*Himachal Journal of Agricultural Research 34(2):40-46, 2008*

# Field efficacy of different insecticides and bio-pesticides against fruit borer (*Helicoverpa armigera*) and greenhouse whitefly (*Trialeurodes vaporariorum*) on tomato (*Lycopersicon esculentum*)

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**Abstract**

**Efficacy of different insecticides, bio-pesticides alone and in combination with bioagent *Trichogramma chilonis* was evaluated against tomato fruit borer, *Helicoverpa armigera* and greenhouse whitefly, *Trialeurodes vaporariorum* on tomato under field conditions. The treatments combining Btk (500g/ha) + endosulfan (0.025%), Btk (500g/ha) + deltamethrin (0.0014%), Btk (500g/ha) + acephate (0.025%), HaNPV (250LE) + Btk (500g/ha) + *T. chilonis* (50,000/ha) and acephate (0.025%) + *T. chilonis* (50,000/ha) proved superior to other treatments in suppressing the larval population of *H. armigera* on tomato. In general, acephate (0.05%) alone as well as in combination to Btk and the bioagent, *T. chilonis* performed better in reducing the pest incidence. The bio-pesticides alone were not as effective but the combination of HaNPV (250LE) + Btk (500 g/ha) + *T. chilonis* (50,000 parasitoids/ha) resulted in significantly higher reduction of larval population indicating thereby that biological control of the pest is possible. Imidacloprid (0.0004%) was most effective in suppressing the adult as well as immature population of *T. vaporariorum* followed by acephate (0.05%) and achook (0.00045%).**

**Key Words**: *Helicoverpa armigera, Trialeurodes vaporariorum,* insecticides, bio-pesticides, *Trichogramma chilonis.*

## Introduction

Tomato, *Lycopersicon esculentum* Mill. is an important vegetable crop grown all over the world for fresh market consumption and processing. In Himachal Pradesh, tomato cultivation is stretched all over the state during summer months (April to October) covering an area of 2366 hectares with an annual production of 53578 metric tones (Anonymous, 2003).

The problem of insect-pests poses a major threat to the successful cultivation of this crop. As many as 21 species of insects have been recorded infesting tomato crop in Himachal Pradesh (Sharma, 1975). *Helicoverpa armigera* (Hubner) is a regular pest on tomato (Bhalla and Pawar, 1977) causing losses ranging from 5 to 30 per cent to the crop (Kakar *et al.,* 1980; Verma *et al.,* 1994; Kumar *et al.,* 1999). The greenhouse whitefly, *Trialeurodes vaporariorum* on the other hand is fast emerging as a serious pest of tomato under agro climatic conditions of Himachal Pradesh (Dhillon, 1999). In view of the adverse effects of pesticides to non-target organisms as well as concern for environmental pollution and health hazards in addition to other problems like development of resistance and pest resurgence, the present studies were conducted to evaluate the efficacy of different insecticides/ bio-pesticides and a parasitoid, *T. chilonis* for management of *H. armigera* and *T. vaporariorum* on tomato to minimize the use of pesticides in management of these pests.

## Material and Methods

The field trials were conducted in randomized block design during 2004 and 2005 summer seasons at two locations viz., Palampur (1290m amsl) and Sullah (1000m amsl). The crop was raised as per recommended package of practices (Anonymous, 2003). The healthy 4 week old seedlings of Palam Pride variety of tomato were transplanted during 4$^{th}$ week of April maintaining 90cm x 30cm spacing between rows and plants, respectively. All the treatments were replicated thrice alongwith untreated control in plots of 4mx3m. Four insecticides viz., acephate (Commando 75 SP), imidacloprid (Confidor 200 SL), deltamethrin (Decis 2.8 EC) and endosulfan (Endohit 35 EC), three commercially available bio-pesticides viz., HaNPV (Helicide 100 LE), *Bacillus thuringiensis* var. *kurstaki* (Biolep) and

azadirachtin (Achook) and one egg parasitoid *T. chilonis* were applied in the field alone and in combination as per details given in Tables 1-4.

Spraying was done during 3rd week of June at Sullah and 4th week of June at Palampur when there was sufficient population of the pests on the crop. The spraying was done in the evening hours to protect HaNPV from sunlight as well as to avoid any adverse effect on natural enemies. Adjuvants like teepol and jaggery were added to HaNPV before spraying. Single spraying was conducted by mixing two components. Four releases of *T. chilonis* were made starting from the appearance of the pest at weekly interval.

Data on number of larvae of *H. armigera* on ten plants from each replication and number of immatures (nymph + pupae) and adults of *T. vaporariorum* on three plants from each replication were recorded before one day of treatment and after 1, 7 and 14 days of treatment.

Reduction in population over untreated check was worked out as per formula given by Fleming and Retnakaran (1985).

$$\text{Per cent reduction in population} = 1 - \frac{\text{Post treatment population in treatment}}{\text{Pre treatment population in treatment}} \times \frac{\text{Pre treatment population in check}}{\text{Post treatment population in check}} \times 100$$

## Results and Discussion

### Field efficacy against *H. armigera*

Present investigation revealed that all the treatments comprising insecticides, bio-pesticides and bioagent alone or in different combinations with each other resulted in significant reduction in larval population (Tables 1 to 4). The results showed that the insecticides which are environmental friendly and compatible with bioagents will remain an integral part of IPM. Bioagents alone or in combination with each other could reduce the larval population effectively after 7 and 14 days of spray. These findings are in line to those obtained by Shenhmar *et al.* (1996) and Mishra and Srivastava (1996). Other workers have also reported these bio-pesticides to be effective against *H. armigera* with varying degree of success. Kulat *et al.* (1999) also found Btk to be most effective in reducing the larval population of *H. armigera* followed by HaNPV whereas Neem seed extract could not prove effective. Similarly, Barwal (2001) found commercial preparations of Bt to be effective against *H. armigera* and recommended spray of Dipel @ 0.5 kg/ha at 10 days interval.

Four releases of the bioagent *T chilonis* (@ 50,000/ha) were effective in reducing the larval population due to parasitism of eggs as was evident from the pre-treatment population which was lower in *T. chilonis* released plots as compared to all other treatments. However, present study revealed that it was unable to compete alone with other treatments simultaneously under field conditions

In the past also the parasitoid has been used against *H. armigera* with varying degree of success by various workers. Yadav *et al.* (1985) obtained a complete check on *H. armigera* infestation by releasing *T. chilonis* @ 2,50,000 parasitoids per ha at weekly intervals from December to January. Kakar *et al.* (1990) observed 100 per cent parasitism of *H. armigera* eggs in tomato fields in Himachal Pradesh following releases of 5 species of *Trichogramma.*

Felkl *et al.* (1994) found four to five releases of *T. chilonis* at densities ranging from 4,50,000 to 10,00,000 parasitoids/release sufficient to manage the pest on tomato. The inability of *T. chilonis* to provide a complete control of *H. armigera* population on tomato during the present study may be due to the fact that slightly lower rate of release (50,000/ha/release) might have resulted in lower parasitism of eggs which ultimately might have led to incomplete control of the pest during the present study.

Generally the most effective treatments in reduction of larval density were Btk (500g/ha) + acephate (0.025%), Btk (500g/ha) + endosulfan (0.025%), Btk (500g/ha)+ deltamethrin (0.0014%), acephate (0.05%) alone and HaNPV (250LE) + Btk (500g/ha)+ *T. chilonis* (50,000/ha) and which proved far superior to other treatments. Acephate alone has been found quite effective in reducing the larval infestation on tomato thereby increasing the yields substantially. Kumar *et al.* (1999) found acephate (0.05%) to be more effective against *H. armigera* on tomato than endosulfan and fenvalerate and obtained lowest yield loss and highest fruit yield by two sprays of acephate, in H.P. Sahoo and Senapati (2000) also reported similar results in reduction of larval population and pod damage on pigeonpea in Orissa.

Acephate (0.025%) when combined with Btk (500g/ha) also performed well in reducing the larval population. Similar findings were revealed by Divyantoro and Siswojo (1988) by obtaining highest yield of tomato after treatment with a mixture of Btk and acephate.

**Table 1.Field efficacy of insecticides and bio-pesticides against *H. armigera* and *T. vaporariorum* infesting tomato at Palampur during 2004**

| Treatments (Dosages) | Per cent reduction in population | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *H. armigera* | | | | *T. vaporariorum* | | | | | | | |
| | Larvae | | | | Adults | | | | Immatures | | | |
| | PTP* | 1 DAS | 7 DAS | 15 DAS | PTP** | 1 DAS | 7 DAS | 15 DAS | PTP** | 1 DAS | 7 DAS | 15 DAS |
| Acephate (0.05%) | 8.67 | 67.29 (55.12) | 67.64 (55.33) | 58.79 (50.06) | 12.00 | 72.94 (58.64) | 78.23 (62.17) | 70.99 (57.42) | 20.67 | 60.75 (51.19) | 68.56 (55.88) | 65.52 (54.02) |
| Imidacloprid (0.004%) | 9.33 | 32.73 (34.86) | 47.14 (43.34) | 38.61 (38.37) | 9.67 | 81.50 (64.52) | 85.12 (67.29) | 81.85 (65.04) | 24.33 | 78.27 (62.20) | 85.04 (67.25) | 85.33 (67.49) |
| *T. chilonis* (50,000 PE/ha) | 5.33 | 23.74 (29.01) | 23.51 (28.72) | 35.18 (36.35) | 8.67 | 7.42 (15.78) | 3.51 (10.44) | 8.56 (16.90) | 23.33 | 3.96 (11.47) | 9.85 (18.28) | 9.78 (18.15) |
| Ha NPV (250 LE) | 8.00 | 17.80 (24.82) | 38.39 (38.22) | 43.05 (40.96) | 9.67 | 7.81 (16.22) | 3.62 (10.88) | 4.39 (11.89) | 20.67 | 6.58 (14.69) | 5.61 (13.45) | 7.43 (15.72) |
| Btk (500 g/ha) | 9.33 | 26.26 (30.78) | 56.55 (48.74) | 57.41 (49.26) | 10.00 | 8.12 (16.54) | 9.47 (17.81) | 11.99 (20.12) | 24.33 | 2.74 (8.47) | 7.05 (15.00) | 9.44 (17.79) |
| Achook (0.00045%) | 8.67 | 27.77 (31.73) | 42.92 (40.89) | 40.27 (39.37) | 11.33 | 76.33 (60.87) | 70.51 (57.09) | 53.24 (46.84) | 26.00 | 18.51 (25.42) | 72.01 (58.04) | 67.63 (55.31) |
| Btk + deltamethrin (500g/ha + 0.0014%) | 8.67 | 53.03 (46.72) | 68.31 (55.78) | 59.72 (50.62) | 11.33 | 16.24 (23.75) | 22.01 (27.89) | 14.69 (22.34) | 24.00 | 13.18 (21.26) | 21.03 (27.26) | 20.28 (26.63) |
| Btk + endosulfan (500 g/ha + 0.025%) | 9.00 | 65.40 (53.96) | 69.87 (56.89) | 80.70 (63.94) | 12.67 | 15.64 (23.28) | 32.15 (34.53) | 20.09 (26.56) | 20.33 | 9.65 (18.04) | 13.41 (21.44) | 13.99 (21.78) |
| Btk + acephate (500 g/ha + 0.025%) | 8.33 | 54.71 (47.69) | 62.34 (52.18) | 79.24 (62.89) | 11.33 | 29.16 (32.65) | 51.44 (45.81) | 30.42 (33.45) | 19.33 | 25.92 (30.59) | 54.28 (47.44) | 36.37 (37.08) |
| Acephate+*T.chilonis* (0.025%+ 50,000 PE/ha) | 9.00 | 58.35 (49.73) | 60.25 (50.94) | 61.73 (51.77) | 13.33 | 24.28 (29.43) | 53.40 (46.93) | 34.03 (35.66) | 23.33 | 27.81 (31.80) | 53.18 (46.80) | 38.92 (38.57) |
| HaNPV+ T. *chilonis* (250 LE + 50,000 PE/ha) | 9.00 | 24.09 (29.25) | 54.75 (47.71) | 61.54 (51.66) | 10.00 | 7.81 (16.22) | 4.30 (11.95) | 3.18 (10.26) | 19.67 | 6.58 (14.69) | 2.07 (6.69) | 4.33 (11.96) |
| Btk+ T. *Chilonis* (500 g/ha+ 50,000 PE/ha) | 7.33 | 18.93 (25.69) | 44.64 (41.90) | 52.78 (46.58) | 11.00 | 5.59 (11.21) | 8.79 (16.72) | 8.21 (16.09) | 21.00 | 6.58 (14.69) | 3.26 (9.91) | 5.65 (13.50) |
| HaNPV + Btk + *T. chilonis* (250 LE + 500 g /ha + 50,000 PE/ha) | 8.67 | 35.22 (36.38) | 68.60 (55.91) | 81.59 (64.65) | 13.00 | 4.03 (10.21) | 8.04 (16.17) | 5.27 (13.24) | 22.33 | 9.27 (17.68) | 7.96 (16.34) | 5.61 (13.41) |
| CD (P=0.05) | - | 3.43 | 5.87 | 5.19 | - | 5.78 | 5.12 | 5.28 | - | 3.02 | 4.20 | 4.24 |

PTP* – Pre-treatment population (Number of larvae per 10 plants),
PTP**- Pre-treatment population i.e. Number of adults/immature per 3 plants (Population sampled on 3 leaves on each plant)
Figures in parentheses are angular transformed values, DAS – Days after spray

Both endosulfan (0.025%) and deltamethrin (0.014%) also combined well with Btk (500gm/ha) to provide comparatively lower larval infestation. Compatibility of Btk with endosulfan stands already proven in providing better control of the pest. This combination (Btk 0.5 L/ha + endosulfan 0.025%) has even been recommended for control of the pest on tomato (Anonymous, 2003). Kumar and Sharma (2004) also observed that application of 500 ml of Btk + 563 ml of endosulfan resulted in lowest fruit infestation (1.13%) and highest marketable yield (199.5 q/ha). On the other hand, Mehta *et al.* (2000) obtained lowest fruit damage (5.58%) and highest fruit yield (157.96 q/ha) with application of deltamethrin in combination with Btk which also supports the results obtained during the present investigation.

The possible combination of all the bioagents, i.e., HaNPV 250 LE/ha + Btk 500 g/ha + *T. chilonis* @ 50,000/ha resulted in significantly higher reduction in larval population. This provides an effective and practically feasible biocontrol option for management of the pest on tomato.

**Field efficacy against *T. vaporariorum***

Efficacy of insecticides evaluated against adults revealed that imidacloprid proved most effective in control of adult whiteflies on tomato during two seasons of study at both the locations with a reduction in adult population ranging from 77.77 to 81.50 per cent (1 DAT), 82.30-87.22 per cent (7 DAT) and 81.57-85.10 per cent (15 DAT). Acephate and neem based biopesticide, achook were also effective in suppressing the adult population after 1, 7 and 15 days of treatment. Whereas reduction in adult population over untreated check was 70.95-72.94, 74.97-78.23 and 64.86-70.99 per cent after 1, 7 and 15 days,

**Table 2. Field efficacy of insecticides and bio-pesticides against *H. armigera* and *T. vaporariorum* infesting tomato at Palampur during 2005**

| Treatments (Dosages) | Per cent reduction in population | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *H. armigera* | | | | *T. vaporariorum* | | | | | | | |
| | Larvae | | | | Adults | | | | Immatures | | | |
| | PTP* | 1 DAS | 7 DAS | 15 DAS | PTP** | 1 DAS | 7 DAS | 15 DAS | PTP** | 1 DAS | 7 DAS | 15 DAS |
| Acephate (0.05%) | 11.33 | 64.83 (53.62) | 71.67 (57.84) | 61.90 (51.95) | 23.00 | 70.95 (57.37) | 74.97 (59.96) | 64.86 (53.64) | 36.67 | 56.72 (48.84) | 66.61 (54.68) | 52.16 (46.22) |
| Imidacloprid (0.004%) | 11.00 | 35.87 (36.77) | 45.00 (42.10) | 40.95 (39.76) | 21.67 | 77.77 (61.85) | 82.30 (65.09) | 85.10 (67.28) | 35.67 | 79.52 (63.07) | 87.32 (69.11) | 85.82 (67.86) |
| *T. chilonis* (50,000 PE/ha) | 7.00 | 21.25 (27.44) | 23.81 (29.14) | 30.61 (33.55) | 20.67 | 6.86 (15.11) | 4.18 (9.15) | 6.68 (14.51) | 36.67 | 2.20 (8.52) | 4.03 (10.68) | 6.66 (14.64) |
| Ha NPV (250 LE) | 9.67 | 20.70 (26.95) | 37.63 (37.81) | 44.44 (41.17) | 22.67 | 5.58 (13.43) | 8.47 (16.91) | 7.71 (15.65) | 39.67 | 1.63 (7.02) | 3.42 (9.82) | 6.86 (14.94) |
| Btk (500 g/ha) | 9.33 | 26.61 (31.03) | 53.89 (47.21) | 57.07 (49.08) | 19.00 | 4.18 (10.73) | 5.71 (11.34) | 9.86 (18.16) | 36.00 | 3.04 (9.85) | 4.56 (12.05) | 5.24 (13.01) |
| Achook (0.00045%) | 10.67 | 25.38 (30.24) | 43.48 (41.23) | 34.46 (35.89) | 23.33 | 71.35 (57.62) | 69.89 (56.70) | 56.33 (48.62) | 39.67 | 23.96 (29.29) | 71.83 (57.92) | 58.12 (49.65) |
| Btk+deltamethrin (500g/ha + 0.0014%) | 11.67 | 55.46 (48.12) | 71.74 (57.87) | 63.42 (52.78) | 20.33 | 13.23 (21.32) | 19.93 (26.48) | 16.08 (23.54) | 35.33 | 13.65 (21.66) | 22.41 (28.24) | 17.68 (24.82) |
| Btk + endosulfan (500g/ha+0.025%) | 9.33 | 60.52 (51.06) | 73.44 (59.04) | 77.35 (61.75) | 23.00 | 13.94 (21.92) | 27.76 (31.77) | 20.85 (27.05) | 34.00 | 8.49 (16.91) | 14.64 (22.48) | 14.48 (22.29) |
| Btk + acephate (500g/ha+ 0.025%) | 10.67 | 54.06 (47.31) | 65.88 (54.24) | 74.76 (60.05) | 22.00 | 29.02 (32.58) | 42.04 (40.39) | 26.87 (31.17) | 38.67 | 26.92 (31.24) | 54.53 (47.58) | 35.37 (36.46) |
| Acephate + *T.chilonis* (0.025%+ 50,000 PE/ha) | 11.00 | 52.66 (46.51) | 64.66 (53.51) | 66.04 (54.36) | 18.67 | 28.38 (32.17) | 42.81 (40.84) | 31.28 (33.99) | 34.67 | 24.03 (29.34) | 50.09 (45.04) | 33.49 (35.33) |
| HaNPV + T. *chilonis* (250LE + 50,000 PE/ha) | 12.00 | 23.73 (29.12) | 61.35 (51.54) | 60.51 (51.07) | 21.67 | 4.94 (12.64) | 5.63 (11.26) | 8.61 (16.94) | 39.67 | 4.80 (12.65) | 3.90 (11.38) | 7.01 (15.15) |
| Btk+ T. *Chilonis* (500g/ha + 50,000 PE/ha) | 12.67 | 17.03 (24.36) | 55.16 (47.94) | 53.11 (46.78) | 21.67 | 7.31 (15.59) | 11.45 (19.71) | 5.96 (13.91) | 36.67 | 2.20 (8.53) | 4.86 (12.72) | 7.17 (15.79) |
| HaNPV+Btk+ *T. chilonis* (250LE+500g/ha+ 50,000 PE/ha) | 10.33 | 34.84 (36.16) | 76.24 (60.83) | 79.13 (63.09) | 23.67 | 4.98 (12.74) | 6.78 (14.93) | 9.56 (17.92) | 40.67 | 3.99 (11.42) | 7.00 (15.30) | 8.19 (16.56) |
| CD (P=0.05) | - | 2.55 | 3.25 | 6.98 | - | 3.62 | 7.29 | 4.57 | - | 2.19 | 3.99 | 4.82 |

PTP* – Pre-treatment population (Number of larvae per 10 plants),
PTP**- Pre-treatment population i.e. Number of adults/immature per 3 plants (Population sampled on 3 leaves on each plant)
Figures in parentheses are angular transformed values, DAS – Days after spray

respectively in acephate treated plots, it ranged from 71.35-76.33, 69.89-73.41 and 53.24- 66.78 per cent in plots treated with achook after 1, 7 and 15 days, respectively. All other treatments were not quite effective except those containing half dose of acephate which exerted some influence on adult population after 7 days only.

The field efficacy of insecticides and bio-pesticides evaluated through two seasons at two locations indicated imidacloprid to be most effective in reducing the population of immature stages (nymph + pupa) resulting in 77.35-79.52, 85.04-87.55 and 79.58-87.91 per cent reduction over untreated check after 1, 7 and 15 days, respectively. Acephate was next in order of efficacy providing upto 60.75 per cent (1 DAT), 69.88 per cent (7 DAT) and 65.52 (15 DAT) per cent reduction of immature population over untreated check. With the passage of time, the effectiveness of achook also improved and it resulted in 71.66-78.52 per cent reduction in immature population after 7 days of application which decreased to 58.12-68.93 per cent by 15$^{th}$ day varying through locations during the seasons.

The superiority of imidacloprid to other insecticides has been established by the findings of earlier workers also (Nolasco and Solis, 1995; Zhu *et al.*, 1998; Sood *et al.*, 2003; Jodki *et al.*, 2004). The results obtained during the present study regarding efficacy of acephate and achook are in line with those obtained by Cresswell *et al.* (1994), Been *et al.* (2000) and Sood *et al.* (2003). Cresswell *et al.* (1994) observed a single dose of acephate to be effective against the immature stages. On the other hand Bene *et al.* (2000) reported the botanical formulation of Neem to give 69 per cent mortality in nymphs of *T. vaporariorum*. Sood (2002) also found both

acephate and achook to be effective in reducing the adult as well as immature population of *T. vaporariorum* on French bean under protected environment.

From the present study, it is concluded that *H. armigera* population can be successfully managed by application of Btk (500 g/ha) + deltamethrin (0.0014%), Btk (500 g/ha) + acephate, endosulfan (0.025%), Btk (500 g/ha) + (0.025%) or acephate (0.05%) alone. However, owing to higher toxicity of deltamethrin to the egg parasitoid, *T. chilonis*, the other three treatments can be safely recommended for management of the pest. The population of *T. vaporariorum* can be managed by application of imidacloprid (0.004%) or achook (0.00045%) or acephate (0.05%). Four releases of *T. chilonis* @ 50,000/ha could not yield desirable results, however, if the parasitoid is used in combination with acephate (0.05%) or HaNPV

**Table 3. Field efficacy of insecticides and bio-pesticides against *H. armigera* and *T. vaporariorum* infesting tomato at Sullah during 2004**

| Treatments (Dosages) | Per cent reduction in population | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *H. armigera* | | | | *T. vaporariorum* | | | | | | | |
| | Larvae | | | | Adults | | | | Immatures | | | |
| | PTP* | 1 DAS | 7 DAS | 15 DAS | PTP** | 1 DAS | 7 DAS | 15 DAS | PTP** | 1 DAS | 7 DAS | 15 DAS |
| Acephate (0.05%) | 9.00 | 67.44 (55.19) | 74.72 (59.80) | 60.68 (51.16) | 11.00 | 71.88 (57.97) | 76.52 (61.01) | 70.55 (57.15) | 30.67 | 56.51 (48.73) | 62.61 (52.29) | 57.91 (59.54) |
| Imidacloprid (0.004%) | 8.67 | 35.33 (36.45) | 52.38 (46.34) | 43.47 (41.22) | 9.67 | 78.94 (62.71) | 85.35 (67.66) | 81.88 (64.94) | 34.33 | 77.99 (62.06) | 85.68 (77.76) | 87.91 (69.62) |
| *T. chilonis* (50,000 PE/ha) | 6.33 | 25.79 (30.49) | 41.07 (39.83) | 35.95 (36.69) | 8.67 | 5.40 (13.37) | 7.89 (16.31) | 9.39 (16.46) | 33.33 | 5.64 (13.46) | 4.53 (10.88) | 10.12 (18.53) |
| Ha NPV (250 LE) | 7.67 | 23.36 (28.88) | 41.25 (39.94) | 41.90 (40.29) | 10.33 | 8.25 (16.53) | 9.13 (17.55) | 10.73 (19.09) | 30.67 | 2.72 (9.48) | 1.17 (5.86) | 8,10 (15.82) |
| Btk (500 g/ha) | 8.00 | 34.09 (35.69) | 54.75 (47.71) | 55.90 (48.37) | 8.33 | 4.69 (12.42) | 7.51 (15.87) | 5.83 (12.95) | 34.33 | 7.49 (15.81) | 9.49 (17.94) | 8.67 (17.05) |
| Achook (0.00045%) | 8.67 | 28.62 (32.21) | 52.37 (46.34) | 39.03 (38.62) | 9.67 | 73.49 (59.04) | 73.41 (58.94) | 66.78 (54.78) | 32.67 | 16.29 (23.70) | 71.66 (57.83) | 68.93 (56.11) |
| Btk + deltamethrin (500g/ha + 0.0014%) | 8.33 | 54.31 (47.46) | 78.33 (62.26) | 63.06 (52.56) | 9.00 | 14.63 (22.45) | 17.79 (24.93) | 16.74 (24.02) | 34.00 | 13.93 (21.73) | 20.56 (26.92) | 16.02 (23.59) |
| Btk + endosulfan (500g/ha + 0.025%) | 9.33 | 55.90 (48.37) | 74.00 (59.35) | 76.86 (61.28) | 11.33 | 18.76 (25.63) | 29.54 (32.87) | 24.40 (29.54) | 29.33 | 6.85 (15.12) | 16.75 (24.09) | 13.51 (21.54) |
| Btk+acephate (500g/ha + 0.025%) | 8.33 | 58.04 (49.61) | 70.00 (56.77) | 79.30 (62.67) | 9.67 | 31.17 (33.92) | 43.86 (41.46) | 26.05 (30.64) | 29.33 | 24.21 (29.46) | 44.55 (41.86) | 32.41 (34.68) |
| Acephate+ *T.chilonis* (0.025%+ 50,000 PE/ha) | 7.67 | 54.25 (47.42) | 66.92 (54.89) | 71.79 (57.91) | 12.33 | 29.55 (32.90) | 44.44 (41.78) | 27.53 (31.63) | 33.33 | 25.49 (30.30) | 41.27 (39.96) | 30.95 (33.79) |
| HaNPV+ T. *chilonis* (250LE+ 50,000 PE/ha) | 9.00 | 21.67 (27.69) | 69.29 (56.34) | 65.56 (54.08) | 8.67 | 5.37 (12.87) | 8.27 (16.69) | 5.36 (12.33) | 31.00 | 4.91 (12.58) | 2.32 (8.44) | 4.97 (12.49) |
| Btk+ T. *chilonis* (500g/ha+ 50,000 PE/ha) | 7.67 | 23.36 (28.88) | 57.71 (49.42) | 54.05 (47.31) | 9.33 | 6.66 (14.78) | 8.58 (17.03) | 8.15 (15.83) | 31.33 | 2.78 (9.59) | 0.97 (4.98) | 1.52 (6.97) |
| HaNPV+Btk+ *T. chilonis* (250LE + 500g/ha+ 50,000 PE/ha) | 8.67 | 34.50 (35.94) | 76.85 (61.22) | 79.83 (63.42) | 10.67 | 8.45 (16.88) | 10.93 (19.13) | 9.71 (18.06) | 31.67 | 3.86 (11.11) | 3.10 (9.99) | 3.89 (10.65) |
| CD (P=0.05) | - | 3.06 | 2.77 | 5.40 | - | 3.20 | 3.47 | 7.15 | - | 3.83 | 4.46 | 4.36 |

PTP* – Pre-treatment population (Number of larvae per 10 plants), PTP**- Pre-treatment population i.e. Number of adults/immature per 3 plants (population sampled on 3 leaves on each plant) Figures in parentheses are angular transformed values, DAS – Days after spray

(250 LE) + Btk (500 g/ha), it can prove a success in management of *H. armigera* .The possible combination of HaNPV (250 LE) + Btk (500 g /ha) + *T. chilonis* (50,000/ha) can successfully manage the *H. armigera* population and thus provides an effective and feasible biocontrol option which can prove an alternative to chemical control for the management of *H. armigera.*

**Table 4. Field efficacy of insecticides and bio-pesticides against *H. armigera* and *T. vaporariorum* infesting tomato at Sullah during 2005**

| Treatments (Dosages) | Per cent reduction in population | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *H. armigera* | | | | *T. vaporariorum* | | | | | | | |
| | Larvae | | | | Adults | | | | Immatures | | | |
| | PTP* | 1 DAS | 7 DAS | 15 DAS | PTP** | 1 DAS | 7 DAS | 15 DAS | PTP** | 1 DAS | 7 DAS | 15 DAS |
| Acephate (0.05%) | 10.00 | 64.76 (53.57) | 73.45 (58.99) | 71.87 (58.03) | 15.67 | 70.99 (57.39) | 76.03 (60.68) | 68.46 (55.84) | 44.00 | 56.66 (48.81) | 69.88 (56.69) | 53.88 (47.21) |
| Imidacloprid (0.004%) | 9.67 | 30.00 (33.19) | 51.52 (45.85) | 41.67 (40.16) | 14.67 | 81.40 (64.43) | 87.22 (69.09) | 81.57 (64.55) | 45.00 | 77.35 (61.56) | 87.55 (69.31) | 79.58 (63.12) |
| *T. chilonis* (50,000 PE/ha) | 5.67 | 20.56 (26.87) | 32.83 (34.88) | 29.17 (32.57) | 13.67 | 4.93 (12.82) | 8.28 (16.71) | 7.73 (15.51) | 41.67 | 2.14 (8.41) | 3.94 (11.22) | 4.36 (11.25) |
| Ha NPV (250 LE) | 9.33 | 13.74 (21.59) | 38.83 (38.51) | 44.21 (41.66) | 15.33 | 5.34 (13.35) | 8.87 (17.28) | 8.86 (16.25) | 45.67 | 1.39 (5.93) | 6.80 (14.95) | 7.91 (16.32) |
| Btk (500 g/ha) | 8.00 | 27.64 (31.59) | 55.79 (48.31) | 54.42 (47.52) | 12.00 | 6.69 (14.60) | 5.96 (14.08) | 2.59 (5.90) | 44.33 | 7.30 (15.43) | 8.63 (16.89) | 11.70 (19.97) |
| Achook (0.00045%) | 10.00 | 29.33 (32.78) | 47.27 (43.22) | 39.58 (38.96) | 15.67 | 74.96 (59.96) | 70.79 (57.28) | 62.77 (52.38) | 43.67 | 17.08 (24.36) | 78.52 (62.37) | 63.51 (52.82) |
| Btk + deltamethrin (500g/ha + 0.0014%) | 9.67 | 53.52 (47.00) | 75.99 (60.67) | 62.36 (52.16) | 14.33 | 15.51 (23.12) | 25.02 (30.00) | 18.39 (25.31) | 41.33 | 13.35 (21.40) | 18.64 (25.55) | 15.37 (23.06) |
| Btk + endosulfan (500g/ha+0.025%) | 9.67 | 60.00 (50.75) | 72.72 (58.48) | 75.00 (59.98) | 16.33 | 14.73 (22.48) | 29.27 (32.74) | 20.12 (26.59) | 40.00 | 8.80 (17.23) | 14.63 (22.42) | 12.07 (20.25) |
| Btk + acephate (500 g/ha+ 0.025%) | 10.33 | 56.18 (48.56) | 71.70 (57.88) | 76.59 (61.04) | 14.67 | 23.54 (29.01) | 48.60 (44.18) | 32.48 (34.72) | 44.67 | 24.25 (29.46) | 47.43 (43.51) | 29.83 (33.05) |
| Acephate + *T.chilonis* (0.025%+ 50,000 PE/ha) | 8.33 | 53.33 (46.89) | 71.05 (57.50) | 66.59 (54.74) | 17.67 | 27.99 (31.91) | 49.78 (44.86) | 28.61 (32.26) | 40.67 | 27.28 (31.46) | 42.39 (40.61) | 27.62 (31.67) |
| HaNPV+ T. *chilonis* (250LE+ 50,000 PE/ha) | 10.33 | 25.42 (30.21) | 63.36 (52.73) | 61.36 (51.55) | 15.00 | 5.21 (13.18) | 3.27 (10.27) | 4.04 (11.08) | 45.67 | 6.46 (14.72) | 9.66 (18.05) | 7.95 (16.13) |
| Btk+ T. *chilonis* (500g/ha+ 50,000 PE/ha) | 10.00 | 19.39 (26.11) | 58.96 (50.15) | 55.68 (48.26) | 16.33 | 5.57 (13.63) | 7.81 (15.70) | 8.95 (17.05) | 44.67 | 8.03 (16.41) | 9.28 (17.73) | 7.61 (15.99) |
| HaNPV+Btk+ *T. chilonis* (250LE+500g/ha+ 50,000 PE/ha) | 9.33 | 34.62 (36.00) | 76.72 (61.13) | 78.88 (62.72) | 16.67 | 3.71 (9.59) | 9.67 (18.10) | 10.84 (19.09) | 40.67 | 6.19 (14.24) | 9.09 (17.39) | 8.64 (17.07) |
| CD (P=0.05) | - | 4.08 | 3.86 | 4.97 | | 3.94 | 2.88 | 7.67 | - | 3.35 | 2.92 | 3.38 |

PTP* – Pre-treatment population (Number of larvae per 10 plants),
PTP**- Pre-treatment population i.e. Number of adults/immature per 3 plants (Population sampled on 3 leaves on each plant)
Figures in parentheses are angular transformed values, DAS – Days after spray

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