprid 17.8% w/w SL)	5.00	45.83 (6.80)	11.67 (3.48)	12.67 (3.62)	17.33 (4.21)	42.33 (6.54)	21.00 (4.46)	59.83 (50.82)
CV %			9.13	9.99	11.03	9.80	8.58	9.85	6.04
SEm (±)			3.44	1.48	1.45	1.72	2.90	1.89	3.07
CD at 5%			10.61	4.55	4.48	5.28	9.21	5.88	9.46

kinnow cultivation is increasing in the adjoining states of Punjab, Haryana and Himachal Pradesh and up to some extent in Karnataka. The area and production under mandrin cultivation in India is 428.31 thousand hectares and 5101.21 thousand metric tonnes. The area and production under mandrin cultivation in Rajasthan is 23.19 thousand hectares and 317.68 thousand metric tonnes (Anonymous 2018).

Table 4. Bio-efficacy of spirotetramat 150 OD and other conventional insecticides against whitefly, *Dialeurodes citri* (Ashmead) 2017 (second spray). *Figures in parentheses are square root values; **Figures in parentheses are arc sin values; BS - Before Spray; DAS – Days After Spray.

Sl. No.	Treatments	Dose (ml/10 liter water)	White fly/20 leaves BS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	Mean percent reduction
1.	Control	-	38.83 (6.27)*	41.17 (6.45)*	44.67 (6.72)*	46.83 (6.88)*	48.67 (7.01)*	45.33 (6.77)*	0.00
2.	Spirotetramat 150 OD	4.00	41.33 (6.47)	12.83 (3.65)	9.17 (3.11)	13.17 (3.69)	34.17 (5.88)	17.33 (4.08)	62.48 (52.49)**
3.	Spirotetramat 150 OD	5.00	39.33 (6.31)	9.50 (3.16)	6.00 (2.54)	10.33 (3.29)	30.83 (5.57)	14.17 (3.64)	69.53 (57.20)
4.	Spirotetramat 150 OD	6.00	40.33 (6.38)	8.17 (2.93)	4.17 (2.15)	8.17 (2.94)	29.17 (5.44)	12.42 (3.37)	73.36 (60.11)
5.	Dicofol 18.5% SC	27.00	39.17 (6.29)	13.33 (3.70)	16.67 (4.13)	22.67 (4.81)	42.00 (6.52)	23.67 (4.79)	48.90 (43.85)
6.	Quinalphos 25% EC	28.00	41.67 (6.49)	10.83 (3.36)	14.00 (3.18)	19.83 (4.51)	40.17 (6.38)	21.21 (4.51)	54.35 (47.28)
7.	Imidacloprid 200 SL (Imidacloprid 17.8% w/w SL)	5.00	40.83 (6.42)	9.33 (3.13)	12.50 (3.60)	16.00 (4.05)	37.67 (6.18)	18.88 (4.24)	59.46 (50.58)
CV %			10.58	9.82	11.23	9.11	9.80	9.99	5.93
SEm (±)			3.48	1.20	1.40	1.46	3.00	1.77	3.02
CD at 5%			10.71	3.71	4.33	4.49	9.25	5.45	9.29

Table 5. Bio-efficacy of spirotetramat 150 OD and otherconventional insecticides against psylla, *Diaphorina citri* Kuwayama, 2016 (first spray). *Figures in parentheses are square root values; **Figures in parentheses are arc sin values; BS - Before Spray; DAS – Days After Spray.

Sl. No.	Treatments	Dose (ml/10 liter water)	Psylla/15 cm twigs BS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	Mean percent reduction
1.	Control	-	70.67 (8.44)*	73.67 (8.61)*	76.83 (8.79)*	78.33 (8.88)*	80.17 (8.98)*	77.25 (8.82)*	0.00
2.	Spirotetramat 150 OD	4.00	75.83 (8.73)	24.33 (4.98)	10.33 (3.29)	20.67 (4.60)	42.33 (6.54)	24.42 (4.85)	68.59 (56.46)**
3.	Spirotetramat 150 OD	5.00	73.17 (8.58)	19.17 (4.43)	4.67 (2.26)	13.67 (3.76)	35.67 (6.00)	18.29 (4.11)	76.48 (62.15)
4.	Spirotetramat 150 OD	6.00	74.33 (8.64)	16.67 (4.12)	1.83 (1.53)	10.33 (3.29)	33.33 (5.81)	15.54 (3.69)	80.04 (65.33)
5.	Dicofol 18.5% SC	27.00	77.67 (8.83)	21.67 (4.70)	28.17 (5.34)	59.33 (7.72)	71.17 (8.46)	45.08 (6.55)	42.35 (39.09)
6.	Quinalphos 25% EC	28.00	71.67 (8.49)	19.83 (4.49)	24.33 (4.98)	49.67 (7.08)	65.67 (8.13)	39.88 (6.17)	49.02 (44.18)
7.	Imidacloprid 200 SL (Imidacloprid 17.8% w/w SL)	5.00	69.67 (8.37)	13.67 (3.76)	18.33 (4.32)	30.17 (5.54)	56.33 (7.53)	29.63 (5.29)	62.20 (52.47)
	CV %		9.68	10.86	12.83	9.74	9.72	10.79	7.00
	SEm (±)		5.79	2.39	2.46	2.98	4.36	3.05	3.43
	CD at 5%		17.84	7.38	7.59	9.18	13.44	9.40	10.58

The Main limiting factor of kinnow production is various insect pests in the field that includes *Citrus psylla*, whitefly, leaf miner, thrips, mealy bug, lemon butterfly, mites among them, *Citrus psylla*, whitefly, leaf miner, thrips and mite is the most important pest of kinnow. These insect pests feed and affect kinnow leaves and fruit by damaging it. *Citrus* cultivation is facing several difficulties and among

Table 6. Bio-efficacy of spirotetramat 150 OD and other conventional insecticides against psylla, *Diaphorina citri* Kuwayama, 2016 (second spray). *Figures in parentheses are square root values; **Figures in parentheses are arc sin values; BS - Before Spray; DAS – Days After Spray.

Sl. No.	Treatments	Dose (ml/10 liter water)	Psylla/15 cm twigs BS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	Mean percent reduction
1.	Control	-	60.17 (7.79)*	62.33 (7.93)*	64.67 (8.07)*	66.83 (8.21)*	69.33 (8.36)*	65.79 (8.14)*	0.00
2.	Spirotetramat 150 OD	4.00	63.67 (8.00)	21.83 (4.72)	10.17 (3.27)	19.00 (4.39)	39.00 (6.28)	22.50 (4.67)	66.15 (54.90)**
3.	Spirotetramat 150 OD	5.00	59.33 (7.73)	17.67 (4.26)	5.33 (2.41)	14.83 (3.91)	35.33 (5.95)	18.29 (4.13)	72.58 (59.36)
4.	Spirotetramat 150 OD	6.00	65.17 (8.08)	14.67 (3.89)	2.67 (1.77)	12.17 (3.55)	32.33 (5.71)	15.46 (3.73)	76.87 (62.74)
5.	Dicofol 18.5% SC	27.00	62.83 (7.95)	18.83 (4.38)	22.83 (4.80)	46.83 (6.88)	61.10 (7.85)	37.40 (5.98)	44.03 (40.87)
6.	Quinalphos 25% EC	28.00	65.33 (8.10)	16.17 (4.07)	19.67 (4.49)	39.67 (6.34)	55.83 (7.51)	32.83 (5.60)	50.94 (45.43)
7.	Imidacloprid 200 SL (Imidacloprid 17.8% w/w SL)	5.00	61.83 (7.89)	12.83 (3.65)	14.67 (3.88)	25.17 (5.06)	49.67 (7.08)	25.58 (4.92)	61.84 (52.22)
CV %			10.25	10.80	13.51	8.94	9.24	10.62	6.94
SEm (±)			5.24	2.07	2.21	2.34	3.69	2.58	3.41
CD at 5%			16.14	6.38	6.80	7.21	11.38	7.94	10.49

Table 7. Bio-efficacy of spirotetramat 150 ODand otherconventional insecticidesagainst psylla, DiaphorinacitriKuwayama, 2017(first spray). *Figures in parentheses are square root values; **Figures in parentheses are arc sin values; BS - Before Spray; DAS – Days After Spray.

Sl. No.	Treatments	Dose (ml/10 liter water)	Psylla/15 cm twigs BS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	Mean percent reduction
1.	Control	-	88.33 (9.42)*	90.67 (9.55)*	92.33 (9.63)*	94.33 (9.74)*	97.17 (9.88)*	93.63 (9.70)*	0.00
2.	Spirotetramat 150 OD	4.00	90.67 (9.54)	31.67 (5.67)	12.83 (3.64)	24.67 (5.02)	53.33 (7.31)	30.63 (5.41)	67.53 (55.82)**
3.	Spirotetramat 150 OD	5.00	87.17 (9.35)	23.33 (4.88)	6.17 (2.54)	17.83 (4.27)	46.67 (6.86)	23.50 (4.64)	75.16 (61.29)
4.	Spirotetramat 150 OD	6.00	92.83 (9.64)	19.67 (4.49)	3.33 (1.95)	12.83 (3.63)	43.17 (6.60)	19.75 (4.17)	79.16 (64.47)
5.	Dicofol 18.5% SC	27.00	91.33 (9.58)	27.33 (5.25)	32.33 (5.72)	68.67 (8.31)	86.00 (9.30)	53.58 (7.14)	43.38 (40.39)
6.	Quinalphos 25% EC	28.00	94.67 (9.75)	22.17 (4.75)	26.67 (5.21)	55.83 (7.50)	78.17 (8.86)	45.71 (6.580)	51.75 (45.88)
7.	Imidacloprid 200 SL (Imidacloprid 17.8% w/w SL)	5.00	89.33 (9.47)	17.33 (4.20)	21.50 (4.66)	34.17 (5.88)	71.50 (8.47)	36.13 (5.80)	61.93 (52.24)
CV %			10.04	10.52	12.24	9.06	9.00	10.21	6.41
SEm (±)			7.43	2.85	2.79	3.26	5.00	3.48	3.19
CD at 5%			22.89	8.78	8.58	10.04	15.40	10.70	9.83

them, pest attack is one of the most important problems which hinder the diversification of citriculture in the world. About 823 species of insects and mites were known to feed on *Citrus* throughout the world (Ebeling 1959) and out of which, more than 250 species were found to attack various *Citrus* species in

Table 8. Bio-efficacy of spirotetramat 150 OD and other conventional insecticides against psylla, *Diaphorina citri* Kuwayama, 2017(second spray). *Figures in parentheses are square root values; **Figures in parentheses are arc sin values; BS - Before Spray; DAS – Days After Spray.

Sl. No.	Treatments	Dose (ml/10 liter water)	Psylla/15 cm twigs BS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	Mean percent reduction
1.	Control	-	57.17 (7.59)*	59.67 (7.76)*	62.33 (7.93)*	65.67 (8.13)*	67.33 (8.24)*	63.75 (8.01)*	0.00
2.	Spirotetramat 150 OD	4.00	55.33 (7.47)	21.83 (4.72)	9.83 (3.21)	18.17 (4.32)	39.67 (6.33)	22.38 (4.65)	65.25 (54.35)**
3.	Spirotetramat 150 OD	5.00	58.67 (7.69)	16.67 (4.14)	4.67 (2.27)	13.17 (3.69)	35.83 (6.02)	17.58 (4.03)	72.85 (59.69)
4.	Spirotetramat 150 OD	6.00	54.83 (7.43)	13.83 (3.79)	2.17 (1.63)	10.33 (3.29)	33.17 (5.77)	14.88 (3.62)	77.08 (63.11)
5.	Dicofol 18.5% SC	27.00	59.83 (7.75)	18.33 (4.34)	21.67 (4.71)	47.33 (6.91)	60.33 (7.80)	36.92 (5.94)	43.21 (40.05)
6.	Quinalphos 25% EC	28.00	53.17 (7.32)	15.50 (4.00)	18.83 (4.39)	40.17 (6.37)	56.00 (7.51)	32.63 (5.57)	49.86 (44.65)
7.	Imidacloprid 200 SL (Imidacloprid 17.8% w/w SL)	5.00	61.33 (7.86)	12.83 (3.60)	16.33 (4.07)	23.33 (4.88)	50.33 (7.11)	25.71 (4.92)	60.52 (51.27)
CV %			9.43	10.73	12.58	9.44	9.39	10.54	6.68
SEm (±)			4.41	1.99	2.04	2.40	3.75	2.55	3.29
CD at 5%			13.57	6.12	6.27	7.40	11.56	7.84	10.14

Table 9. Bio-efficacy of spirotetramat 150 OD and other conventional insecticides against mite, *Oligonychus citri* McGregor, 2016 (first spray). *Figures in parentheses are square root values; **Figures in parentheses are arc sin values; B.S. - Before Spray; DAS – Days After Spray.

Sl. No.	Treatments	Dose (ml/10 liter water)	Mite/15 cm twigs BS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	Mean percent reduction
1.	Control	-	86.33 (9.32)*	90.33 (9.53)*	92.67 (9.65)*	94.33 (9.74)*	95.83 (9.81)*	93.29 (9.68)*	0.00
2.	Spirotetramat 150 OD	4.00	89.17 (9.47)	35.67 (6.01)	20.33 (4.56)	29.67 (5.49)	49.33 (7.05)	33.75 (5.78)	63.92 (53.29)**
3.	Spirotetramat 150 OD	5.00	92.83 (9.66)	28.33 (5.39)	13.17 (3.70)	22.00 (4.74)	43.00 (6.59)	26.75 (5.10)	71.43 (58.14)
4.	Spirotetramat 150 OD	6.00	87.50 (9.34)	24.17 (4.97)	9.83 (3.21)	17.67 (4.26)	38.50 (6.24)	22.54 (4.67)	75.94 (61.20)
5.	Dicofol 18.5% SC	27.00	85.67 (9.27)	17.33 (4.22)	25.33 (5.08)	51.00 (7.16)	71.33 (8.47)	41.25 (6.23)	56.25 (48.86)
6.	Quinalphos 25% EC	28.00	91.33 (9.58)	22.17 (4.76)	28.83 (5.37)	57.67 (7.62)	75.00 (8.69)	45.92 (6.61)	51.24 (45.70)
7.	Imidacloprid 200 SL (Imidacloprid 17.8% w/w SL)	5.00	88.67 (9.44)	23.33 (4.84)	28.00 (5.33)	47.67 (6.94)	67.33 (8.22)	41.58 (6.33)	55.79 (48.42)
	CV %		10.70	10.37	11.71	9.11	8.96	10.04	7.01
	SEm (±)		7.76	2.92	2.98	3.40	4.60	3.48	3.37
	CD at 5%		23.90	9.01	9.18	10.48	14.17	10.71	10.38

India (Srivastava and Butani 1999) , whereas only 34 species were reported in Punjab (Sharma *et al.* 2011, Sharma 2010). Among the various pest species of *Citrus*, thrips and mites are causing significant damage on leaves, flowers and fruits, thus reducing the quality of fruits. Red and black flat mite, *Brevipalpus*

Table 10. Bio-efficacy of spirotetramat 150 OD and other conventional insecticides against mite, *Oligonychus citri* McGregor, 2016 (second spray). *Figures in parentheses are square root values; **Figures in parentheses are arc sin values; BS - Before Spray; DAS – Days After Spray.

Sl. No.	Treatments	Dose (ml/10 liter water)	Mite/15 cm twigs BS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	Mean percent reduction
1.	Control	-	71.17 (8.46)*	73.67 (8.61)*	75.50 (8.72)*	76.83 (8.79)*	77.67 (8.84)*	75.92 (8.74)*	0.00
2.	Spirotetramat 150 OD	4.00	69.67 (8.37)	26.67 (5.21)	13.67 (3.76)	22.33 (4.78)	41.67 (6.47)	26.08 (5.05)	65.73 (54.50)**
3.	Spirotetramat 150 OD	5.00	74.17 (8.64)	20.33 (4.56)	6.83 (2.70)	15.17 (3.96)	36.33 (6.06)	19.67 (4.32)	74.19 (60.31)
4.	Spirotetramat 150 OD	6.00	75.50 (8.72)	16.50 (4.12)	3.33 (1.95)	11.33 (3.44)	32.17 (5.70)	15.83 (3.80)	79.28 (64.25)
5.	Dicofol 18.5% SC	27.00	70.33 (8.41)	13.33 (3.71)	19.33 (4.40)	41.00 (6.41)	61.33 (7.86)	33.75 (5.60)	56.05 (48.76)
6.	Quinalphos 25% EC	28.00	67.83 (8.22)	15.33 (3.98)	22.67 (4.81)	45.33 (6.76)	65.33 (8.11)	37.17 (5.92)	51.50 (45.70)
7.	Imidacloprid 200 SL (Imidacloprid 17.8% w/w SL)	5.00	75.67 (8.73)	15.67 (3.99)	20.50 (4.58)	36.67 (6.10)	57.67 (7.62)	32.63 (5.57)	57.34 (49.45)
	CV %		10.95	12.15	12.25	10.16	8.96	10.88	6.37
	SEm (±)		6.44	2.57	2.31	2.95	3.89	2.93	3.17
	CD at 5%		19.84	7.93	7.12	9.08	11.98	9.03	9.77

Table 11. Bio-efficacy of spirotetramat 150 OD and other conventional insecticides against mite, *Oligonychus citri* McGregor, 2017 (first spray). *Figures in parentheses are square root values; **Figures in parentheses are arc sin values; BS - Before Spray; DAS – Days After Spray.

Sl. No.	Treatments	Dose (ml/10 liter water)	Mite/15 cm twigs BS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	Mean percent reduction
1.	Control	-	93.67 (9.70)*	95.33 (9.79)*	96.83 (9.87)*	97.67 (9.91)*	99.17 (9.98)*	97.25 (9.89)*	0.00
2.	Spirotetramat 150 OD	4.00	97.33 (9.89)	32.67 (5.76)	16.83 (4.16)	26.00 (5.15)	53.83 (7.37)	32.33 (5.61)	66.86 (55.23)**
3.	Spirotetramat 150 OD	5.00	89.17 (9.47)	24.33 (4.92)	7.83 (2.88)	16.33 (4.10)	46.33 (6.84)	23.71 (4.68)	75.73 (61.53)
4.	Spirotetramat 150 OD	6.00	94.50 (9.74)	19.17 (4.43)	2.67 (1.77)	10.33 (3.29)	42.17 (6.50)	18.58 (4.00)	81.01 (66.05)
5.	Dicofol 18.5% SC	27.00	90.33 (9.53)	15.00 (3.94)	25.50 (5.10)	50.67 (7.14)	78.50 (8.87)	42.42 (6.26)	56.73 (49.05)
6.	Quinalphos 25% EC	28.00	88.83 (9.45)	18.33 (4.32)	30.33 (5.55)	53.83 (7.36)	82.67 (9.12)	46.29 (6.59)	52.74 (46.49)
7.	Imidacloprid 200 SL (Imidacloprid 17.8% w/w SL)	5.00	95.67 (9.77)	16.67 (4.09)	27.67 (5.26)	45.67 (6.79)	73.33 (8.59)	40.83 (6.18)	58.30 (50.22)
CV %			10.32	11.51	13.16	10.13	10.41	11.30	6.49
SEm (±)			7.82	2.97	3.19	3.55	5.78	3.87	3.35
CD at 5%			24.10	9.17	9.82	10.94	17.82	11.94	10.32

phoenicis (Geijskes) has been reported from all the *Citrus* growing areas in India (Gupta 1985, Kumari and Sadana 1990). This mite feeds both on leaves and fruits but is more severe on younger fruits. *B. phoenicis* was found to be associated with rind-disorder of different *Citrus* fruits from November to February in Punjab (Dhooria *et al*. 1997). Commercially there are of several insecticides and their formulations available in market but only few have a proven efficiency against kinnow pest complex. Considering these a field evaluation of spirotetramat 150 OD (Movento 150 OD) along with conventional insecticide was carried out to control insect pests in kinnow. Spirotetramat 150 OD belonging to the Ketoenol family. Spirotetramat is a novel insecticide, belonging to the chemical class of ketoenols and is a tetramic acid derivative effective against a wide spectrum of sucking insects including aphids (Combs and Reissig 2008), thrips (Alston *et al.* 2008), psyllids (Fischer 2008), mealybugs (Varela *et al.* 2008). It is said to interfere with lipid biosynthesis, leading to death of juveniles within two to ten days after application (Palumbo 2007).It is systemic in action, xylem and phloem mobile, allowing acropetal and basipetal translocation in the plant. However, barring a few studies of this compound against sucking pests very limited work has been done on this chemical. Hence the present study is aimed at suppressing the sucking pest complex in kinnow with this new compound (spirotetramat).

MATERIALS AND METHODS

The field trials were conducted at Agricultural Research Station, Sriganganagar (Swami Keshwanand Rajasthan Agriculture University, Bikaner) during 2016 and 2017. The experiment was laid out in a Randomized Block Design with 7 treatments and three replications including untreated check. Trial layout carried out in kinnow orchard with 2 trees per treatment/ replication. All the horticultural practices were followed as per the recommended package of practices except plant protection measures against sucking pest. Six bio-rationales and other insecticides of different chemistry viz., spirotetramat 150 OD @ 0.4 ml/l, spirotetramat 150 OD @ 0.5 ml/l, spirotetramat 150 OD @ 0.6 ml/l, Dicofol 18.5% SC @ 2.7ml/l, quinalphos 25% EC @ 2.8 ml/l, imidacloprid 200 SL (imidacloprid 17.8% w/w SL @ 0.5 ml/l) were evaluated for the management of sucking pest in the

Table 12. Bio-efficacy of spirotetramat 150 OD and other conventional insecticides against mite, *Oligonichus citri* McGregor, 2017 (second spray). *Figures in parentheses are square root values; **Figures in parentheses are arc sin values; BS - Before Spray; DAS – Days After Spray.

Sl. No.	Treatments	Dose (ml/10 liter water)	Mite/15 cm twigs BS	3 DAS	7 DAS	10 DAS	14 DAS	Mean	Mean percent reduction
1.	Control	-	67.67 (8.26)*	68.50 (8.31)*	71.67 (8.50)*	72.83 (8.56)*	75.33 (8.71)*	72.08 (8.52)*	0.00
2.	Spirotetramat 150 OD	4.00	69.33 (8.35)	25.33 (5.05)	12.83 (3.65)	20.33 (4.56)	42.33 (6.54)	25.21 (4.95)	65.25 (54.28)**
3.	Spirotetramat 150 OD	5.00	64.50 (8.06)	18.83 (4.39)	6.17 (2.58)	14.17 (3.83)	36.17 (6.06)	18.83 (4.21)	74.10 (60.30)
4.	Spirotetramat 150 OD	6.00	70.50 (8.43)	14.97 (3.93)	2.33 (1.68)	10.33 (3.29)	32.67 (5.76)	15.08 (3.66)	79.33 (64.60)
5.	Dicofol 18.5% SC	27.00	66.17 (8.12)	12.17 (3.56)	18.67 (4.35)	38.17 (6.21)	57.83 (7.64)	31.71 (5.44)	56.74 (49.22)
6.	Quinalphos 25% EC	28.00	72.33 (8.53)	14.50 (3.87)	21.83 (4.72)	42.67 (6.56)	61.67 (7.88)	35.17 (5.76)	51.98 (46.02)
7.	Imidacloprid 200 SL (Imidacloprid 17.8% w/w SL)	5.00	68.67 (8.32)	17.00 (4.18)	20.50 (4.56)	33.67 (5.84)	52.83 (7.27)	31.00 (5.46)	57.55 (49.41)
CV %			10.10	12.61	13.28	10.62	10.15	11.67	7.22
SEm (±)			5.65	2.52	2.39	2.88	4.25	4.01	3.63
CD at 5%			17.40	7.76	7.35	8.87	13.08	9.27	11.19

field. The first application was made when insect pest population are present in sufficient numbers (i.e., ETL) using a water volume of 10 liters per treatment. Second application was imposed on a need basis at an interval. The population of whitefly, psylla and mite was recorded at one day before spraying and 3, 7, 10 and 14 days after each spray. The observations on population of whitefly nymph and adult per 20 leaves were made from a tree. Observation was also taken on psylla population per 10 terminal twigs about 15 cm in length/ tree and work out of mite population, 10 flowers/terminal twigs about 15 cm length with leaves were taken from each treatment. The samples immediately put in poly bag, properly labelled and brought in laboratory for further examination. The fruit yield was recorded after harvesting the crop at maturity and expressed in q/ha.

The per cent reduction in the population of whitefly, psylla and mites were worked out and then transformed to arcsine values and the data were pooled and subjected to ANOVA variance for 2016 and 2017 separately. The percentage reduction in population was calculated using formula given by (Henderson and Tilton 1955) which is modification of Abbott (1925) formula.

Per cent reduction in population

$$=\{1-(T_a \times C_b / T_b \times C_a)\ 100\}$$

Where,

T_a = Number of insect after treatment in treated plot

T_b = Number of insect before treatment in treated plot

C_a = Number of insect in untreated check after treatment

C_b = Number of insect in untreated check before treatment

RESULTS AND DISCUSSION

Citrus whitefly, *Dialeurodes citri* (Ashmead)

Six bio-rationales and other insecticides of different chemistry were evaluated against the whitefly on kinnow under irrigated north western plain zone. The observations were taken one day before first spray on

Table 13. Impact of spirotetramat 150 OD and other conventional insecticides on fruit yield of kinnow.

Sl. No.	Treatments	Dose (ml/10 liter water)	Yield (q/ha) 2016	2017
1.	Control	-	266.53	247.87
2.	Spirotetramat 150 OD	4.00	355.67	370.17
3.	Spirotetramat 150 OD	5.00	395.67	417.07
4.	Spirotetramat 150 OD	6.00	417.60	439.27
5.	Dicofol 18.5% SC	27.00	309.57	322.90
6.	Quinalphos 25% EC	28.00	312.63	332.63
7.	Imidacloprid 200 SL (Imidacloprid 17.8% w/w SL)	5.00	335.20	351.87
	CV %		5.98	6.85
	SEm (±)		16.70	19.83
	CD at 5%		50.65	60.13

white fly population in all the treatments including untreated check revealed non-significant among them in both the years. Analysis of variance shows that treatment application had significant effect on the mortality of whitefly over the untreated control in all application during both the years. However, the significant difference existed among them. The data on percentage mortality obtained after each sprays are summarized in Tables 1-4. The trend of relative efficacy of various treatments has been described below.

The study revealed that all treatments significantly recorded less whitefly population (10.17-16.33, 3.67-19.50, 9.17-25.67 and 31.50 – 54.17 and 6.96-11.17, 2.67-12.83, 6.67-17.17 and 22.67-33.17) over untreated control (49.56, 52.83, 53.67 and 54.17 and 31.83, 33.33, 35.33 and 37.83) on 3rd, 7th, 10th and 14th days after 1st and 2nd spray. Minimum whitefly population (10.17, 3.67, 9.17 and 31.50 and 6.96, 2.67, 6.67 and 22.67white fly/20 leaves) was recorded in spirotetramat 150 OD @ 6.0 ml/ 10 liter of water followed by spiro tetramat 150 OD @ 5.0 ml/10 liter of water (12.33, 5.83, 11.50 and 34.17 and 8.33, 4.17, 8.00 and 24.33 whitefly/20 leaves), spirotetramat 150 OD 4.0 ml/10 liter of water (15.83, 9.33, 14.83 and 37.00 and 11.00, 6.50, 10.83 and 26.83 whitefly/20 leaves) and imidacloprid 200 SL (imidacloprid 17.8% w/w SL) @ 5.0 ml/10 liter of water (10.50, 14.00, 18.33 and 41.00 and 7.83, 9.50, 13.00 and 29.67 whitefly/20 leaves) over the control (49.56, 52.83, 53.67 and 54.17 and 31.83, 33.33, 35.33 and 37.83) whitefly/20 leaves on 3rd, 7th, 10th and 14th days after 1st and 2nd spray, respectively. Therefore, spirotetramat 150 OD@ 6.0 ml/10 liter of water was noticed maximum mean percent reduction of whitefly (74.32 and 72.82 %) followed by spirotetramat 150 OD@ 5.0 ml/10 liter of water (69.91 and 68.56 %) and spirotetramat 150 OD@ 4.0 ml/10 liter of water (63.53 and 61.03 %), it was at par with spirotetramat 150 OD @ 6.0 ml/10 liter of water. The rest of treatments viz., imidacloprid 200 SL (imidacloprid 17.8% w/w SL) @ 5.0 ml, quinalphos 25 % EC @ 28.0 ml and dicofol 18.5% SC @ 27.0 ml/10 liter of water also checked the whitefly population, it was 60.56 and 57.97, 54.64 and 52.74, 49.31 and 47.56 % respectively, during 2016.

Similar result was observed during 2017, spirotetramat 150 OD @ 6.0 ml/10 liter of water was recorded significantly less whitefly population (10.67, 3.67, 8.33 and 33.17 and 8.17, 4.17, 8.17 and 29.17 whitefly/20 leaves) followed by spirotetramat 150 OD @ 5.0 ml/10 liter of water (12.33, 6.17, 10.67 and 35.33 and 9.50, 6.00, 10.33 and 30.83 whitefly/20 leaves) and spirotetramat 150 OD @ 4.0 ml/10 liter of water (15.83, 10.33, 14.17 and 38.83 and 12.83, 9.17, 13.17 and 34.17 whitefly/20 leaves) over the control (46.83, 48.67, 52.83 and 55.17 and 41.17, 44.67, 46.83 and 48.67 whitefly/20 leaves) on 3rd, 7th, 10th and 14th days after 1st and 2nd spray, respectively. Therefore, spirotetramat 150 OD @ 6.0 ml/ 10 liter of water was gave maximum mean percent reduction of whitefly (73.47 and 73.36%) followed by spirotetramat 150 OD @ 5.0 ml/10 liter of water (69. 18 and 69.53%) and spirotetramat 150 OD @ 4.0 ml/10 liter of water (61.91 and 62.48%) respectively, it was at par with spirotetramat 150 OD @ 6.0 ml/10 liter of water. The rest of treatments viz.,

imidacloprid 200 SL (imidacloprid 17.8% w/w SL) @ 5.0 ml, quinalphos 25 % EC @ 28.0 ml and dicofol 18.5 % SC @ 27.0 ml/10 liter of water alsoreduced the whitefly population, it was 59.83 and 59.46, 54.48 and 54.35, 48.93 and 48.90%, respectively (Tables 3 and 4). Similar trend was found in second application. Findings by Kumar *et al*. (2009), Meena *et al.* (2019) confirm these findings who reported spirotetramat 150 OD was most effective against cotton whitefly. The present findings are in agreement to that of Kumar *et al.* (2008) who reported spirotetramat 150 OD proved most effective followed by imidacloprid 17.8 SL in reducing sucking pest (Mealy bug) in cotton.The present findings are in agreement to that of Seni and Sahoo (2015) who reported spirotetramat 150 OD proved effective reduced of papaya mealy bug. The findings are also in line with the work of Gajalakshmi *et al.* (2015) who reported after second round of application, spirotetramat 150 OD at 90 and 75 g a.i/ha were found to be more effective and recorded lowest mean whitefly population of 1.20 and 1.40/five leaves with mean reduction of 95.12 and 93.75%, respectively. *Citrus psylla* : *Diaphorinacitri* (Kuwayama) During 2016, spirotetramat 150 OD@ 6.0 ml/10 liter of water was recorded significantly less psylla population (16.67, 1.83, 10.33 and 33.33 and 14.67, 2.67, 12.17 and 32.33 psylla/15 cm twigs) followed by spirotetramat 150 OD @ 5.0 ml/10 liter of water (19.17, 4.67, 13.67 and 35.67 and 17.67, 5.33, 14.83 and 35.33 psylla/15 cm twigs) and spirotetramat 150 OD @ 4.0 ml/10 liter of water (24.33, 10.33, 20.67 and 42.33 and 21.83, 10.17, 19.00 and 39.00 psylla/15 cm twigs),over the control (73.67, 76.83, 78.33 and 80.17 and 62.33, 64.67, 66.83 and 69.33 psylla /15 cm twigs) on 3rd, 7th, 10th and 14th days after 1st and 2nd spray, respectively. Therefore, spirotetramat 150 OD @ 6.0 ml/10 liter of water was noticed maximum mean percent reduction of whitefly (80.04 and 76.84%) followed by spirotetramat 150 OD @ 5.0 ml/10 liter of water (76.84 and 72.58%) and spirotetramat 150 OD @ 4.0 ml/10 liter of water (68.59 and 66.15 %), respectively, it was at par with spirotetramat 150 OD @ 6.0 ml/10 liter of water. The rest of treatments viz., imidacloprid 200 SL (imidacloprid 17.8% w/w SL) @ 5.0 ml, quinalphos 25 % EC @ 28.0 ml and dicofol 18.5% SC @ 27.00 ml/10 liter of water also reduced the whitefly population, it was 62.20 and 61.84, 49.20 and 50.94, 42.35 and 44.03%, respectively (Tables 5 and 6). Similar result was observed during 2017, Tables 7 and 8, revealed that spirotetramat 150 OD @ 6.0 ml/10 liter of water was recorded significantly less psylla population (19.67, 3.33, 12.83 and 43.17 and 13.83, 2.17, 10.33 and 33.17 psylla/15 cm twigs) followed by spirotetramat 150 OD @ 5.0 ml/10 liter of water (23.33, 6.17, 17.83 and 46.67 and 16.67, 4.67, 13.17 and 35.83 psylla/15 cm twigs) over the control (90.67, 92.33, 94.33 and 97.17 and 59.67, 62.33, 65.67 and 67.33 psylla/15 cm twigs) on 3rd, 7th, 10th and 14th days after 1st and 2nd spray. Therefore, spirotetramat 150 OD @ 6.0 ml/10 liter of water was noticed highest mean percent reduction of psylla (79.16 and 77.08%) followed by spirotetramat 150 OD @ 5.0 ml/10 liter of water (75.16 and 72.85%), spirotetramat 150 OD @ 4.0 ml/10 liter of water (67.53 and 65.25%), respectively, it was at par with spirotetramat 150 OD @ 6.0 ml/10 liter of water. The rest of treatments viz., imidacloprid 200 SL (imidacloprid 17.8% w/w SL) @ 5.0 ml, quinalphos 25 % EC @ 28.0 ml and dicofol 18.5% SC @ 27.0 ml/10 liter of water also reduced the psylla population and it was 61.93 and 60.52, 51.75 and 49.86, 43.38 and 45.21%, respectively. Superiority of imidacloprid against *Citrus psylla* of *Citrus* has been well documented by Iqbal *et al*. (2020), Qasim and Hussian (2015).

Mite : *Oligonychus citri* (McGregor)

The data of two sprays in respect of mite infestation in kinnow are presented in Tables 9 and 10, revealed that all treatments significantly recorded less infestation (17.33-35.67,9.83-28.83, 17.67-57.67, 38.50-75.00, 13.33-26.67, 3.33-22.67, 11.33-45.33 and 32.17-65.33 mite/15 cm twigs) over untreated control (90.33, 92.67, 94.33, 95.83 and 73.67, 75.50, 76.83 and 77.67 mite/15 cm twigs) on 3rd, 7th, 10th and 14th days after 1st and 2nd spray. Minimum mite population (24.17, 9.83, 17.67, 38.50, 16.50, 3.33, 11.33 and 32.17 mite/15 cm twigs) was recorded in treatment contains spirotetramat 150 OD @ 6.0 ml/10 liter of water followed by spirotetramat 150 OD @ 5.0 ml/10 liter of water (28.83, 13.17, 22.00, 43.00, 20.33, 6.83,15.17 and 36.33 mite/15 cm twigs) and spirotetramat 150 OD @ 4.0 ml/10 literof water (35.67, 20.33, 29.67, 49.33, 26.67, 13.67, 23.33 and

41.67 mite/15 cm twigs) recorded on 3rd , 7th , 10th and 14th days after 1st and 2nd spray, respectively. Therefore, spirotetramat 150 OD @ 6.0 ml/10 liter of water was noticed maximum mean percent reduction of mite (75.94 and 79.28%) followed by spirotetramat 150 OD @ 5.0 ml/10 liter of water (71.43 and 74.19%) and spirotetram at 150 OD @ 4.0 ml/10 l of water (63.92 and 65.73%), respectively, it was at par with spirotetram at 150 OD @ 6.0 ml/10 liter of water. The rest of treatments viz., imidacloprid 200 SL (imidacloprid 17.8% w/w SL) @ 5.0 ml, dicofol 18.5% SC @ 27.0 ml and quinalphos 25 % EC @ 28.0 ml and ml/10 liter of water also reduced the mite population, it was 56.25 and 56.05, 55.79 and 57.34, 51.24 and 51.50%, respectively.

Similar result was observed during 2017, Tables 11 and 12, revealed that spirotetramat 150 OD @ 6.0 ml/10 liter of water was recorded significantly less mite population (19.17, 2.67, 10.33, 42.17, 14.97, 2.33, 10.33 and 32.67 mite/15 cm twigs) followed by spirotetramat 150 OD @ 5.0 ml/10 liter of water (24.33, 7.83, 16.33, 46.33, 18.83, 6.17, 14.17 and 36.17 mite/15 cm twigs) over the control (95.33, 96.83, 97.67, 99.17, 68.50, 71.67, 72.83 and 75.33 mite/15 cm twigs) on 3rd, 7th, 10th and 14th days after 1st and 2nd spray. Therefore, spirotetramat 150 OD@ 6.0 ml/10 liter of water was noticed highest mean percent reduction of mite (81.01 and 79.33 %) followed by spirotetramat 150 OD @ 5.0 ml/10 liter of water (75.73 and 74.10%) and spirotetramat 150 OD @ 4.0 ml/10 liter of water (66.86 and 65.25%), respectively, it was at par with spirotetram 150 OD @ 6.0 ml/10 liter of water. The rest of treatments viz., imidacloprid 200 SL (imidacloprid 17.8% w/w SL) @ 5.0 ml, Dicofol 18.5 % SC @ 27.0 ml and quinalphos 25 % EC @ 28.0 ml /10 liter of water also reduced the psylla population, it was 58.30, 57.55, 56.73, 56.74, 52.74 and 51.98%, respectively. Least effective of dicofol against two spotted mite on chrysanthemum has been well documented by Reddy *et al.* (2014).

Fruit yield

The data presented in Table 13 revealed that fruit yield was recorded significantly higher in all the insecticidal treated plots over control. Highest fruit yield was recorded in the plots treated with spirotetramat 150 OD @ 6.0 ml/ 10 liter of water (417.60 q/ha) which is at par with spirotetramat 150 OD @ 5.0 ml/10 liter of water (395.67 q/ha). All other treatments were also found superior over the untreated control (266.53 q/ha).

Similarly, during second season spirotetramat 150 OD @ 6.0 ml/10 liter of water has recorded significantly highest yield (439.27 q/ha) followed by spirotetramat 150 OD @ 5.0 ml/10 liter of water (417.07 q/ha). All other treatments were also found superior over the untreated control (247.87 q/ha). Superiority of spirotetramat 150 OD and imidacloprid against sucking pests of cotton has been well documented by Meena *et al*. (2019).

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