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Effectiveness of Various Modules Against Pest Complex on Capsicum (*Capsicum annum* L.) under Protected Conditions

Gupta J.K.[1], Meena K.A.[1*], Meena R.L.[2] and Nagal G.[3]
[1]Assistant Professor, Department of Entomology,
SKN Agriculture University, Jobner, Jaipur (Rajasthan), India.
[2]Assistant Professor, Department of Plant Pathology,
SKN Agriculture University, Jobner, Jaipur (Rajasthan), India.
[3]Subject Matter Specialist (Plant Protection),
Krishi Vigyan Kendra, Phalodi, Jodhpur-II, Agriculture University, Jodhpur (Rajasthan), India.

(Corresponding author: Meena K.A.)*
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ABSTRACT: The field experiment was conducted under shade net house at Hi-Tech Horticulture Farm, Rajasthan Agricultural Research Institute, Durgapura (Sri Karan Narendra Agriculture University, Jobner), Jaipur, Rajasthan to investigate the effectiveness of IPM modules on the reduction of yellow mite, thrips, whitefly, aphid and beet armyworm during summer 2014 and 2015 on capsicum (*Capsicum annum* L). The experiment comprised three IPM modules along with local check replicated seven times under randomized block design. The treatments were imposed at an interval of 20 days, starting from initial notice of pest population up to six treatment spray observation. The results revealed that during 2014 and 2015 all the treatments significantly reduce the population of capsicum pests over untreated control. The findings revealed that Module-II (M-II), chemically intensive module (imidacloprid 17.8 SL (0.0089%) - dimethoate 30 EC (0.051%) - emamectin benzoate 5 SG (0.002%) - fenazaquin 10 EC (0.02%) - dicofol 18.5 EC (0.37%) - acephate 75 SP (0.075%) proved significantly most effective reducing mite (62.38%), thrips (61.48%), whitefly (58.54%), aphid (58.46%) and beet armyworm (46.80%) on the basis of Pooled observation of 1, 3, 7 and 15 days after spray during 2014 and 2015. Module-I (M-I), IIHR based module comprising (profenophos 50 EC (0.1%) - NSKE 5% - emamectin benzoate 5 SG (0.002%) - *Verticillium lecanii* (0.004%) - fenazaquin 10 EC (0.02%) - profenophos 50 EC (0.1%) showed effective reduction against mite, aphid and beet army worm and least effective against whitefly and thrips. Module-III (M-III), bio-rational module comprising (imidacloprid 17.8 SL (0.0058%) - azadirachtin 0.15 EC (0.0003%) - emamectin benzoate 5 SG (0.002%) - NSKE (5%) - *Verticillium lecanii* (0.004%) - imidacloprid 17.8 SL (0.0058%) observed effective in reduction of whitefly, thrips, aphid and beet armyworm and least effective against mite. Study revealed that imidacloprid 17.8 SL @ 0.5 ml/l, dimethoate 30 EC @ 1.7 ml/l, emamectin benzoate 5 SG @ 0.4 gm/l, fenazaquin 10 EC @ 1 ml/l, dicofol 18.5 EC @ 2 ml/l and acephate 75 SP @ 1 gm/l can be suggested to the farmers for the management of various pest on capsicum under shade net house conditions during summer for off season production.

Keywords: *Capsicum annum*, pest complex, shade net house, protected conditions, efficacy, modules.

INTRODUCTION

Capsicum is one of the most popular and highly remunerative vegetable crops grown in most parts of the world, *viz.*, China, Spain, Mexico, Romania, Yugoslavia, Bulgaria, USA, India, Europe, Central and South America are the major countries producing capsicum. In India, capsicum is extensively cultivated in Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Himachal Pradesh, and hilly areas of Uttar Pradesh. Capsicum, also known as sweet pepper, bell pepper, green pepper or Shimla mirch, is one of the popular vegetables grown throughout India. It differs from hot chilli in size, fruit shape, capsaicin content and usage. It is a cool season crop, but it can be grown round the year using protected structures. A fresh, crisp green bell pepper is a tasty vegetable that can be a regular part of our healthy eating plan. This vegetable is low in calories and contains zero grams of fat and is a good supplier of vitamins and minerals. Annual capsicum production in India in the year 2023 accounted to 602 thousand metric tons from an area of 39 thousand ha (Anonymous, 2023).

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 provides 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 with 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. Reddy (2005) reported that chilli mite (*Polyphagotarsonemus latus* Banks) and thrips (*S. dorsalis)* as major pest infesting sweet pepper both under protected and open field conditions. Sunitha (2007) has also revealed the occurrence of aphids, thrips and mites as major pests in capsicum. Gupta *et al.* (2016) reported yellow mite as prominent pest infesting capsicum under shade net house in Rajasthan. Meena *et al.* (2013) reported the yellow mite as an important pest infesting chilli in Rajasthan. Both nymphs and adults feed on leaves, bud and fruits and suck sap from plant parts which in turn cause upward curling of leaves and 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 hectare 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 50-90 per cent due to insect pests (Borah, 1987; Nelson and Natrajan 1994). The damage due to mites and thrips together had been estimated to the tune of 34.4 and 50 per cent under open field conditions (Ahmed *et al.*, 1987; Kandasamy *et al*., 1990). Considering the economic importance of pest, the study was conducted to test the efficacy of bio-rationals and newer insecticides molecules against pest complex under shade net house conditions.

MATERIAL AND METHODS

The field trials were conducted under shade net house at Hi-Tech Horticulture Farm, Rajasthan Agriculture Research Institute, Durgapura (Sri Karan Narendra Agriculture University, Jobner), Jaipur, Rajasthan during summer 2014 and 2015. The experiment was laid out in a Randomized Block Design with 4 modules and seven replications including untreated check. Thirty days old seedling of capsicum were transplanted in each treatment with plot size 4 × 1.0 m^2, keeping row to row and plant to plant distance of 0.50 m and 0.40 m. The details of four modules consisting of 11 insecticides/bio-pesticides have been given in Table 1, were evaluated for effectiveness against pest complex under protected conditions. Six consecutive sprays were applied at 20 days interval starting from sufficient pest built-up. Treatments were imposed by using pre calibrated knapsack sprayer with 500-550 liters spray solution/ha depending on 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 pest complex was recorded at one day before spraying and 1, 3, 7 and 15 days after each spray. The pests were counted on five randomly selected tagged plants per plot during early hours of the day when they remain less active. The population of yellow mite was recorded by counting both nymphs and adults from three leaves representing top, middle and bottom portion of each tagged plant were plucked randomly and kept in separate polythene bags, which were properly labelled and brought to the laboratory for observing in binocular. The per cent reduction in the population of pest complex was worked out and transformed to arc sine values and the data were subjected to analysis of variance for 2014 and 2015 separately and Pooled. The per cent 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 = $\{1-(T_a \times C_b / T_b \times C_a)\ 100\}$

Where,

T_a= Number of insects after treatment in treated plot

T_b= Number of insects before treatment in treated plot

C_a= Number of insects in untreated check after treatment

C_b= Number of insects in untreated check before treatment

Table 1: Details of different modules.

Sr. No.	Spray	Module-I / M-I (IIHR based)	Module-II / M-II (Chemically Intensive)	Module-III / M –III (Bio-rationals)	Module-IV / M-IV (Untreated check)
1.	First spray	Profenophos 50 EC 2 ml/l	Imidacloprid 17.8 SL 0.5 ml/l	Imidacloprid 17.8 SL 0.5 ml/l	Water Spray
2.	Second spray	NSKE 5%	Dimethoate 30 EC 1.7 ml/l	Azadirachtin 0.15 EC 2 ml/l	Water Spray
3.	Third spray	Emamectin benzoate 5 SG 0.4 gm/l	Emamectin benzoate 5 SG 0.4 gm/l	Emamectin benzoate 5 SG 0.4 gm/l	Water Spray
4.	Fourth spray	*Verticillium lecanii* 2 gm/l	Fenazaquin 10 EC 1 ml/l	NSKE 5%	Water Spray
5.	Fifth spray	Fenazaquin 10 EC 1 ml/l	Dicofol 18.5 EC 2 ml/l	*Verticillium lecanii* 2 gm/l	Water Spray
6.	Sixth Spray	Profenophos 50 EC 2 ml/l	Acephate 75 SP 1 gm/l	Imidacloprid 17.8 SL 0.5 ml/l	Water Spray

RESULTS AND DISCUSSION

The results of effectiveness of different IPM modules, namely Module-I (IIHR based) comprising profenophos 50 EC (0.1%) - NSKE 5% - emamectin benzoate 5 SG (0.002%) - *Verticillium lecanii* (0.004%) - fenazaquin 10 EC (0.02%) - profenophos 50 EC (0.1%); Module-II (chemically intensive) comprising imidacloprid 17.8 SL (0.0089%) - dimethoate 30 EC (0.051%) - emamectin benzoate 5 SG (0.002%) - fenazaquin 10 EC (0.02%) - dicofol 18.5 EC (0.37%) - acephate (0.075%) and Module-III (Bio-rationals) comprising imidacloprid 17.8 SL (0.0058%) - azadirachtin 0.15 EC (0.0003%) - emamectin benzoate 5 SG (0.002%) - NSKE (5%) - V*erticillium lecanii* (0.004%) - imidacloprid 17.8 SL (0.0058%) were evaluated against the pest complex on capsicum under shade net house conditions. The observations were taken one day before the first spray on yellow mite population in all the treatments including untreated check revealed non-significant among them in both the years. Analysis of variance showed that treatment applications had significant effect on the mortality of pests over the untreated control in all applications during both the years. However, significant differences existed among them. The data on per cent reduction obtained after each spray are summarized in Table 2-11 inclusive Pooled data for two years. The trend of relative efficacy of various treatments has been described below based on Pooled data.

The application of Module-II (M-II) proved significantly most effective in reducing population of mite (52.48%), thrips (47.96%), aphids (49.80%), white fly (46.22%), beet army worm (46.69%) at one day after spray. The next module in order of efficacy was Module-I (M-I) with 46.47 per cent in mite population reduction. With regards to other insects, Module-III (M-III) proved next, in order of efficacy with 41.34, 42.23, 42.13 and 41.57 per cent reduction in thrips, aphids, whitefly and beet armyworm population, respectively. Module-I (M-I) proved the least effective with 39.56, 38.5, 39.21 and 37.18 per cent reduction in thrips, aphids, whitefly and beet armyworm population, respectively. At three days after spray, Module-II (M-II) proved significantly most effective in reducing population of mite (72.05%), thrips (74.83 %), aphids (70.22 %), whitefly (70.90%) and beet armyworm (71.05 %). With regards to other insects, Module-III (M-III) proved next, in order of efficacy with 66.04, 63.15, 64.66 and 58.24 per cent reduction in thrips, aphids, whitefly and beet armyworm population, respectively. Module-I (M-I) proved the least effective with 65.25, 61.33, 61.62 and 56.93 per cent reduction in thrips, aphids, whitefly and beet armyworm population, respectively. At seven days after spray, Module-II (M-II) proved significantly most effective in reducing population of mite (68.65%), thrips (73.91%), aphids (69.85%), white fly (70.99%) and beet armyworm (64.56%). The next module in order of efficacy was Module-I (M-I) with 63.23 per cent reduction in mite population. With regards to other insects, Module-III (M-III) proved next, in order of efficacy with 64.96, 60.80, 66.55 and 58.75 per cent reduction in thrips, aphids, whitefly and beet armyworm population, respectively. Module-I (M-I) proved least effective with 64.03, 60.73, 62.93 and 57.67 per cent reduction in thrips, aphids, whitefly and beet armyworm population, respectively. At fifteen days after spray, Module-II (M-II) proved significantly most effective in reducing population of mite (56.35%), thrips (49.40%), aphids (43.99%), white fly (46.62%) and beet armyworm (43.82%). The next module in order of efficacy was Module-I (M-I) with 48.36 per cent reduction in mite population. With regards to other insects, Module-III (M-III) proved next, in order of efficacy with 45.07, 39.17, 41.98 and 37.88 per cent reduction in thrips, aphids, whitefly and beet armyworm population, respectively. Module-I (M-I) proved least effective with 41.29, 35.67, 39.76 and 36.07 per cent reduction in thrips, aphids, whitefly and beet armyworm population, respectively. Module-I (M-I) was found to be in the middle order of efficacy. Module-III (M-III) was proved to be least effective. Honnamma Rani (2001); Reddy and Kumar (2006); Nandini *et al*. (2011); Halder *et al.* (2016); Kurbett *et al.* (2018) support the present findings.

Table 2: Efficacy of different IPM modules against yellow mite, *Polyphagotarsonemus latus* Banks on capsicum during 2014 and 2015.

Module	Treatments	Per cent reduction in population of yellow mite days after spray*					
		1 DAS			3 DAS		
		2014	2015	Pooled	2014	2015	Pooled
M-I (IIHR Based)	Profenophos 50 EC (0.1%) - NSKE 5% - Emamectin benzoate 5 SG (0.002%) - *Verticillium lecanii* (0.004%) - Fenazaquin 10 EC (0.02%) - Profenophos 50 EC (0.1%)	51.22 (45.70)	42.26 (40.54)	46.47 (43.12)	63.70 (52.98)	64.52 (53.46)	64.11 (53.22)
M-II (Chemically intensive)	Imidacloprid 17.8 SL (0.0089%) - Dimethoate 30 EC (0.051%) - Emamectin benzoate 5 SG (0.002%) - Fenazaquin 10 EC (0.02%) - Dicofol 18.5 EC (0.37%) - Acephate (0.075%)	56.50 (48.75)	48.46 (44.12)	52.48 (46.44)	74.69 (59.82)	69.40 (56.43)	72.05 (58.13)
M-III (Bio-rational)	Imidacloprid 17.8 SL (0.0058%) - Azadirachtin 0.15 EC (0.0003%) - Emamectin benzoate 5 SG (0.002%) - NSKE (5%) - *Verticillium lecanii* (0.004%) - Imidacloprid 17.8 SL (0.0058%)	43.33 (41.16)	34.05 (35.69)	38.69 (38.43)	52.90 (46.66)	45.72 (42.54)	49.31 (44.60)
M-IV (control)	**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)
	S Em±	(1.12)	(0.84)	(0.70)	(1.06)	(0.92)	(0.70)
	C.D (P=0.05)	(3.34)	(2.48)	(2.01)	(3.15)	(2.74)	(2.01)

*Mean of six sprays and three replications; Figures in the parentheses are arc sine transformed values; DAS: Days after spray

Table 3: Efficacy of different IPM modules against yellow mite, *Polyphagotarsonemus latus* Banks on capsicum during 2014 and 2015.

Module	Treatments	Per cent reduction in population of yellow mite days after spray*					
		7 DAS			15 DAS		
		2014	2015	Pooled	2014	2015	Pooled
M-I (IIHR Based)	Profenophos 50 EC (0.1%) - NSKE 5%- Emamectin benzoate 5 SG (0.002%) -*Verticillium lecanii* (0.004%) - Fenazaquin 10 EC (0.02%) - Profenophos 50 EC (0.1%)	62.86 (52.50)	61.59 (51.71)	62.23 (52.11)	49.65 (44.80)	47.06 (43.31)	48.36 (44.06)
M-II (Chemically intensive)	Imidacloprid 17.8 SL (0.0089%) - Dimethoate 30 EC (0.051%) - Emamectin benzoate 5 SG (0.002%) - Fenazaquin 10 EC (0.02%) - Dicofol 18.5 EC (0.37%) - Acephate (0.075%)	71.87 (58.01)	65.42 (54.01)	68.65 (56.01)	56.83 (48.93)	55.87 (48.38)	56.35 (48.66)
M-III (Bio-rational)	Imidacloprid 17.8 SL (0.0058%) - Azadirachtin 0.15 EC (0.0003%) - Emamectin benzoate 5 SG (0.002%) - NSKE (5%) - *Verticillium lecanii* (0.004%) - Imidacloprid 17.8 SL (0.0058%)	53.52 (47.02)	46.74 (43.13)	50.13 (45.08)	41.04 (39.83)	39.94 (39.18)	40.49 (39.51)
M-IV (control)	**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)
	Sem±	(1.54)	(0.94)	(0.90)	(1.01)	(0.78)	(0.64)
	C.D (5%)	(4.56)	(2.79)	(2.58)	(3.00)	(2.32)	(1.83)

*Mean of six sprays and three replications
Figures in the parentheses are arc sine transformed values
DAS: Days after spray

Table 4: Efficacy of different IPM modules against thrips, *Scirtothrips dorsalis* Hood on capsicum during 2014 and 2015.

Module	Treatments	Per cent reduction in population of thrips days after spray*					
		1 DAS			3 DAS		
		2014	2015	Pooled	2014	2015	Pooled
M-I (IIHR Based)	Profenophos 50 EC (0.1%) - NSKE 5% - Emamectin benzoate 5 SG (0.002%) -*Verticillium lecanii* (0.004%) - Fenazaquin 10 EC (0.02%) - Profenophos 50 EC (0.1%)	39.77 (39.09)	39.34 (38.83)	39.56 (38.96)	64.56 (53.5)	65.93 (54.35)	65.25 (53.93)
M-II (Chemically intensive)	Imidacloprid 17.8 SL (0.0089%) - Dimethoate 30 EC (0.051%) - Emamectin benzoate 5 SG (0.002%) - Fenazaquin 10 EC (0.02%) - Dicofol 18.5 EC (0.37%) - Acephate (0.075%)	47.61 (43.63)	47.96 (43.82)	47.79 (43.73)	74.47 (59.67)	75.18 (60.14)	74.83 (59.91)
M-III (Bio-rational)	Imidacloprid 17.8 SL (0.0058%) - Azadirachtin 0.15 EC (0.0003%) - Emamectin benzoate 5 SG (0.002%) - NSKE (5%) - *Verticillium lecanii* (0.004%) - Imidacloprid 17.8 SL (0.0058%)	40.03 (39.24)	42.65 (40.77)	41.34 (40.01)	65.37 (54.01)	66.71 (54.77)	66.04 (54.39)
M-IV (control)	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)
	Sem±	(0.7)	(0.78)	(0.52)	(1.21)	(0.91)	(0.76)
	C.D (5%)	(2.07)	(2.31)	(1.50)	(3.6)	(2.7)	(2.17)

*Mean of three sprays and three replications
Figures in the parentheses are arc sine transformed values
DAS: Days after spray

Table 5: Efficacy of different IPM modules against thrips, *Scirtothrips dorsalis* Hood on capsicum during 2014 and 2015.

Module	**Treatments**	**Per cent reduction in population of thrips days after spray***					
		7 DAS			**15 DAS**		
		2014	**2015**	**Pooled**	**2014**	**2015**	**Pooled**
M-I (IIHR Based)	Profenophos 50 EC (0.1%) - NSKE 5% - Emamectin benzoate 5 SG (0.002%) -*Verticillium lecanii* (0.004%) - Fenazaquin 10 EC (0.02%) - Profenophos 50 EC (0.1%)	61.74 (51.82)	66.31 (54.54)	64.03 (53.18)	40.17 (39.31)	42.41 (40.61)	41.29 (39.96)
M-II (Chemically intensive)	Imidacloprid 17.8 SL (0.0089%) - Dimethoate 30 EC (0.051%) - Emamectin benzoate 5 SG (0.002%) - Fenazaquin 10 EC (0.02%) - Dicofol 18.5 EC (0.37%) - Acephate (0.075%)	73.73 (59.22)	74.08 (59.44)	73.91 (59.33)	48.96 (44.4)	49.83 (44.9)	49.40 (44.65)
M-III (Bio-rational)	Imidacloprid 17.8 SL (0.0058%) - Azadirachtin 0.15 EC (0.0003%) - Emamectin benzoate 5 SG (0.002%) - NSKE (5%) - *Verticillium lecanii* (0.004%) - Imidacloprid 17.8 SL (0.0058%)	66.67 (54.74)	67.25 (55.09)	66.96 (54.92)	44.53 (41.86)	45.60 (42.47)	45.07 (42.17)
M-IV (control)	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)
	Sem±	(0.96)	(0.89)	(0.65)	(0.86)	(0.87)	(0.61)
	C.D (5%)	(2.85)	(2.65)	(1.88)	(2.54)	(2.57)	(1.75)

*Mean of three sprays and three replications
Figures in the parentheses are arc sine transformed values
DAS; Days after spray

Table 6: Efficacy of different IPM modules against aphids, *Aphis gosspii* on capsicum during 2014 and 2015.

Module	**Treatments**	**Per cent reduction in population of aphid days after spray***					
		1 DAS			**3 DAS**		
		2014	**2015**	**Pooled**	**2014**	**2015**	**Pooled**
M-I (IIHR Based)	Profenophos 50 EC (0.1%) - NSKE 5% - Emamectin benzoate 5 SG (0.002%) -*Verticillium lecanii* (0.004%) - Fenazaquin 10 EC (0.02%) - Profenophos 50 EC (0.1%)	37.44 (37.56)	39.66 (39.02)	38.55 (38.29)	61.81 (51.86)	60.85 (51.3)	61.33 (51.58)
M-II (Chemically intensive)	Imidacloprid 17.8 SL (0.0089%) - Dimethoate 30 EC (0.051%) - Emamectin benzoate 5 SG (0.002%) - Fenazaquin 10 EC (0.02%) - Dicofol 18.5 EC (0.37%) - Acephate (0.075%)	51.19 (45.68)	48.40 (44.07)	49.80 (44.87)	72.00 (58.06)	68.44 (55.95)	70.22 (57.01)
M-III (Bio-rational)	Imidacloprid 17.8 SL (0.0058%) - Azadirachtin 0.15 EC (0.0003%) - Emamectin benzoate 5 SG (0.002%) - NSKE (5%) - *Verticillium lecanii* (0.004%) - Imidacloprid 17.8 SL (0.0058%)	43.40 (41.2)	41.06 (39.81)	42.23 (40.5)	64.36 (53.36)	61.93 (51.93)	63.15 (52.65)
M-IV (control)	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)
	S Em±	(1.61)	(1.03)	(0.95)	(0.99)	(1.41)	(0.86)
	C.D (P=0.05)	(4.77)	(3.07)	(2.74)	(2.95)	(4.2)	(2.48)

*Mean of three sprays and three replications
Figures in the parentheses are arc sine transformed values
DAS: Days after spray

Table 7: Efficacy of different IPM modules against aphids, *Aphis gosspii* on capsicum during 2014 and 2015.

Module	Treatments	Per cent reduction in population of aphid days after spray*					
		7 DAS			15 DAS		
		2014	2015	Pooled	2014	2015	Pooled
M-I (IIHR Based)	Profenophos 50 EC (0.1%) - NSKE 5% - Emamectin benzoate 5 SG (0.002%) -*Verticillium lecanii* (0.004%) - Fenazaquin 10 EC (0.02%) - Profenophos 50 EC (0.1%)	59.48 (50.5)	61.98 (51.95)	60.73 (51.22)	36.14 (36.94)	35.20 (36.33)	35.67 (36.66)
M-II (Chemically intensive)	Imidacloprid 17.8 SL (0.0089%) - Dimethoate 30 EC (0.051%) - Emamectin benzoate 5 SG (0.002%) - Fenazaquin 10 EC (0.02%) - Dicofol 18.5 EC (0.37%) - Acephate (0.075%)	71.17 (57.54)	68.52 (55.93)	69.85 (56.73)	44.20 (41.67)	43.78 (41.42)	43.99 (41.55)
M-III (Bio-rational)	Imidacloprid 17.8 SL (0.0058%) - Azadirachtin 0.15 EC (0.0003%) - Emamectin benzoate 5 SG (0.002%) - NSKE (5%) - *Verticillium lecanii* (0.004%) - Imidacloprid 17.8 SL (0.0058%)	62.43 (52.25)	59.16 (50.31)	60.80 (51.28)	39.78 (39.1)	38.56 (38.37)	39.17 (38.74)
M-IV (control)	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)
	Sem±	(1.55)	(1.76)	(1.17)	(0.8)	(1.13)	(0.69)
	C.D (5%)	(4.60)	(5.24)	(3.36)	(2.38)	(3.37)	(1.99)

*Mean of three sprays and three replications
Figures in the parentheses are arc sine transformed values
DAS: Days after spray

Table 8: Efficacy of different IPM modules against whitefly, *Bemisia tabaci* on capsicum during 2014 and 2015.

Module	Treatments	Per cent reduction in population of whitefly days after spray*					
		1 DAS			3 DAS		
		2014	2015	Pooled	2014	2015	Pooled
M-I (IIHR Based)	Profenophos 50 EC (0.1%) - NSKE 5% - Emamectin benzoate 5 SG (0.002%) -*Verticillium lecanii* (0.004%) - Fenazaquin 10 EC (0.02%) - Profenophos 50 EC (0.1%)	40.83 (39.71)	37.59 (37.78)	39.21 (38.75)	62.53 (52.26)	60.71 (51.22)	61.62 (51.74)
M-II (Chemically intensive)	Imidacloprid 17.8 SL (0.0089%) - Dimethoate 30 EC (0.051%) - Emamectin benzoate 5 SG (0.002%) - Fenazaquin 10 EC (0.02%) - Dicofol 18.5 EC (0.37%) - Acephate (0.075%)	47.59 (43.62)	44.84 (42)	46.22 (42.81)	72.23 (58.21)	69.56 (56.58)	70.90 (57.4)
M-III (Bio-rational)	Imidacloprid 17.8 SL (0.0058%) - Azadirachtin 0.15 EC (0.0003%) - Emamectin benzoate 5 SG (0.002%) - NSKE (5%) - *Verticillium lecanii* (0.004%) - Imidacloprid 17.8 SL (0.0058%)	43.29 (41.13)	40.97 (39.78)	42.13 (40.46)	66.96 (55.06)	62.35 (52.17)	64.66 (53.62)
M-IV (control)	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)
	Sem±	(0.96)	(1.21)	(0.77)	(1.47)	(1.16)	(0.94)
	C.D (5%)	(2.85)	(3.6)	(2.21)	(4.37)	(3.45)	(2.69)

*Mean of three sprays and three replications
Figures in the parentheses are arc sine transformed values
DAS: Days after spray

Table 9: Efficacy of different IPM modules against whitefly, *Bemisia tabaci* on capsicum during 2014 and 2015.

Module	Treatments	Per cent reduction in population of whitefly days after spray*					
		7 DAS			15 DAS		
		2014	2015	Pooled	2014	2015	Pooled
M-I (IIHR Based)	Profenophos 50 EC (0.1%) - NSKE 5% - Emamectin benzoate 5 SG (0.002%) -*Verticillium lecanii* (0.004%) - Fenazaquin 10 EC (0.02%) - Profenophos 50 EC (0.1%)	64.32 (53.32)	61.53 (51.7)	62.93 (52.51)	41.07 (39.85)	38.44 (38.25)	39.76 (39.05)
M-II (Chemically intensive)	Imidacloprid 17.8 SL (0.0089%) - Dimethoate 30 EC (0.051%) - Emamectin benzoate 5 SG (0.002%) - Fenazaquin 10 EC (0.02%) - Dicofol 18.5 EC (0.37%) - Acephate (0.075%)	72.30 (58.27)	69.67 (56.7)	70.99 (57.49)	47.74 (43.7)	45.49 (42.37)	46.62 (43.04)
M-III (Bio-rational)	Imidacloprid 17.8 SL (0.0058%) - Azadirachtin 0.15 EC (0.0003%) - Emamectin benzoate 5 SG (0.002%) - NSKE (5%) - *Verticillium lecanii* (0.004%) - Imidacloprid 17.8 SL (0.0058%)	66.77 (54.81)	66.33 (54.56)	66.55 (54.69)	43.64 (41.33)	40.32 (39.39)	41.98 (40.36)
M-IV (control)	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)
	Sem±	(0.72)	(1.47)	(0.82)	(0.94)	(1.36)	(0.83)
	C.D (5%)	(2.13)	(4.36)	(2.34)	(2.8)	(4.03)	(2.37)

*Mean of three sprays and three replications
Figures in the parentheses are arc sine transformed values
DAS: Days after spray

Table 10: Efficacy of different IPM modules against beet army worm, *Spodoptera exigua* on capsicum during 2014 and 2015.

Module	Treatments	Per cent reduction in population of beet armyworm days after spray*					
		1 DAS			3 DAS		
		2014	2015	Pooled	2014	2015	Pooled
M-I (IIHR Based)	Profenophos 50 EC (0.1%) - NSKE 5% - Emamectin benzoate 5 SG (0.002%) -*Verticillium lecanii* (0.004%) - Fenazaquin 10 EC (0.02%) - Profenophos 50 EC (0.1%)	37.40 (37.67)	36.95 (37.36)	37.18 (37.52)	57.37 (49.26)	55.49 (48.17)	56.43 (48.72)
M-II (Chemically intensive)	Imidacloprid 17.8 SL (0.0089%) - Dimethoate 30 EC (0.051%) - Emamectin benzoate 5 SG (0.002%) - Fenazaquin 10 EC (0.02%) - Dicofol 18.5 EC (0.37%) - Acephate (0.075%)	47.53 (43.58)	45.84 (42.6)	46.69 (43.09)	70.53 (57.15)	71.56 (57.88)	71.05 (57.52)
M-III (Bio-rational)	Imidacloprid 17.8 SL (0.0058%) - Azadirachtin 0.15 EC (0.0003%) - Emamectin benzoate 5 SG (0.002%) - NSKE (5%) - *Verticillium lecanii* (0.004%) - Imidacloprid 17.8 SL (0.0058%)	42.21 (40.5)	40.93 (39.71)	41.57 (40.11)	59.73 (50.62)	56.75 (48.91)	58.24 (49.77)
M-IV (control)	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)
	Sem±	(0.94)	(1.32)	(0.81)	(1.06)	(1.62)	(0.97)
	C.D (5%)	(2.79)	(3.92)	(2.32)	(3.16)	(4.83)	(2.78)

*Mean of four sprays and three replications
Figures in the parentheses are arc sine transformed values
DAS: Days after spray

Table 11: Efficacy of different IPM modules against beet army worm, *Spodoptera exigua* on capsicum during 2014 and 2015.

Module	Treatments	Per cent reduction in population of beet armyworm days after spray*					
		7 DAS			15 DAS		
		2014	2015	Pooled	2014	2015	Pooled
M-I (IIHR Based)	Profenophos 50 EC (0.1%) - NSKE 5% - Emamectin benzoate 5 SG (0.002%) -*Verticillium lecanii* (0.004%) - Fenazaquin 10 EC (0.02%) - Profenophos 50 EC (0.1%)	58.42 (49.88)	56.91 (49.00)	57.67 (49.44)	36.78 (37.28)	35.36 (36.44)	36.07 (36.86)
M-II (Chemically intensive)	Imidacloprid 17.8 SL (0.0089%) - Dimethoate 30 EC (0.051%) - Emamectin benzoate 5 SG (0.002%) - Fenazaquin 10 EC (0.02%) - Dicofol 18.5 EC (0.37%) - Acephate (0.075%)	66.15 (54.44)	62.97 (52.57)	64.56 (53.51)	45.54 (42.44)	42.10 (40.41)	43.82 (41.43)
M-III (Bio-rational)	Imidacloprid 17.8 SL (0.0058%) - Azadirachtin 0.15 EC (0.0003%) - Emamectin benzoate 5 SG (0.002%) - NSKE (5%) - *Verticillium lecanii* (0.004%) - Imidacloprid 17.8 SL (0.0058%)	60.45 (51.04)	57.05 (49.07)	58.75 (50.06)	38.07 (38.04)	37.50 (37.72)	37.79 (37.88)
M-IV (control)	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)
	Sem±	(1.00)	(1.35)	(0.84)	(1.36)	(1.22)	(0.91)
	C.D (5%)	(2.97)	(4.02)	(2.41)	(4.03)	(3.63)	(2.62)

*Mean of four sprays and three replications
Figures in the parentheses are arc sine transformed values
DAS: Days after spray

CONCLUSIONS

Studies on evaluation of IPM module for the management of pest complex under shade net conditions indicated that chemically intensive module (M-II) was found significantly superior. The module based on IIHR Bangalore (M-I) showed effective reduction of mite and bio-rationals module (M-III) with respect to crop damage (leaf curl due to mite), and chemically intensive module (M-II) was found significantly superior. Module-I (M-I) was moderate in effectiveness. Module-III (M-III) was found to be the least effective.

FUTURE SCOPE

For effective management of pest complex on capsicum under protected conditions in the future, a suitable IPM module is essential. In developing countries, like India, where pest complex on capsicum under protected conditions poses a severe threat, so there is a critical need for further research. This research should focus on developing and optimizing IPM modules tailored to present conditions and exploring alternative control methods. By advancing these areas, we can enhance the efficacy of pest management efforts and reduce the economic impact of pest complex on capsicum under protected conditions. These modules would also help the farmers to reduce the indiscriminate use of pesticides under protected conditions.

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