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Efficacy of New Molecules and Botanicals against Chilli (*Capsicum annuum* L.) Pests

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Field experiments were conducted during 2011-12, at Agricultural Research Station, UAS, Dharwad, Karnataka, South India to know the efficacy of new molecules and botanicals against chilli pests. *viz.*, green peach aphid (*Myzys persicae* Sulzer, *Aphis gossypi* Glover), thrips (*Scirtothrips dorsalis* Hood), yellow mite (*Polyphagotarsonemus latus* Banks) and fruit borer (*Helicoverpa armigera* Hubner). The results revealed that thiamethoxam 25WG @ 1 g/l, abamectin 1.8EC @ 0.5ml/l, diafenthiuron 50 WP @ 0.75g/l were highly effective for the management of chilli sucking pests. Against *H. armigera*, novaluron 10 EC @ 0.75ml/l, emamectin benzoate 5SG @ 0.4g/l and spinosad45SC @ 0.3ml/l were found quite promising. The pesticides from biological origin and neem based formulations might be relatively less harmful to the natural enemies than insecticide like imidacloprid and cypermethrin. Significantly increased yield (4.65 q/ha) was recorded in diafenthiuron 50 WP @ 0.75g/l with higher net returns (Rs 22,661/ ha).

Key words: Botanicals, Fruit borer, Natural enemies, Neonicotinoids, Sucking pests

Chilli (*Capsicum annuum* L.) is one of the important spice crops of India and is being widely cultivated throughout warm temperate, tropical and subtropical countries. Chilli is famous for its pleasant aromatic flavour, pungency and high colouring substance. Its cultivation is mostly concentrated in the southern states viz., Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu, occupying nearly 75 per cent of total area under chilli in India, which is the second largest exporter of chilli in the world. One of the practical means of increasing chilli production is to minimize losses caused by major insect pests, the most important among them are green peach aphid (*Myzys persicae* Sulzer, *Aphis gossypi* Glover), thrips (*Scirtothrips dorsalis* Hood), yellow mite (*Polyphagotarsonemus latus* Banks) and fruit borer (*Helicoverpa armigera* Hubner) (Berke and Sheih, 2000). In Karnataka, identified sucking pests of chilli are thrips, mites, aphids and whiteflies, of which chilli leaf curl spread by mite and thrips are serious (Puttarudriah, 1959). Besides, a number of viruses are transmitted by aphids, whiteflies *etc,* to which result into a leaf curl disease (Gundannavar *et al*., 2007). The yield losses due to these pests are estimated to be 50 per cent (Hosmani, 2007). The loss caused by the thrips is reported to range from 50 to 90 per cent and fruit borers account to 90 per cent (Reddy and Reddy, 1999).

Chilli growers in India depend heavily on synthetic pesticides to combat sucking pests. Atleast 8-9 sprays are given against major pests. Due to continuous and indiscriminate use of synthetic insecticides, there is resistance development among pests and hence, the efficacy of insecticides has become less reliable. To overcome this problem discovery and use of novel molecules and botanicals with different biochemical targets and effective at low doses are needed.

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Materials and Methods

Field experiments were laid out at Agricultural Research Station, University of Agricultural Sciences, Dharwad, India under rainfed conditions in deep black cotton soil to know the efficacy of newer molecules and botanicals against chilli pests. The experiment consisted of fifteen treatments *viz.*, acetamiprid 20 SP, thiamethoxam 25 WG, thiacloprid 480 SC, abamectin 1.8 EC, NSKE 5%, diafenthiuron 50 WP, buprofezin 10 EC, novuluron 10 EC, emamectin benzoate 5 SG, spinosad 45 SC, imidacloprid 17.8 SL (C), propargite 57 EC (C), profenophos 50 EC (C), Garlic Chilli Kerosene Extract (GCKE) 0.5% (C) and untreated check, which were replicated thrice in Randomised Complete Block Design (RCBD). The seedlings of chilli (cv, Byadagi kaddi) were transplanted during 3rd and 1st week of July in plots of size 5.4 X 4.8 m with a spacing of 60 X 60 cm. Each plot had a density of 72 hills with two plants per hill. All management practices were followed as per recommended package of practices (POP UASD, 2014) except the plant protection measures against target pests.

For counting the population, five plants were selected randomly in each plot and tagged. Six leaves on the top canopy of each selected plant were observed by using binocular microscope in laboratory following destructive sampling procedure. Ten plants were selected randomly in each plot and scored for leaf curling index (LCI) at 70 and 100 DAT visually following the 0-4 scale (Niles, 1980) and subjected for statistical analysis. The population count of aphids and thrips were taken at 30, 60 and 90 days after transplanting (DAT), while the population count of mite was taken at 60 and 90 DAT. The observations on larval population of chilli fruit borer, *H. armigera* were made on five randomly selected plants from each treatment at 60, 90 and 120 DAT. The per cent fruit damage was worked out by counting total number of fruits per plant and number of damaged fruits per plant on five randomly selected plants in each treatment at every picking.

Population count of both grubs and adults of natural enemy fauna including coccinellid beetles, *Menochilus sexmaculatus* (Fab.) and chrysopids, *Chrysoperla zastrow sillemi* (Esben-Peterson) were recorded in each treatment by following the standard procedure (Daniel *et al*., 2008). Population count was taken on five randomly selected plants at 60 and 90 DAT. The population density of predators was recorded as number of coccinellids per plant and chrysopids per plant, respectively. Pooled analysis for both the years was done with the help of M Stat C statistical software. Green chillies were harvested from five randomly selected plants in each plot as well as from entire plot separately and yield per plant and per plot was recorded during each picking. Total yield was calculated by adding the yield of each picking. Totally four pickings were done and the average was calculated to estimate the yield per hectare. Dry chilli yield was obtained from the green chilli yield as per the procedure (Gundannavar *et al.*, 2007) with the ratio of conversion of green chilli to dry chilli being 10:1. Cost effectiveness of each treatment was assessed based on net returns and the B:C ratio was worked out. The data on mean population of sucking pests, natural enemies and fruit borer were transformed to square root values and the per cent damage was transformed to arcsine values and subjected to one way ANOVA using M-STATC ® software package. The treatment effect was compared by following Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Results and Discussion

The results obtained from the study revealed that, thiamethoxam 25 WG had recorded significantly less

Table 1. Efficacy of new molecules on sucking pests and leaf curl index in chilli

Treatment	Aphid count (No./leaf)			Thrips count (No./leaf)			Mite count (No./leaf)			Leaf curl index		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_{1}- Acetamiprid 20 SP @0.3g/l	0.17e	0.16d	0.15e	0.23e	0.21f	0.20f	0.73bc	0.71c	0.74c	0.46c	0.44d	0.46d
	(0.91)	(0.90)	(0.89)	(0.98)	(0.96)	(0.95)	(1.35)	(1.34)	(1.36)	(1.18)	(1.16)	(1.18)
T_{2}- Thiamethoxam 25 WG @1g/l	0.12f	0.11e	0.11e	0.12f	0.11g	0.12g	0.84ab	0.82b	0.82b	0.29d	0.26e	0.28e
	(0.95)	(0.83)	(0.91)	(0.85)	(0.83)	(0.85)	(1.42)	(1.41)	(1.41)	(1.04)	(1.01)	(1.03)
T_{3}- Thiacloprid 480 SC @ 1ml/l	0.21e	0.22d	0.22e	0.49c	0.45d	0.47c	0.98a	0.94a	0.96a	0.59b	0.57cd	0.56c
	(0.96)	(0.98)	(0.97)	(1.27)	(1.24)	(1.25)	(1.49)	(1.47)	(1.48)	(1.27)	(1.25)	(1.24)
T_{4}- Abamectin 1.8 EC @ 0.5ml/l	0.55b	0.52b	0.54b	0.58b	0.52c	0.55b	0.19d	0.15d	0.17d	0.51b	0.48d	0.50c
	(1.24)	(1.22)	(1.23)	(1.32)	(1.29)	(1.31)	(0.94)	(0.99)	(0.91)	(1.21)	(1.19)	(1.20)
T_{5}- NSKE 5% @ 50ml/l	0.36c	0.33c	0.35c	0.21e	0.24f	0.21f	0.39cd	0.32cd	0.36cd	0.69b	0.68bc	0.69b
	(1.10)	(1.07)	(1.09)	(1.03)	(1.04)	(1.03)	(1.12)	(1.07)	(1.10)	(1.33)	(1.32)	(1.33)
T_{6}- Diafenthiuron 50 WP @0.75g/l	0.21e	0.19d	0.19e	0.20e	0.21f	0.21f	0.18d	0.16d	0.14d	0.24d	0.22e	0.21e
	(0.96)	(0.94)	(0.94)	(0.95)	(0.96)	(0.96)	(0.92)	(0.90)	(0.88)	(0.99)	(0.97)	(0.96)
T_{7}- Buprofezin 10 EC @ 0.75ml/l	0.19e	0.16d	0.18e	0.22e	0.22f	0.22f	0.24d	0.20d	0.23d	0.41c	0.38d	0.40d
	(0.94)	(0.90)	(0.92)	(0.97)	(0.97)	(0.97)	(0.99)	(0.95)	(0.98)	(1.14)	(1.12)	(1.13)
T_{8}- Novaluron 10 EC @ 0.75ml/l	0.61a	0.57a	0.60a	0.92a	0.91a	0.92a	0.97a	0.81b	0.89a	0.91a	0.93a	0.94a
	(1.24)	(1.22)	(1.23)	(1.46)	(1.45)	(1.46)	(1.48)	(1.40)	(1.44)	(1.45)	(1.46)	(1.47)
T_{9}- Emamectin benzoate 5 SG @ 0.4g/l	0.64a	0.61a	0.62a	0.89a	0.82b	0.86a	0.41cd	0.39cd	0.40cd	0.93a	0.91a	0.91a
	(1.30)	(1.28)	(1.29)	(1.44)	(1.41)	(1.43)	(1.14)	(1.12)	(1.13)	(1.46)	(1.45)	(1.45)
T_{10}- Spinosad 45 SC @ 0.3ml/l	0.59ab	0.47b	0.51b	0.40cd	0.38de	0.36d	0.96a	0.93a	0.95a	0.78ab	0.75b	0.77ab
	(1.27)	(1.19)	(1.22)	(1.13)	(1.12)	(1.10)	(1.48)	(1.46)	(1.47)	(1.38)	(1.37)	(1.38)
T_{11}- Imidacloprid 17.8 SL @ 0.3ml/l	0.19e	0.15d	0.18e	0.29d	0.28e	0.29e	0.87ab	0.84b	0.86b	0.32cd	0.29e	0.31de
	(0.94)	(0.89)	(0.93)	(1.04)	(1.03)	(1.04)	(1.43)	(1.42)	(1.43)	(1.07)	(1.04)	(1.06)
T_{12}- Propargite 57 EC @ 2.5ml/l	0.37c	0.35c	0.35c	0.45c	0.42d	0.44c	0.23d	0.20d	0.22d	0.38c	0.36d	0.36d
	(1.09)	(1.07)	(1.07)	(1.31)	(1.29)	(1.30)	(0.98)	(0.95)	(0.97)	(1.12)	(1.10)	(1.10)
T_{12}- Profenofos 50 EC @ 2ml/l	0.23de	0.21de	0.20de	0.31d	0.30e	0.31e	0.31cd	0.27d	0.29cd	0.37c	0.35de	0.36d
	(0.99)	(0.96)	(0.95)	(1.06)	(1.05)	(1.06)	(1.06)	(1.02)	(1.04)	(1.11)	(1.09)	(1.10)
T_{14}- Garlic Chilli Kerosene	0.31d	0.29c	0.30d	0.31d	0.29e	0.30e	0.42cd	0.37cd	0.40cd	0.58b	0.55d	0.57c
Extract 0.5% @ 5ml/l	(1.06)	(1.04)	(1.05)	(1.06)	(1.04)	(1.05)	(1.15)	(1.11)	(1.13)	(1.26)	(1.24)	(1.25)
T_{15}- Untreated check	0.67a	0.64a	0.66a	0.95a	0.93a	0.96a	1.01a	0.96a	0.97a	0.95a	0.92a	0.94a
	(1.32)	(1.30)	(1.31)	(1.49)	(1.47)	(1.50)	(1.51)	(1.48)	(1.49)	(1.46)	(1.45)	(1.46)
CV	11.60	11.40	11.63	12.50	7.82	9.29	9.86	7.95	6.52	6.15	6.72	6.13
S. Em±	0.01	0.03	0.02	0.03	0.01	0.02	0.03	0.02	0.02	0.06	0.04	0.05
C.D. at 5%	0.04	0.09	0.06	0.08	0.04	0.06	0.08	0.06	0.05	0.17	0.11	0.15

Figures in parenthesis are arc sine transformed values
In a column means followed by the same alphabet did not differ significantly by DMRT (p=0.05)

incidence of aphids of 0.12 and 0.11 during 2010-11 and 2011-12, respectively followed by acetamiprid 20 SP (0.17 and 0.16). Moderate pest activity was recorded in recommended insecticides like profenophos 50 EC (0.23 and 0.21), GCKE 0.5% (0.31 and 0.29) and NSKE 5% (0.36 and 0.33), whereas more incidence of aphids was found in untreated check (0.67 and 0.64 aphids/leaf) (Table 1). Significantly lower incidence of thrips (0.12/leaf) was registered with thiamethoxam 25 WG spray, which was also on par with diafenthiuron 50 WP (0.21/ leaf), buprofezin 10 EC (0.22/leaf) and imidacloprid 17.8 SL (0.29/leaf) spray, respectively (Table 1). Thiamethoxam 25 WG recorded significantly least number of thrips (0.11/leaf), but it was found to be on par with difenthiuron 50 WP (0.21), acetamiprid 20SP (0.21) and buprofezin 10 EC (0.22). Whereas, the untreated check registered highest thrips population of 0.93 during 2011-12. The recommended chemicals like imidacloprid 20SP, profenophos 50 EC, GCKE 0.5% and NSKE 5% also performed better when compared to untreated check. Pooled data also revealed similar trend of treatment significance (Table 1).

Table 2. Efficacy of new molecules on population of chilli fruit borer, fruit damage per cent and natural enemies in chilli

Treatment	Fruit borer (larva/plant)			Fruit damage (%)			Cocconellids/plant			Chrysopids/plant		
	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled	2010-11	2011-12	Pooled
T_1- Acetamiprid 20 SP @0.3g/l	1.05ab	1.03ab	1.02b	10.61c	10.37c	10.49c	0.71d	0.68d	0.70e	1.21de	1.18cd	1.20de
	(1.52)	(1.51)	(1.50)	(19.00)	(18.72)	(18.81)	(1.34)	(1.32)	(1.34)	(1.60)	(1.59)	(1.60)
T_2- Thiamethoxam 25 WG @1g/l	1.19a	1.15a	1.16a	10.81c	10.52c	10.67c	0.65d	0.63d	0.64e	1.24d	1.21c	1.23d
	(1.59)	(1.57)	(1.58)	(19.19)	(18.91)	(19.00)	(1.31)	(1.29)	(1.30)	(1.61)	(1.60)	(1.61)
T_3- Thiacloprid 480 SC @ 1ml/l	0.97b	0.95b	0.97bc	11.85b	11.48b	11.67b	0.82c	0.79cd	0.81d	1.26d	1.22c	1.24d
	(1.48)	(1.47)	(1.48)	(20.09)	(19.73)	(19.91)	(1.41)	(1.39)	(1.40)	(1.62)	(1.60)	(1.61)
T_4- Abamectin 1.8 EC @ 0.5ml/l	0.92c	0.90bc	0.89c	11.12bc	10.79c	10.96bc	0.98b	0.95b	0.97b	1.78a	1.72a	1.75a
	(1.46)	(1.45)	(1.44)	(19.46)	(19.09)	(19.28)	(1.49)	(1.47)	(1.48)	(1.83)	(1.81)	(1.82)
T_5- NSKE 5% @ 50ml/l	0.74d	0.69d	0.72d	8.89de	8.61d	8.75e	1.12a	1.10a	1.11a	1.82a	1.78a	1.80a
	(1.36)	(1.33)	(1.35)	(17.26)	(17.05)	(17.16)	(1.56)	(1.55)	(1.55)	(1.85)	(1.83)	(1.84)
T_6- Diafenthiuron 50 WP @ 0.75g/l	0.58e	0.53e	0.56e	8.64e	8.27de	8.46e	0.82c	0.79cd	0.81d	1.19de	1.15d	1.17de
	(1.26)	(1.23)	(1.25)	(17.05)	(16.64)	(16.85)	(1.41)	(1.39)	(1.40)	(1.59)	(1.57)	(1.58)
T_7- Buprofezin 10 EC @ 0.75ml/l	0.97b	0.92b	0.95bc	12.62a	12.32b	12.47ab	0.87bc	0.84c	0.86cd	1.27d	1.23c	1.25d
	(1.48)	(1.46)	(1.47)	(20.79)	(20.53)	(20.65)	(1.43)	(1.42)	(1.43)	(1.63)	(1.61)	(1.62)
T_8- Novaluron 10 EC @ 0.75ml/l	0.29f	0.27f	0.28g	6.52f	6.24f	6.38g	0.93b	0.90bc	0.92c	1.36c	1.31c	1.34d
	(1.04)	(1.02)	(1.03)	(14.77)	(14.42)	(14.54)	(1.46)	(1.45)	(1.46)	(1.67)	(1.64)	(1.66)
T_9- Emamectin benzoate 5 SG @ 0.4g/l	0.30f	0.28f	0.29g	6.94f	6.79f	6.87fg	1.08a	1.01ab	1.05ab	1.42c	1.39b	1.41c
	(1.05)	(1.03)	(1.04)	(15.23)	(15.00)	(15.12)	(1.54)	(1.40)	(1.52)	(1.69)	(1.68)	(1.69)
T_{10}- Spinosad 45 SC @ 0.3ml/l	0.32f	0.29f	0.31g	7.11ef	7.02e	7.07f	1.14a	1.11a	1.13a	1.39c	1.35c	1.37cd
	(1.07)	(1.04)	(1.06)	(15.45)	(15.34)	(15.34)	(1.57)	(1.55)	(1.56)	(1.68)	(1.66)	(1.67)
T_{11}- Imidacloprid 17.8 SL @ 0.3ml/l	1.12a	1.08a	1.11a	12.86a	13.42a	12.69a	0.86c	0.82c	0.84d	1.11e	1.04d	1.08e
	(1.56)	(1.54)	(1.55)	(20.96)	(21.47)	(20.79)	(1.43)	(1.41)	(1.42)	(1.55)	(1.52)	(1.54)
T_{12}- Propargite 57 EC @ 2.5ml/l	1.05ab	0.98b	1.02b	13.63a	12.51a	13.53a	0.43e	0.40e	0.42f	1.02e	0.96e	0.99e
	(1.52)	(1.50)	(1.51)	(21.64)	(20.70)	(21.56)	(1.16)	(1.13)	(1.15)	(1.51)	(1.48)	(1.49)
T_{12}- Profenofos 50 EC @ 2ml/l	0.36f	0.33f	0.35fg	7.23f	7.06e	7.15f	0.31e	0.26e	0.29g	0.62f	0.58ab	0.60f
	(1.10)	(1.07)	(1.09)	(15.56)	(15.34)	(15.45)	(1.06)	(1.01)	(1.04)	(1.29)	(1.26)	(1.27)
T_{14}- Garlic Chilli Kerosene	0.45e	0.41ef	0.43f	9.24d	8.91d	9.08d	0.96b	0.91b	0.94b	1.67b	1.63a	1.65b
Extract 0.5% @ 5ml/l	(1.17)	(1.14)	(1.16)	(17.66)	(17.36)	(17.46)	(1.48)	(1.45)	(1.47)	(1.79)	(1.78)	(1.78)
T_{15}- Untreated check	1.17a	1.13a	1.14a	12.76a	13.28a	13.02a	1.17a	1.13a	1.15a	1.86a	1.81a	1.84a
	(1.58)	(1.56)	(1.57)	(20.88)	(21.28)	(21.08)	(1.59)	(1.56)	(1.58)	(1.89)	(1.85)	(1.86)
CV	7.56	8.41	6.93	6.71	5.91	6.31	6.56	6.04	5.21	5.34	9.40	5.63
S. Em±	0.04	0.04	0.03	0.41	0.35	0.38	0.04	0.03	0.02	0.04	0.07	0.04
C.D. at 5%	0.12	0.12	0.09	1.19	1.03	1.11	0.11	0.08	0.06	0.12	0.21	0.12

In a column means followed by the same alphabet did not differ significantly by DMRT (p=0.05)

DAT : Days After Transplanting, Figures in parenthesis are square root transformed values

During 2010-11, diafenthiuron 50 WP recorded significantly less number of mite population (0.18/ leaf) and it was found to be on par with abamectin 1.8 EC. However, during 2011-12, abamectin 1.8 EC recorded the least number of mite count (0.15) and was found to be on par with diafenthuioron 50 WP (0.16), buprofezin 10 EC (0.20), propargite 57 EC (0.20) and profenophos 50 EC (0.27) as compared to untreated check (0.96) (Table 1). Pooled data of 70 and 100 DAT showed that diafethiuron 50 WP had recorded significantly less leaf curl score (0.24 and 0.22 during 2010-11 and 2011-12, respectively) followed by thiamethoxam 25 WG (0.29 and 0.26).

The superiority of thiamethoxam 25 WG, diafenthiuron 50 WP and abamectin 1.8 EC in management of sucking pests *viz.,* aphids, thrips and mites are in agreement with the findings of Nandini *et al.* (2012), Mandal (2012) and Muthukumar *et al.* (2007) also reported the effectiveness of difenthiuron 50 WP, thiamethoxam 77.5g.a.i./ha followed by acetamiprid 20 SP, for the management of aphids and thrips. In the present investigation, NSKE 5 per cent was found to be a promising biorational pesticide against chilli pests. NSKE 5% has been the popular recommendation in IPM of many crops, due to its easy procurabality and simplicity in preparation. Varghese (2003) and Ramaraju (2001) reported the effectiveness of NSKE against sucking pests of chilli, bhendi and brinjal. Sequencial application of NSKE 5% and GCKE 0.5% was found to be effective against sucking insects as reported by Gundannavar *et al.* (2007). In a similar study, Sanjayreddy (2003) reported that the NSKE (2.5%) + GCK (0.5%) would reduce mite population in chilli.

Fruit borer larvae population recorded per plant at different crop stages is presented in Table 2. Pooled data of 60, 90 and 120 DAT shows that significantly minimum number of fruit borer larvae per plant (0.29) was noticed in novuluron 10 EC sprayed plots, which was statistically on par with emamectin benzoate 5 SG (0.30) and spinosad 45 SC (0.32) sprays. But, during 2011-12, novuluron 10 EC spray recorded significantly less number of fruit borer larvae (0.27/plant). However, this was found to be on par with emamectin benzoate 5 SG and spinosad 45 SC.

Table 3. Efficacy of new molecules on dry chilli yield and cost economics

Treatments	Dry chilli yield (q/ha)			Gross Returns (‘/ha)	Total cost of production (‘/ha)	Net Returns (‘/ha)	C:B ratio
	2010-11	2011-12	Pooled				
T_1- Acetamiprid 20 SP @0.3g/l	3.42cd	3.00e	3.21d	26322	13788	12534	1: 1.91
T_2- Thiamethoxam 25 WG @1g/l	3.65c	3.85c	3.75c	38130	15469	22661	1: 2.46
T_3- Thiacloprid 480 SC @ 1ml/l	3.28d	3.68c	3.48d	28536	14359	14177	1: 1.98
T_4- Abamectin 1.8 EC @ 0.5ml/l	3.91b	4.12b	3.83c	31406	14485	16921	1: 2.17
T_5- NSKE 5% @ 50ml/l	2.58e	2.50f	2.54f	20828	12169	8659	1: 1.71
T_6- Diafenthiuron 50 WP @0.75g/l	4.55a	4.75a	4.65a	38130	14835	23295	1: 2.57
T_7- Buprofezin 10 EC @ 0.75ml/l	4.58a	4.40a	4.49a	36818	15372	21446	1: 2.40
T_8- Novaluron 10 EC @ 0.75ml/l	4.00b	4.24b	4.12b	33784	15618	18166	1: 2.16
T_9- Emamectin benzoate 5 SG @ 0.4g/l	4.76a	4.25b	4.51a	36982	16685	20277	1: 2.22
T_{10}- Spinosad 45 SC @ 0.3ml/l	4.50a	4.64a	4.57a	37474	17165	20309	1: 2.18
T_{11}- Imidacloprid 17.8 SL @ 0.3ml/l	3.51cd	3.61c	3.56d	29192	14458	14734	1: 2.02
T_{12}- Propargite 57 EC @ 2.5ml/l	3.00d	3.28d	3.14d	25748	12975	12773	1: 1.98
T_{12}- Profenofos 50 EC @ 2ml/l	3.03d	2.83e	2.93e	24026	12469	11557	1: 1.93
T_{14}- Garlic Chilli Kerosene Extract 0.5% @ 5ml/l	2.74e	2.54f	2.64f	21648	12378	9270	1: 1.75
T_{15}- Untreated check	2.12e	2.03e	2.07e	16,974	11341	5633	1: 1.49
CV	6.78	7.02	6.38				
S. Em±	0.15	0.17	0.09				
C.D. at 5%	0.41	0.42	0.32				

Pooled mean of four pickings indicated that novaluron 10 EC had recorded significantly less fruit damage (6.52%) and was found to be on par with emamectin benzoate 5 SG, spinosad 45 SC and profenophos 50 EC. These findings are in agreement with the report of Ghosh *et al*. (2009), Udikeri *et al*. (2004), Giraddi *et al*. (2004) and Mallapur (2002). The effect of botanicals on fruit damage was found to be superior to untreated check, but was inferior to new molecules.

The population of coccinellids ranged from 0.31 to 1.17 and 0.26 to 1.13 during 2010-11 and 2011-12, respectively. Significantly higher number of coccinellids (1.17 and 1.13) was noticed in untreated check.However, spraying with spinosad 45 SC (1.14 and 1.11), NSKE 5% (1.12 and 1.10) and ememectin benzoate 5 SG (1.08 and 1.01) was also found to be on par (Table 2). The population of chrysoperla varied from 0.62 (in profenophos 50 EC) to 1.86 (in untreated check) during 2010-11 and 0.58 to 1.81 during 2011-12, respectively. In both the years, significantly less number of chrysoperla was noticed in profenophos 50 EC treated plots (0.62 and 0.58) when compared to other treatments. The present results are in accordance with the findings of Smitha and Giraddi (2006), who reported that the botanical pesticides were quite safe to predatory coccinellids and mites in chilli. Seal *et al.* (2006) also studied the compatibility of insecticides against natural enemies on pepper. Spinosad was found to be slightly harmful while, chlorfenapyr was moderately harmful to *Cryptolaemus* sp. predators. Ghosh *et al.* (2010) indicated that spinosad at 73 to 84 g a.i./ ha was very safe to important predators. Sheeba and Kuttalam (2011) reported that emamectin benzoate 5 SG and 1.9 EC would be safer to coccinellids. The present studies indicted that the pesticides from biological origin and neem based formulations might be relatively less harmful to the natural enemies than insecticide like imidacloprid and cypermethrin.

Pooled data revealed that significantly higher yield (4.65 q/ha) was recorded in difenthiuron 50 WP treatment. Cost effectiveness of each treatment was analysed based on net returns. Among the different treatments thiamethoxam 70WS spray registered the maximum net return (Rs 22,661) (Table 3). The result of present experiments conclusively revealed that thiamethoxam 25WG @ 1 g/l, abamectin 1.8EC @ 0.5ml/l, diafenthiuron 50 WP @ 0.75g/l could be effectively used for the management of chilli sucking pests. Novaluron 10 EC @ 0.75ml/l, emamectin benzoate 5SG @ 0.4g/l and spinosad 45 SC @ 0.3ml/l will be quite promising to control *H. armigera*. Significantly increased yield (4.65 q/ha) was recorded with diafenthiuron 50 WP @ 0.75g/l treatment with the maximum net return (Rs 22,661/ ha).

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