CONCLUSION

*P. xylostella* (Linn.) is a major pest of cauliflower and cabbage crops. They are significantly differed in their impact on the life table parameters of *P. xylostella* under the influence of biopesticides at constant temperatures. Survivorship (*I*<sub>x</sub>) was significantly decreased by increasing the temperature from 10° to 35°C. The *I*<sub>x</sub> was prolonged to 121 days treated with LC<sub>50</sub> of imidacloprid on cabbage as compared to 92 days in the untreated control at 10°C. 20 ppm of neemazal has also increased the survivorship to 42 and 44 days as compared to 29 and 32 days on cauliflower and cabbage, respectively at 25°C. Hatching of eggs were reduced when *P. xylostella* reared on treated cabbage as compared to the treated cauliflower irrespective of concentrations and constant temperatures. The highest (83.10%) numbers of eggs were hatched by 5ppm of biolep on cauliflower, and reduced to 79% by 5 ppm of biolep on cabbage at 25°C. 1<sup>st</sup> instars were survived to 58.7% by LC<sub>50</sub> of imidacloprid and 70.7% in the untreated control on cabbage at 35°C. Survival of 2<sup>nd</sup> instars on cauliflower was greater than those reared on cabbage irrespective of concentrations and constant temperatures. However, survival of 3<sup>rd</sup> instars is higher in all the treatments on cauliflower than the cabbage at constant temperatures. Pupal survival was highest in all the treatments on cauliflower and cabbage at 25°C. The oviposition period was decreased with increasing the concentrations from 5 to 20 ppm and temperature from 10° to 35°C. Post oviposition period was concentration dependent of neemazal, biolep and imidacloprid at constant temperatures. Longevity of adults was concentration dependent and decreased with increase of temperature from 10° to 35°C. Daily fecundity rate (*m*<sub>x</sub>) was significantly increased with increase of temperature from 10° to 25°C and decreased when *P. xylostella* reared at 30° and 35°C. The *m*<sub>x</sub> was highest on 3<sup>rd</sup> day irrespective of biopesticide concentrations and constant temperatures. The *m*<sub>x</sub> was greater on cauliflower than that to cabbage at 25°C.

The potential fecundity (*P*<sub>f</sub>) was significantly reduced by increasing the concentrations from 5 to 20 ppm and increased with increasing the temperature from 10° to 25°C and then decreased from 30° to 35°C. 95.60females/female/generation was obtained by 5 ppm of neemazal on cabbage at 25°C. Greater numbers of progeny were born at 25°C than to other temperatures. The net reproductive rate (*R*<sub>0</sub>) was greatly reduced to 0.26 and 0.29females/female/generation exposed to LC<sub>50</sub> of imidacloprid as compared to 6.02 and 21.49 in the untreated control on cabbage at 35° and 10°C, respectively. The highest *R*<sub>0</sub> occurred at 25°C when *P. xylostella* reared on cauliflower than cabbage under the influence of biopesticides at constant temperatures. The intrinsic rate of increase (*r*<sub>m</sub>) was significantly differed at constant temperatures and reduced significantly with increasing the concentrations
from 5 to 20 ppm. Negative values of $r_m$ have occurred when *P. xylostella* exposed to 20 and 15 ppm of neemazal and LC$_{30}$ and LC$_{25}$ of imidacloprid on cauliflower and cabbage at 10° and 35°C, respectively. A greater value of $r_m$ i.e. 0.058 females/female/day has occurred with 5 ppm of biolep on cauliflower at 25°C, while the same concentration gave 0.052 on cabbage. The values of finite rate of increase ($\lambda$) are significantly declined by exposure of 20 ppm of neemazal and LC$_{50}$ of imidacloprid on cauliflower at 10° and 35°C. The progeny production was greater when *P. xylostella* exposed to 5 ppm of biolep on cauliflower than on cabbage at 25°C. The mean generation time ($T_e$) was greatly prolonged to 107.38 days for completion of a single generation treated with LC$_{50}$ of imidacloprid as compared to untreated control (72.24 days) at 10°C. *P. xylostella* can complete a single generation in 21.41 days in unexposed groups as compared to 26.9 days exposed to 5 ppm of neemazal on cauliflower at 25°C. Almost similar trend of corrected generation time ($t$) was also obtained by treatment of neemazal, biolep, LC$_{50}$ and LC$_{25}$ of imidacloprid on cauliflower and cabbage at constant temperatures. Population of *P. xylostella* will become double (DT) in 4.2 days in the untreated control at 30°C as compared to 4.46 days at 25°C on cauliflower. The negative values of DT were calculated when treated with 20 ppm of neemazal at 10°C and 20 and 15 ppm of neemazal at 35°C, LC$_{50}$ and LC$_{25}$ of imidacloprid at 10° and 35°C on cabbage. The population will favourably be multiplied fast at 25°C in both exposed and unexposed of *P. xylostella*.

Development period decreases with decrease of concentrations from 20 to 5 ppm and increase of temperature from 10° and 35° C. Life cycle was shortest at 35°C and prolonged at 10°C. Incubation period was delayed to 17.6 days with LC$_{50}$ of imidacloprid on cabbage as compared to concentrations tested of neemazal and biolep on cauliflower and cabbage at 10°C. A significantly increase in the development time of larva was 64.3 and 61.7 days treated with LC$_{50}$ of imidacloprid as compared to 57.8 and 42.1 days in the untreated control on cabbage and cauliflower, respectively. At 25°C, larval development was completed in 22 and 21.4 days treated with LC$_{50}$ of imidacloprid and 20 ppm neemazal, respectively on cabbage as compared to 12.7 in the untreated control. Pupal period was also prolonged to 17 days with LC$_{50}$ of imidacloprid on cabbage at 10°C; this value was greater to other treatments on cabbage and cauliflower. Developmental period of immature stages was greatly increased from 15.6 to 103.3 days with decreasing the temperature from 35° to 10°C with LC$_{50}$ of imidacloprid on cabbage; however, it was greater than other treatments. The adult lived for 17.7 days and 4.4 days with LC$_{50}$ of imidacloprid on cabbage at 10° and 35°C, respectively.

$T_{min}$ for embryonic development increases with decreasing the concentrations of neemazal, biolep and imidacloprid on cauliflower and cabbage. $T_{min}$ for egg stage was 7.91°C treated with LC$_{25}$ of imidacloprid on cauliflower than to the untreated control on both treated
with neemazal, and biolep. It was decreased to 6.71°C treated with LC$_{50}$ of imidacloprid as compared to 8.02°C for untreated control on cabbage. $T_{\text{min}}$ was lower for larval stages treated with neemazal, biolep and imidacloprid on cabbage and cauliflower than to the untreated control of both. $T_{\text{min}}$ for pupa was ranged from 7.18° to 7.91°C with neemazal on cauliflower while, 6.97° to 7.63°C on cabbage. Same trend was observed in biolep and imidacloprid.

A greater quantity of heat (95.2°C-day) was required for embryonic development with LC$_{50}$ of imidacloprid on cabbage than to other treatments on cabbage and cauliflower A total of 446.3°C-day required by larva to complete its development and reduced to 192.8°C-day on cabbage treated with biolep 5 ppm and the lowest i.e. 34.6 to 44.6°C-day in the unexposed groups on cauliflower. Thermal heat required for pre-pupal and pupal stages increased with increasing the concentrations of neemazal, biolep and imidacloprid on cauliflower and cabbage. Adult stage required a higher amount of heat (277.8°C-day) treated with 5 ppm of biolep than to 181.8°C-day in cabbage (only).

Degree day (DD) requirement increased with increasing the temperature from 10° to 30°C and decreased above 30°C in all the treatments on cauliflower and cabbage. Degree day requirement for immature development was greater when treated with LC$_{50}$ of imidacloprid than to other treatments on cauliflower. Pupal stage accumulated higher heat units than to other treated and the untreated control at constant temperatures. Total degree day requirement in immature stages from egg to pupa was maximum with imidacloprid in both cauliflower and cabbage and minimum with biolep and neemazal at constant temperatures.

$T_{\text{max}}$ for embryonic development was 42.53°C in the untreated cauliflower and 41.96°C treated with 10 ppm of biolep. While, $T_{\text{max}}$ was 42.02°C treated with 10 ppm of neemazal on cabbage and it was decreased to about 40°C in other treatments. Substantial variations were determined in $T_{\text{max}}$ of 1$^{\text{st}}$, 2$^{\text{nd}}$ and 4$^{\text{th}}$ instars in the treated and untreated control. Minimum threshold temperature ($T_{\text{min}}$) for embryonic development was 8.59°C in untreated cabbage and decreased in the treated groups, while 8.86°C on untreated cauliflower. 3$^{\text{rd}}$ instar was more sensitive to decreasing temperature than to other instars in the treatment groups. The variations in $T_{\text{opt}}$ were substantial in both treated and untreated control.

The oviposition of *P. xylostella* was decreased with increasing concentrations of neemarin, neemix and neemazal from 5 to 20 ppm in the no-choice tests. Cabbage varieties i.e. Golden Acre, Parvati and NS-25 were less preferred for oviposition than to cauliflower varieties; Aghani was more preferred than Pusi and Pusa Snowboll-k-1. A greater reduction was determined in the oviposition on Pusi treated with neemazal on different combinations than to neemarin and neemix on Aghani and Pusa Snowboll-K-1. Golden Acre was least preferred for oviposition than to Parvati and NS-25. Neemazal was more effective in reducing the
number of eggs than to neemarin and neemix. Whereas, in the two-choice tests, 20+15 ppm received a lower number of eggs than to other combinations of neem insecticides in both seasons of 2008-09 to 2009-2010. Golden Acre was least preferred and 36.4/55.3 and 34.2/51.4 eggs were obtained in 2008-09 and 2009-10, respectively.

Neemazal and neemix @ 20 ppm were most effective in reducing the population of *P. xylostella* as compared to neemarin, neemexcel and multineem on cauliflower and cabbage varieties in two sprays during 2008-09 and 2009-10. Multineem @ 20 ppm and NSKE @ 5% showed the lowest reduction in both the cropping seasons. Reduction in the population of *P. xylostella* was higher in cauliflower varieties than to cabbage.

The parasite of *P. xylostella* was greatly affected with neemazal 20 ppm as compared to neemix and neemarin while, multineem 20 ppm was least harmful to parasites. Biolep and bioasp @ 20 ppm gave a substantial effect on parasites. NSKE was found safer to parasite of *P. xylostella* on cauliflower and cabbage during both the cropping seasons.

Combined application of neemazal (15 ppm) and neemix (15 ppm) with imidacloprid (10 ppm) and cypermethrin (15 ppm) reduced *P. xylostella* effectively on cauliflower and cabbage in two sprays during 2008-09 and 2009-10. Neemarin (15 ppm) and neemexcel (15 ppm) with imidacloprid (10 ppm) and cypermethrin (15 ppm) caused the highest reduction of *P. xylostella* on Pusi in 1st spray and on Aghani in 2nd spray in 2008-09. Whereas, density was greatly reduced on NS-25 and Golden Acre in 1st and 2nd spray in 2009-10 and 2008-09, respectively.

Neemazal with imidacloprid (15+10 ppm) reduced the parasite of *P. xylostella* as compared to other combinations of biopesticides and insecticides. NSKE (3%) with imidacloprid (10 ppm) and cypermethrin (15 ppm) was least harmful to the parasite as compared to neem formulations used on cauliflower and cabbage.

Maximum yield of cauliflower was obtained in neemazal i.e. 281.6 and 287.3q/ha in 2008-09 and 2009-10, respectively followed by neemix, neemarin, neemexcel and multineem. Neemazal exhibited the highest benefit cost ratio (13.1:1) followed by neemix (8.5:1), neemarin (6.1:1), neemexcel (5.1:1) and NSKE (4.8:1) in 2008-09. Whereas, a substantially higher benefit cost ratio was obtained in neemazal (15.1:1) followed by neemix (10.3:1), neemarin (8.3:1), neemexcel (6.3:1) and NSKE (5.7:1) in 2009-10.

Cabbage yield was the highest with neemazal i.e. 288.2 and 292.9q/ha in 2008-09 and 2009-10, respectively followed by neemix, neemarin and multineem. Cabbage production was increased in biolep and bioasp treated plots to 245.3 and 240.2q/ha in 2008-09, while 249.4 and 241.6 q/ha respectively in 2009-10. The highest benefit cost ratio was exhibited in neemazal (13.3:1) followed by neemix (9.5:1), neemarin (8.5:1), neemexcel (8.3:1) and
multineem (4.8:1) in 2008-09, however, increased to 13.5:1 with neemazal followed by neemix (10.7:1), neemarin (8.7:1), neemexcel (8.4:1) and multineem (5.1:1) in 2009-10.

Combined effect of neemazal with imidacloprid and cypermethrin gave a significantly high yield of cauliflower (287.8 and 292.7q/ha$^{-1}$) in 2008-09 and 2009-10, respectively followed by neemix, neemarin, neemexcel and multineem. However, Biolep and bioasp with imidacloprid and cypermethrin treatments have increased the cauliflower yield to 243.7 and 239.7q/ha$^{-1}$ in 2008-09, while 248.5 and 244.8q/ha$^{-1}$, respectively during 2009-10. The highest benefit cost ratio (15.4:1) was exhibited by neemazal with imidacloprid and cypermethrin combinations followed by neemix (11.6:1), neemarin (8.3:1), neemexcel (6.6:1) and NSKE (5.9:1) with imidacloprid and cypermethrin combinations in 2008-09, whereas 16.3:1 by neemazal with imidacloprid and cypermethrin combinations followed by neemix (12.4:1), neemarin (9.1:1), neemexcel (7.1:1) and NSKE (6.2:1) with tested insecticides in 2009-10.

The combination of neemazal with imidacloprid and cypermethrin exhibited the highest cabbage yield of 293.3 and 296.4q/ha$^{-1}$ in 2008-09 and 2009-10, respectively followed by neemix, neemarin, biolep and bioasp and other combinations. Neemazal with imidacloprid and cypermethrin gave the highest benefit cost ratio of 14.5:1 followed by neemix (11.7:1), neemarin (10.5:1), neemexcel (9.9:1) and multineem (8.1:1) in 2008-09, whereas 14.6:1 with neemazal followed by neemix (12.1:1), neemarin (10.6:1), neemexcel (10.3:1) and multineem (8.6:1) with imidacloprid and cypermethrin in 2009-10. Benefit cost ratio in NSKE and insecticides was 6.7:1 in 2008-09, while 7.3:1 in 2009-10. Biolep and bioasp offered 5.0:1 and 3.8:1 in 2008-09, while, 5.4:1 and 4.5:1 in 2009-10, respectively.