Environment and Ecology 40 (2C) : 969—975, April—June 2022
ISSN 0970-0420

Comparative Efficacy of Novel Insecticides against Whitefly, *Bemisia tabaci* (Gennadius) on *Capsicum* under Shade Net House

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Received 21 August 2021, Accepted 4 February 2022, Published on 7 June 2022

ABSTRACT

Field experiments were conducted under shade net house at Hi-Tech Horticulture Farm, Rajasthan Agricultural Research Institute, Durgapura, Jaipur (SKN Agriculture University, Jobner, Jaipur, Rajasthan) to study the bio-efficacy of newer insecticides molecules against Whitefly, *Bemisia tabaci* (Gennadius) on capsicum during summer 2014 and 2015. The results indicated that among different insecticides fipronil 5 SC at 0.005% found as the most effective treatment by recording highest per cent reduction of 73.48 of whitefly followed by imidacloprid at 0.0058% with 72.08% reduction, acephate at 0.075% (69.82%) and emamectin benzoate at 0.002% (67.01%), whereas, azadirachtin 0.15% and NSKE 5% recorded the lowest mortality of whitefly 37.18 and 41.49%, respectively. Study revealed that fipronil 5 SC @ 1ml/l or imidacloprid 17.8 @ 0.33ml/l can be suggested to the farmers for the management of whitefly on *Capsicum* under shade net house conditions.

Keywords *Capsicum,* Comparative efficacy, Novel insecticide, Shade net house, Whitefly.

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INTRODUCTION

Chilli (*Capsicum annuum* L.) representing a diverse vegetable group belongs to Solanaceae family (Bhatt and Karnatak 2020). Among them bell pepper is one of the most popular and highly remunerative vegetable crops. It is grown in most parts of the world, viz., China, Spain, Mexico, Romania, Yugoslavia, Bulgaria, USA, India, Europe, Central and South America. In India, *Capsicum* is extensively cultivated in Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Himachal Pradesh and hilly areas of Uttaranchal. *Capsicum* also known as sweet pepper, bell pepper, green pepper or shimla mirch, is one of the popular vegetables grown throughout India. It is a cool season crop but it can be grown round the year using protected structures. A fresh, crisp green capsicum is a tasty vegetable that can be a regular part of our healthy eating plan. This vegetable is low in calories and contains zero gram of fat and a good supplier of vitamins and minerals. Annual capsicum production in India in the year 2019-2020 amounted

Table 1. Comparative efficacy of bio-rationales and newer insecticides against whitefly, *Bemisia tabaci* (Gennadius) on capsicum during 2014. * Figures in parentheses are arc sin transformed values. DAS : Days after spray.

Sl. No.	Treatments	Conc. (%)	Mean reduction (%) in whitefly population days after: First spray 1 DAS	First spray 3 DAS	First spray 7 DAS	First spray 15 DAS	Second spray 1 DAS	Second spray 3 DAS	Second spray 7 DAS	Second spray 15 DAS
1	Spiromesifen 22.9 SC	0.0229	41.70 (40.22)*	52.31 (46.33)	56.41 (48.69)	42.38 (40.62)	38.74 (38.49)	46.20 (42.82)	59.50 (50.54)	47.36 (43.49)
2	Emamectin benzoate 5 SG	0.002	55.23 (48.01)	77.32 (61.65)	79.26 (63.01)	53.67 (47.11)	55.74 (48.35)	77.95 (62.6)	79.42 (63.25)	65.04 (53.9)
3	Acephate 75 SP	0.075	60.03 (50.81)	76.95 (61.59)	77.76 (61.92)	58.16 (49.71)	60.82 (51.3)	77.24 (61.51)	80.88 (64.13)	67.12 (55.07)
4	Indoxacarb 14.5 SC	0.0116	40.28 (39.39)	63.91 (53.09)	62.56 (52.28)	48.44 (44.1)	38.74 (38.44)	53.55 (47.04)	52.14 (46.23)	39.32 (38.82)
5	Propargite 57 EC	0.114	42.38 (40.61)	52.70 (46.55)	52.65 (46.54)	41.53 (40.12)	36.79 (37.31)	47.11 (43.34)	55.33 (48.07)	34.05 (35.68)
6	Fipronil 5 SC	0.005	63.55 (52.88)	81.82 (64.76)	83.38 (65.95)	60.86 (51.37)	64.67 (53.59)	82.21 (65.07)	82.58 (67.78)	68.47 (55.99)
7	Novaluron 10 EC	0.01	35.27 (36.41)	55.87 (48.39)	57.96 (49.59)	41.78 (40.26)	35.86 (36.71)	52.05 (46.18)	48.33 (44.04)	31.95 (34.4)
8	Imidacloprid 17.8 SL	0.0058	65.40 (53.99)	82.53 (65.32)	82.51 (65.28)	59.28 (50.35)	63.23 (52.7)	76.23 (60.85)	80.16 (63.6)	65.83 (54.29)
9	Azadirachtin 0.15%	0.0003	30.55 (33.55)	46.60 (43.04)	46.25 (42.84)	32.86 (34.96)	30.15 (33.26)	45.10 (42.19)	39.47 (38.92)	31.28 (33.92)
10	NSKE (self-prepared)	5	35.35 (36.48)	46.83 (43.18)	51.29 (45.74)	37.42 (37.67)	36.63 (37.24)	47.15 (43.37)	44.62 (41.91)	28.96 (32.55)
11	Spinosad 45 SC	0.0135	42.46 (40.63)	58.52 (49.92)	60.65 (51.15)	45.14 (42.21)	43.50 (41.26)	51.26 (45.72)	64.65 (53.52)	52.90 (46.67)
12	Untreated check	-	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
SEm±			(1.21)	(1.69)	(1.82)	(1.42)	(1.68)	(1.66)	(1.57)	(2.32)
CD (p=0.05)			(3.55)	(4.95)	(5.35)	(4.17)	(4.93)	(4.86)	(4.61)	(6.79)

to 534 thousand metric tons from an area of 34 thousand hectares (Anonymous 2020-21).

Temperature, relative humidity and energy may influence the growth of sweet pepper under open field cultivation. Under protected cultivation, all these factors are maintained for its efficient productivity (Singh and Joshi 2020). Protected cultivation is the most intensive method of crop production and provides protection to crop plant from adverse environment condition (Sood *et al.* 2015). The protected environment also provide stable and congenial micro-climate which is favorable for the multiplication of insect pests which in turn become of the limiting factors for the successful crop production under protected environment (Kaur *et al.* 2010). Often, the natural enemies that keep pests under control outside are not present under protected environment. For these reasons, pest situations often develop in the indoor environment more rapidly and greater severity than outdoors. Mite, thrips, whitefly, leaf miner, aphid, gall midge and nematode are serious problems on vegetable crops under protected conditions. The productivity of *Capsicum* is very low due to several limiting factors. Among them, insect pests cause severe losses, *Capsicum* is attacked by several insect and mite pests from seedling to fruiting stage. About 35 species of insect and mite pests reported (Vos and Frinking 1998, Sorensen 2005 Berke *et al.* 2003) under Punjab conditions pose severe problems. Whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera : Aleyrodidae), is one of the most damaging pests of crops grown in open field and under protected conditions. Owing to the indiscriminate use of insecticides, whitefly has developed resistance against various insecticides belonging to different chemical groups (Ghongade and Sangha 2021). Singh *et al.* (2004a), Hatala Zseller (2008), Anitha and Nandihalli

Table 2. Comparative efficacy of bio-rationales and newer insecticides against whitefly, *Bemisia tabaci* (Gennadius) on capsicum during 2015. * Figures in parentheses are arc sin transformed values. DAS: Days after spray.

Sl. No.	Treatments	Conc (%)	Mean reduction (%) in whitefly population days after: First spray 1 DAS	First spray 3 DAS	First spray 7 DAS	First spray 15 DAS	Second spray 1 DAS	Second spray 3 DAS	Second spray 7 DAS	Second spray 15 DAS
1	Spiromesifen 22.9 SC	0.0229	40.00 (39.18)*	44.08 (41.6)	49.68 (44.82)	37.17 (37.57)	37.86 (37.96)	48.72 (44.26)	57.27 (49.18)	52.41 (46.39)
2	Emamectin benzoate 5 SG	0.002	59.66 (50.6)	78.85 (62.66)	75.67 (60.45)	53.88 (47.23)	52.16 (46.24)	72.55 (58.42)	76.13 (60.81)	59.66 (50.69)
3	Acephate 75 SP	0.075	60.57 (51.1)	75.62 (60.43)	77.32 (61.57)	55.53 (48.18)	59.23 (50.32)	78.00 (62.05)	81.81 (64.85)	70.18 (56.94)
4	Indoxacarb 14.5 SC	0.0116	37.34 (37.66)	59.36 (50.41)	57.66 (49.41)	47.23 (43.41)	38.48 (38.32)	54.73 (47.72)	54.28 (47.46)	43.82 (41.41)
5	Propargite 57 EC	0.114	40.88 (39.74)	51.20 (45.69)	55.99 (48.44)	37.67 (37.86)	35.73 (36.7)	47.31 (43.45)	56.43 (48.7)	37.76 (37.86)
6	Fipronil 5 SC	0.005	61.04 (51.38)	80.49 (63.8)	81.83 (64.78)	63.71 (53.05)	63.39 (52.81)	82.29 (65.13)	88.87 (70.58)	63.53 (52.87)
7	Novaluron 10 EC	0.01	31.76 (34.26)	56.86 (49.01)	56.17 (48.57)	38.75 (38.48)	35.67 (36.65)	41.34 (39.92)	47.65 (43.65)	43.19 (41.08)
8	Imidacloprid 17.8 SL	0.0058	62.53 (52.27)	82.59 (65.38)	83.75 (66.28)	58.35 (49.83)	60.28 (50.93)	76.38 (60.94)	86.18 (71.97)	68.06 (55.61)
9	Azadirachtin 0.15%	0.0003	23.90 (29.26)	41.96 (40.36)	40.89 (39.75)	30.38 (33.44)	30.31 (33.36)	46.36 (42.91)	42.10 (40.45)	36.80 (37.34)
10	NSKE (self-prepared)	5	36.42 (37.11)	47.16 (43.37)	52.20 (46.26)	37.90 (37.99)	35.67 (36.67)	47.38 (43.5)	45.97 (42.69)	32.88 (34.91)
11	Spinosad 45 SC	0.0135	39.28 (38.79)	54.97 (47.86)	61.59 (51.71)	44.86 (42.05)	40.29 (39.39)	44.91 (42.07)	64.53 (53.46)	60.83 (51.27)
12	Untreated check	–	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
SEm±			(1.26)	(1.54)	(1)	(1.35)	(1.25)	(1.48)	(2.83)	(1.87)
CD(p=0.05)			(3.7)	(4.53)	(2.94)	(3.97)	(3.66)	(4.36)	(8.31)	(5.48)

(2008) has also revealed the occurrence of whitefly as major pest in *Capsicum*. Gupta *et al.* (2016) and Meena *et al*. (2013) reported whitefly as important pest infesting *Capsicum* in Rajasthan. Both nymphs and and adults of whitefly are found in large colonies on the under surface of leaves and growing shoots of plants, sucking the cell sap which reduce leaf growth, plant growth, yield and market value of produce. Among different pests reported on *Capsicum* there is information indicating significant crop losses due to key pests. Reddy and Kumar (2006) in an IPM trial estimated per ha crop loss of 40 to 60 tons of *Capsicum* if the crop is not subjected to insecticidal control. However, in other related crops like chilli reported significant yield losses range from 50 to 90% due to insect pests. No sincere attempt has been made in the past to evaluation of novel insecticides against whitefly, *Bemisia tabaci* (Gennadius) on *Capsicum* under shade net house in Rajasthan. Considering the economic importance of pest, the study was conducted to test the efficacy of bio-rationales and newer insecticides molecules against whitefly under shade net house conditions.

MATERIALS AND METHODS

The field trials were conducted under shade net house at Hi-Tech Horticulture Farm, Rajasthan Agricultural Research Institute, Durgapura, Jaipur (SKN Agriculture University, Jobner, Jaipur, Rajasthan) during summer 2014 and 2015. The experiment was laid out in a Randomized Block Design with 12 treatments and three replications including an untreated check. One month old seedlings of *Capsicum* variety PSO-26 were transplanted in each treatment with plot size 3.5 × 1.0 m, keeping row to row and plant to plant distance of 0.50 m and 0.40 m. Eleven bio-rationales and newer insecticides of different chemistry viz., spiromesifen 22.9 SC @ 1 ml/l, emamectin benzoate 5 SG @ 0.4 g/l, acephate 75 SP @ 1 g/l, indoxacarb 14.5

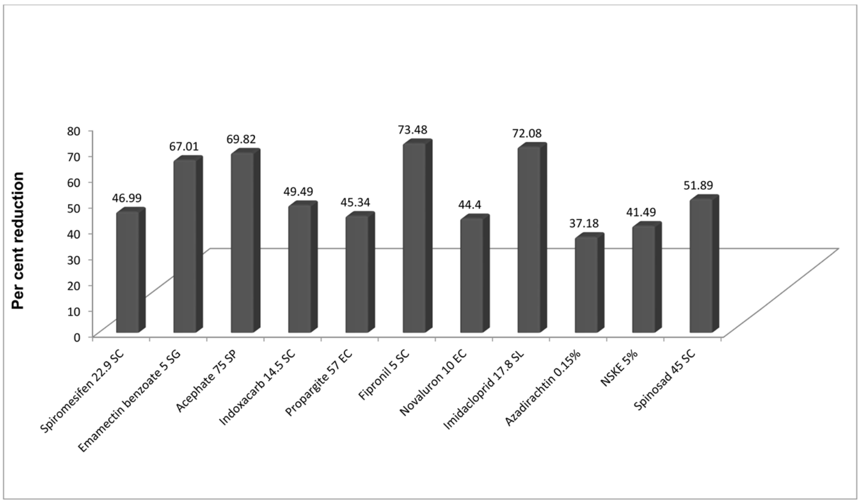

Fig. 1. Overall efficacy of bio-rationales and newer insecticides against whitefly, *Bemisia tabaci* (Gennadius) on capsicum.

SC @ 0.8 ml/l, propergite 57 EC @ 2 ml/l, fipronil 5 SC @ 1 ml/l, novaluron 10 EC @ 1 ml/l , imidacloprid 17.8 SL @ 0.33 ml/l, Azadirachtin 0.15 EC @ 2 ml/l, NSKE 5% and spinosad 45 SC @ 0.3 ml/l were evaluated for the management of whitefly under protected environment. Two consecutive sprays were applied at twenty days interval starting from sufficient pest built-up. Treatments were imposed by using pre-calibrated knapsack sprayer @ 500–550 liters of spray solution/ha (1st and 2nd spray respectively) depending on the stage of the crop. Care was taken to check the drift of insecticides by putting polythene sheet screen around each plot at the time of spraying. The population of whitefly (both nymphs and adults) was recorded at one day before spraying and 1, 3, 7 and 15 days after each spray. Whiteflies were counted on five randomly selected tagged plants per plot during early hours of the day when they remain less active. The population of whitefly was counted visually on three leaves from upper, middle and lower portion of each tagged plant. For counting the whitefly population, the leaf was held at the petiole by thumb and fore finger and twisted until the entire under side of leaf was clearly visible (Butter and Vir 1990). The number was recorded as whiteflies/ three leaves.

The per cent reduction in the population of whitefly were worked out and then transformed to arc sine values and the data were pooled and subjected to ANOVA variance for 2014 and 2015 separately. The percentage reduction in population was calculated using formula given by Henderson and Tilton (1955) which is modification of Abbott's (1925) formula.

Per cent reduction in population = {1-(Ta × Cb / Tb × Ca) 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

Eleven bio-rationales and newer insecticides viz., spiromesifen, propargite, fipronil, emamectin benzoate, acephate, indoxacarb, novaluron, imidacloprid, spinosad, azadirachtin and NSKE were evaluated against the whitefly, *Bemisia tabaci* (Gennadius) on capsicum under shade net house conditions. The observations were taken one day before first spray on whitefly population in all the treatments including untreated check revealed non-significant among them in both the years. Analysis of variance shows

Table 3. Comparative efficacy of bio-rationales and newer insecticides against whitefly, *Bemisia tabaci* (Gennadius) on capsicum (Pooled of 2014 and 2015). * Figures in parentheses are arc sin transformed values. DAS : Days after spray.

Sl. No.	Treatments	Conc. (%)	Mean reduction (%) in whitefly population days after — First spray 1 DAS	3 DAS	7 DAS	15 DAS	Second spray 1 DAS	3 DAS	7 DAS	15 DAS
1	Spiromesifen 22.9 SC	0.0229	40.85 (39.70)*	48.20 (43.97)	53.05 (46.76)	39.78 (39.1)	38.30 (38.23)	47.46 (43.54)	58.39 (49.86)	49.89 (44.94)
2	Emamectin benzoate 5 SG	0.002	57.45 (49.31)	78.09 (62.16)	77.47 (61.73)	53.78 (47.17)	53.95 (47.3)	75.25 (60.51)	77.78 (62.03)	62.35 (52.3)
3	Acephate 75 SP	0.075	60.30 (50.96)	76.29 (61.01)	77.54 (61.75)	56.85 (48.95)	60.03 (50.81)	77.62 (61.78)	81.35 (64.49)	68.65 (56.01)
4	Indoxacarb 14.5 SC	0.0116	38.81 (38.53)	61.64 (51.75)	60.11 (50.85)	47.84 (43.76)	38.61 (38.38)	54.14 (47.38)	53.21 (46.85)	41.57 (40.12)
5	Propargite 57 EC	0.114	41.63 (40.18)	51.95 (46.12)	54.32 (47.49)	39.60 (38.99)	36.26 (37.01)	47.21 (43.4)	55.88 (48.39)	35.91 (36.77)
6	Fipronil 5 SC	0.005	62.30 (52.13)	81.16 (64.28)	82.61 (65.37)	62.29 (52.21)	64.03 (53.2)	82.25 (65.1)	87.23 (69.18)	66.00 (54.43)
7	Novaluron 10 EC	0.01	33.52 (35.34)	56.37 (48.7)	57.07 (49.08)	40.27 (39.37)	35.77 (36.68)	46.70 (43.05)	47.99 (43.85)	37.57 (37.74)
8	Imidacloprid 17.8 SL	0.0058	63.97 (53.13)	82.56 (65.35)	83.13 (65.78)	58.82 (50.09)	61.76 (51.82)	76.31 (60.9)	83.17 (67.79)	66.95 (54.95)
9	Azadirachtin 0.15%	0.0003	27.23 (31.41)	44.28 (41.70)	43.57 (41.30)	31.62 (34.20)	30.23 (33.31)	45.73 (42.55)	40.79 (39.69)	34.04 (35.63)
10	NSKE (self-prepared)	5	35.89 (36.8)	47.00 (43.28)	51.75 (46.00)	37.66 (37.83)	36.15 (36.96)	47.27 (43.44)	45.30 (42.3)	30.92 (33.73)
11	Spinosad 45 SC	0.0135	40.87 (39.71)	56.75 (48.89)	61.12 (51.43)	45.00 (42.13)	41.90 (40.33)	48.09 (43.9)	64.59 (53.49)	56.87 (48.97)
12	Untreated check	-	0.00 (0.00)	0.00 (0.00).	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	SEm±		(0.87)	(1.14)	(1.04)	(0.98)	(1.05)	(1.11)	(1.62)	(1.49)
	CD(p=0.05)		(2.49)	(3.26)	(2.97)	(2.80)	(2.99)	(3.17)	(4.62)	(4.24)

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, 2 and pooled data for two years are depicted in Table 3. The trend of relative efficacy of various treatments has been described below on the basis of pooled data.

The observations on mortality of whitefly recorded at one day after first application of different bio-rationales and newer insecticides the maximum reduction in whitefly population was recorded in the plots treated with imidacloprid at 0.0058% (63.97%) followed by fipronil at 0.005% (62.30%) and acephate at 0.075%, however, emamectin benzoate at 0.002% was found at par with acephate at 0.075%. In second application, the most effective reduction in whitefly population was recorded in the plots treated with fipronil at 0.005% followed by imidacloprid at 0.0058% which is at par. The present findings are in agreement to that of Singh *et al.* (2004b) who reported that imidacloprid proved most effective in reducing whitefly followed by acephate and Aina *et al.* (2017) who reported that imidacloprid proved effective reduction of whitefly.

After three days of first application, the most effective reduction was recorded in the plots treated with imidacloprid at 0.0058% (82.56%) followed by fipronil at 0.005% (81.16%) which is at par and emamectin benzoate at 0.002% (78.09%), however, acephate at 0.075% was found at par with emamectin benzoate at 0.002%. In second application, the most effective reduction in whitefly population was recorded in the plots treated with fipronil at 0.005% followed by imidacloprid at 0.0058%, acephate at 0.075% and emamectin benzoate at 0.002%. Findings of Mishra (2005) confirm these findings who reported imidacloprid was most effective against whitefly. The present findings are in agreement to that of Singh *et al.* (2004b) who reported imidacloprid proved most effective followed by acephate in reducing whitefly population and Kumawat *et al.* (2015) who reported that fipronil 5 SC proved effective reduction of whitefly.

After seven days of first application, the most effective reduction was recorded in the plots treated with imidacloprid at 0.0058% followed by fipronil at 0.005%. Acephate at 0.075% and emamectin benzoate at 0.002% showed effective in reducing whitefly population. In second application, the most effective reduction in whitefly population was recorded in the plots treated with fipronil at 0.005% followed by acephate at 0.075% and imidacloprid at 0.0058%. Earlier Jain and Ameta (2006) also reported that imidacloprid was most effective against sucking pests of chilli that support the present finding. The present finding are in agreement to that of Singh *et al*. (2004b) who reported that imidacloprid proved most effective in reducing whitefly followed by acephate at 0.075% and and Kumawat *et al.* (2015) who reported that fipronil 5 SC proved effective reduction of whitefly.

After fifteen days of first application, the most effective reduction was recorded in the plots treated with fipronil at 0.005% followed by imidacloprid at 0.0058%, however, acephate at 0.075% was found at par with imidacloprid at 0.0058%. In second application, the maximum reduction was recorded in the plot treated with acephate at 0.075% followed by imidacloprid at 0.0058%, fipronil at 0.005% and emamectin benzoate at 0.002%. The present findings are in partially agreement to that of Singh *et al.* (2004b) who reported that imidacloprid proved most effective in reducing whitefly followed by acephate. The results are also in agreement with that of Mhaske and Mote (2005) who reported that imidacloprid was found most effective against whitefly.

On the basis of pooled and overall efficacy (Fig. 1), the maximum reduction in whitefly population was recorded in the plots treated with fipronil at 0.005% (73.48%), followed by imidacloprid at 0.0058% (72.08%), acephate at 0.075% (69.82%) and emamectin benzoate at 0.002% (67.01%). The present findings are in agreement to that of Elbert *et al.* (1991) and Yadav V *et al.* (2012) who reported maximum reduction of whitefly by imidacloprid and Patil *et al.* (2009) who reported effective reduction of pest complex in cotton.

ACKNOWLEDGEMENT

I express my cordial thanks to the all Professors of Division of Entomology; the Director, Rajasthan Agricultural Research Institute, Durgapura, Jaipur, Dr KC Kumawat, Professor Entomology, SKN College of Agriculture, Jobner and the Director Research, SKN Agriculture University, Jobner for providing valuable suggestions, assistance and necessary facilities during the course of investigations.

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