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EFFECT OF IPM MODULES ON MAJOR PESTS AND THEIR NATURAL ENEMIES IN KING CHILLI *CAPSICUM CHINENSE* IN NORTHEAST INDIA

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ABSTRACT

A field experiment to evaluate some IPM modules against major pests viz., *Aphis gossypii*, *Myzus persicae*, *Bemisia tabaci* and their natural enemies viz., coccinellids and spiders occurring in king chilli *Capsicum chinense* Jacquin was carried out during rabi (2014-16) at Jorhat, Assam. The results revealed that module M2 with seedling root dip treatment with imidacloprid 17.8 SL @ 40g a.i./ ha + growing of border crop (okra)+ spraying of imidacloprid 17.8SL @ 40g a.i./ ha at 20 days after transplanting at 15 days interval is the most effective in suppressing aphids and whitefly followed by lambdacyhalothrin instead of imidacloprid in both the seasons. The insecticidal treatment modules had a significant effect on the pest and the viral diseases, thereby increasing the yield, with maximum yield obtained in module M_2 (3564.44 kg/ ha) and with a maximum cost-benefit ratio of 1: 4.85.

Key words: *Capsicum chinense*, IPM modules, *Aphis gossypii*, *Myzus persicae*, *Bemisia tabaci*, coccinellids, spiders, imidacloprid, lambdacyhalothrin, seed treatment, spray, yield, cost benefits, Assam

King chilli (*Capsicum chinense* Jacquin) is a semiperennial crop grown extensively in the Northeastern region. This is one of the hottest chilli, with a pleasant and palatable aroma (Baruah et al., 2014), and an important cash crop in the region. Parasar and Deka (2013) reported that this chilli's cost-benefit ratio/ ha was 1: 11.85 in Assam. However, this chilli attracts many insect pests and highly susceptible to viral diseases, which hamper its production. Begam et al. (2016), Thangjam et al. (2017) and Buragohain et al. (2017) reported 19 species of arthropod pests from king chilli, of which sucking pests viz., *Aphis gossypii*, *Myzus persicae* and *Bemisia tabaci* are the primary pests in Assam transmitting major viral diseases. Talukdar et al. (2015) and Baruah et al. (2016) also reported Cucumber Mosaic Virus (CMV), Potato Virus Y (PVY), Tomato spotted wilt virus (TSWV) and ChLCV from this chilli transmitted by aphids, thrips and whitefly, respectively. These deseases reduce the productivity of the crop. Since little work has been done on the management of king chilli's pests, the present study evaluates few IPM modules against the major pests.

MATERIALS AND METHODS

Two field experiments were conducted during rabi 2014-15 and 2015-16 in the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat (26º47´N,94º12´E). The experiment was laid out in an area of 331.5 m^2 following the randomized block design (RBD) with 6 treatments and 4 replications, with each plot measuring 7.5m^2 (3x 2.5m), and the inner spacing between replications and plots were 1 and 0.5 m, respectively. The local variety seeds were sown on 15th September 2014 and transplanted on 10th January 2015 for the first experiment; and sowing was on 20th September 2015 and transplanting on 14th January 2016. A spacing of 75x75 cm was maintained and all the recommended package of practices were followed. The details of the IPM modules are as follows: M1=Soil solarisation of nursery bed for 15 days followed by application of organic amendment (neem cake) @ 50 g/ m^2 +nylon netting (50 mesh size) of nursery+ clean cultivation (weeding and hoeing) at 15 days interval or as and when necessary and spraying of NSKE @4% at 20 days after transplanting at 15 days interval (4 sprays); M2= Seedling root dip treatment with imidacloprid 17.8SL @ 40 g a.i./ ha for 30 min just before transplanting+ growing of border crop (okra) 30 days before transplanting the main crop and spraying of imidacloprid 17.8SL @ 40g a.i./ ha at 20 days after transplanting at 15 days interval (4 sprays); M3= Seedling root dip treatment with imidacloprid 17.8SL @ 40 g a.i./ ha for 30 min just before transplanting+ growing of border crop (marigold) 30 days before transplanting the main crop+ spraying of emamectin benzoate 5%SG @ 10 g a.i./ ha at 20 days after transplanting at 15 days interval (4 sprays); M4= Seedling root dip treatment with imidacloprid 17.8SL @ 40 g a.i./ ha for 30 min just before transplanting+ growing of border crop (maize) 30 days before transplanting the main crop and spraying of lambda cyhalothrin 5EC @ 25 g a.i./ ha starting from 20 days after transplanting (4 sprays); M5= Releases of *Trichogramma chilonis* 6 times @ 1 lakh/ ha/ week at 10 days interval+ spraying of *Beauveria bassiana* @ 2ml/ l at 15 days interval starting from 20 days after transplanting (4 sprays)+ application of spinosad 45SC @ 45 g a.i./ ha starting from 20 days after transplanting (4 sprays)+ installation of yellow sticky traps @ 25 traps/ ha at the time of transplanting; and M6= Untreated control.

During the study, 19 pest species viz., *A. gossypii*, *M. persicae*, *B. tabaci*, *Bactrocera latifrons*, *Scirtothrips dorsalis* and *Polyphagotarsonemus latus*, *Gryllotalpa africana*, *Cofana* sp., *Empoasca* sp., *Amrasca biguttula biguttula*, *Sogatella* sp., *Coccus* sp., *Phenacoccus* sp., *Monolepta signata*, *Spodoptera litura*, *Orvasca* sp., *Agrotis ipsilon*, *Blattella* sp. and *Tetranychus* sp. were observed; however, the incidence of most of these were negligible except the sucking pests, coccinellid beetle and spiders. Therefore these ones were considered for the study. The incidence of insect pests and their natural enemies were recorded from nursery to harvesting at fortnightly interval starting from February's 1st fortnight. For recording the sucking insect pests (aphids and whiteflies), five plants were randomly selected/ plot. The number of insects was recorded from each plant from the top, middle and bottom canopy using a magnifying lens and expressed in numbers/ leaf. The larger ones like e coccinellids and spiders were recorded by counting their number on five plants selected randomly/ plot. The % disease incidence was also calculated by counting the number of infected plants. The Benefit**:** Cost ratio was calculated using the pooled data (2014-16), considering the cost of production and the benefit obtained from each module's yield. The ratio then was estimated over the net return. Net return was calculated by subtracting the total cost of production from the total return. For obtaining the total return, the wholesale price of king chilli (Rs. 250/ kg) was used. The data were subjected to ANOVA using SPSS 16v. The differences between treatments were ascertained by Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

The results of the pooled data (2014-16) reveal that the modules M_2- Seedling root dip treatment with imidacloprid 17.8SL @ 40 g a.i./ ha for 30 min just before transplanting+ growing of border crop (okra) 30 days before transplanting the main crop and spraying of imidacloprid 17.8SL @ 40g a.i./ ha at 20 days after transplanting at 15 days interval (4 sprays) and M_4- Seedling root dip treatment with imidacloprid 17.8SL @ 40 g a.i./ ha for 30 min just before transplanting+ growing of border crop (maize) 30 days before transplanting the main crop and spraying of lambda cyhalothrin 5EC @ 25 g a.i./ ha starting from 20 days after transplanting (4 sprays) were found to be the most effective against aphids and whitefly. However, these modules reveal a negative effect on the coccinellids and spiders. The module M_2 was observed to lead to the least number of aphids (0.15/ leaf) followed by M_4 (0.24/ leaf) and both were on par. The least effective module was found to be M_6 with the highest number of aphids (3.07/ leaf) followed by M_5 (1.38/ leaf) Similar trend was also observed with whitefly- M_2 and M_4 led to the least incidence of whitefly (0.04 and 0.11/ leaf respectively) and were on par (Table 1). These results agree with those of Baruah et al. (2016) on seed treatment with imidacloprid @ 0.25/ l, nursery netting and foliar spray with imidacloprid @ 2ml/ l at 15 days interval in *Bhut Jolokia*. Nadaf (2002) also observed that seed treatment and seedling dip with imidacloprid followed by three sprays is effective in transplanted chilli. Chiranjeevi et al. (2002) also found that seedling root dip with imidacloprid followed by foliar spray of imidacloprid at 15 days interval and foliar spraying of lambda-cyhalothrin were found to be very effective against aphids in chilli. Pawar et al. (2016) and Begum et al. (2016) also found that imidacloprid 17.8 SL @ 20g to 50 g a.i./ ha very effective against aphids and whiteflies in okra and brinjal. Similar results were also reported by Patil et al. (2002), Pandey et al. (2010), Varghese and Mathew (2012) and Das (2013).

The predators coccinellid beetles and spiders were

Tables 1. Effect of IPM modules on sucking pests and their natural enemies in king chilli with their cost benefits (2014-16, pooled)

Treatment modules	Aphid (Number leaf^{-1})	Whitefly (Number leaf^{-1})#	Coccinellid beetles (Number plant^{-1})#	Spiders (Number plant^{-1})#	Viral diseaxe incidecne 60 DAT$	Viral diseaxe incidecne 90 DAT$	Viral diseaxe incidecne 120 DAT$	Viral diseaxe incidecne 150 DAT$
M_1	0.70 (1.09)^b	0.21 (0.84)^b	0.35 (0.92)^b	0.38 (0.94)^c	3.13^a (10.18)	7.29^{ab} (15.66)	12.50^{bc} (20.70)	19.79^b (26.41)
M_2	0.15 (0.81)^a	0.04 (0.73)^a	0.20 (0.83)^a	0.23 (0.85)^b	1.04^a (5.85)	3.13^a (10.18)	5.21^a (13.19)	7.29^a (15.66)
M_3	0.78 (1.13)^b	0.31 (0.90)^c	0.65 (1.07)^d	0.35 (0.92)^c	6.25^b (14.48)	9.38^b (17.83)	16.67^c (24.09)	23.96^b (29.31)
M_4	0.24 (0.86)^a	0.11 (0.78)^a	0.25 (0.87)^a	0.15 (0.80)^a	2.08^a (8.29)	4.17^a (11.78)	8.33^{ab} (16.78)	11.46^a (19.79)
M_5	1.38 (1.37)^c	0.38 (0.94)^c	0.44 (0.97)^c	0.53 (1.01)^d	9.38^c (17.83)	15.63^c (23.28)	25.00^d (30.00)	34.38^c (35.90)
M_6	3.07 (1.89)^d	0.60 (1.05)^d	0.92 (1.19)^e	0.72 (1.10)^e	14.59^d (22.45)	30.21^d (33.34)	43.75^e (41.41)	56.25^d (48.59)
S.Ed. (±)	0.14	0.04	0.04	0.02	1.11	1.80	1.96	1.96
CD $_{(0.05)}$	0.37	0.12	0.09	0.06	2.92	4.74	5.14	5.14

Treatment modules	Total cost of cultivation (Rs./ ha)	*Yield (kg/ ha)	Gross returns (Rs./ ha)	Net returns (Rs./ ha)	B:C ratio
M_1	183781	2303.98	575995.00	392214.00	2.13 : 1
M_2	152201	3564.44	891110.00	738909.00	4.85 : 1
M_3	176318	2100.15	525037.50	348719.50	1.98 : 1
M_4	153881	2687.94	671985.00	518104.00	3.37 : 1
M_5	145691	1511.41	377852.50	232161.50	1.59 : 1
M_6	116181	1059.29	264822.50	148641.50	1.28 : 1

M1=Soil solarisation of nursery bed for 15 days followed by application of organic amendment (neem cake) @ 50 g/ m^2 +nylon netting (50 mesh size) of nursery+ clean cultivation (weeding and hoeing) at 15 days interval or as and when necessary and spraying of NSKE @4% at 20 days after transplanting at 15 days interval (4 sprays); M2= Seedling root dip treatment with imidacloprid 17.8SL @ 40 g a.i./ ha for 30 min just before transplanting+ growing of border crop (okra) 30 days before transplanting the main crop and spraying of imidacloprid 17.8SL @ 40g a.i./ ha at 20 days after transplanting at 15 days interval (4 sprays); M3= Seedling root dip treatment with imidacloprid 17.8SL @ 40 g a.i./ ha for 30 min just before transplanting+ growing of border crop (marigold) 30 days before transplanting the main crop+ spraying of emamectin benzoate 5%SG @ 10 g a.i./ ha at 20 days after transplanting at 15 days interval (4 sprays); M4= Seedling root dip treatment with imidacloprid 17.8SL @ 40 g a.i./ ha for 30 min just before transplanting+ growing of border crop (maize) 30 days before transplanting the main crop and spraying of lambda cyhalothrin 5EC @ 25 g a.i./ ha starting from 20 days after transplanting (4 sprays); M5= Releases of *Trichogramma chilonis* 6 times @ 1 lakh/ ha/ week at 10 days interval+ spraying of *Beauveria bassiana* @ 2ml/ l at 15 days interval starting from 20 days after transplanting (4 sprays)+ application of spinosad 45SC @ 45 g a.i./ ha starting from 20 days after transplanting (4 sprays)+ installation of yellow sticky traps @ 25 traps/ ha at the time of transplanting; and M6= Untreated control. *Data are pooled mean; #Figures in the parentheses are $\sqrt{X+0.5}$ transformed values; $ Figures in the parentheses angular transformed values; In a columns, mean followed by similar letters do not differ statistically by DMRT (p= 0.05); DAT= Days after transplanting; Price of king chilli/ kg Rs. 250

significantly suppressed by the modules with systemic insecticides i.e, M_2 and M_4 led to the least number of coccinellids and spiders due to imidacloprid and lambda cyhalothrin; in these coccinellids (0.20 and 0.25/ plant, respectively) were less, followed by M_1 (0.35/ plant). The module M_4 with lambda cyhalothrin led to the least number of spiders (0.15/ plant) followed by M_2 (imidacloprid as a foliar spray- 0.23/ plant) and significantly differing from each other (Table 1). Maximum number of spiders were observd in M_6 untreated control (0.72/ plant) followed by M_5 (0.53/ plant) and were significantly different. Similar results were obtained by Sechser et al. (2003), Seal et al. (2006) and Khani et al. (2012) with imidacloprid proved to be harmful to coccinellids. Karthikeyan et al. (2008), Fritz et al. (2013) and Rodrigues et al. (2013) observed that spiders were significantly reduced with lambda cyhalothrin was sprayed in rice. Sasikumar and Kumar (2012) also observed that the spiders are reduced with foliar application of lambda cyhalothrin and imidacloprid in sesame crop and Sherawat et al. (2015) with imidacloprid on spiders in Pakistan. The pooled data presented in Table 1 reveals that there was a significant reduction in viral disease incidence in all the treatment modules, ranging from 7.29 to 56.25% at 150 days after transplanting; and among the modules, M_2 was the most effective (7.29 %) followed by M_4 (11.46%) which were on par. These results corroborate with those of Pandey et al. (2010) and Panduranga et al. (2011). Baruah et al. (2016) also observed that seed treatment with imidacloprid @ 0.25/ l + nursery net + foliar spray with imidacloprid @ 2ml/ l at 15 days interval up to 60 days after transplantation was found to be the most effective in reducing the viral disease complex in *Bhut Jolokia*. Raju S.G. (2010) who observed imidacloprid as the most effective minimizing the vector of chilli leaf curl virus as well as disease incidence in chilli. The insecticidal treatment modules had significant effect not only in reducing the aphids and whitefly pests, and viral diseases, but also increased the yield- maximum yield was obtained in module M_2 (3564.44 kg/ ha). The Benefit: Cost ratio was also more in module M_2 (4.85: 1). Similar results were obtained by Baruah (2014) and Begam (2015) in hot chilli from Assam.

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