International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
DOI: 10.22192/ijarbs Coden: IJARQG (USA) Volume 8, Issue 2 -2021

Research Article

DOI: http://dx.doi.org/10.22192/ijarbs.2021.08.02.020

Abundances of different arthropod predators in bacterial - fermented biopesticides treated tomato field

Gopal Das[1], Mst Rokeya Khatun[2] and Md. Eftekhar Uddin[3]

[1]Professor, Department of Entomology, Bangladesh Agricultural University, Mymensingh - 2202, Bangladesh.

[2]Assistant Professor, Department of Entomology, Bangladesh Agricultural University, Mymensingh - 2202, Bangladesh.

[3]Rice Farming Systems Division, Bangladesh Rice Research Institute (BRRI), Gazipur-1701, Bangladesh.

*Corresponding author: Prof. Dr. Gopal Das, E-mail: *gopal_entom@bau.edu.bd*

Abstract

Emamectin Benzoate, Spinosad and Abamectin are soil bacterial fermented biopesticides used for controlling various groups of insects viz. sucking, chewing, borer etc. In the present study, three bacterial fermented biopesticides viz. Suspend 5SG @ 1.0 & 1.5 g/L, Libsen 45 SC @ 0.25 & 0.50 ml/L and Ambush 1.8EC @ 2.0 & 3.0 ml/L were evaluated against tomato fruit borer, *Helicoverpa armigera* (Hubner) infesting tomato in field condition during rabi season of 2017-18. A total of four sprays were given at 10 days interval. Data were collected on the abundances of various predators viz. ladybird beetle, lynx spiders and carabid beetle per tomato plant. The present study revealed that Emamectin Benzoate (Suspend 5 SG) and Abamectin (Ambush 1.8EC) were found safe and less toxic against three predators as populations were not changed significantly in the treated plots as well as in the control plots. But unexpectedly Spinosad (Libsen 45 SC) showed moderate toxicity to all the predators, as 30-40% of the predator populations were reduced over control when tomato plants were treated with Libsen 45 SC @ 0.25 ml/L and >50% reductions were observed from 0.50 ml/L of Libsen 45 SC.

Keywords: Arthropod, Predators, Biopesticides, Abundances, Toxicity

Introduction

Tomato, (*Lycopersicum esculentum*) belongs to the family Solaneceae and genus *Solanum* is one of the most important and popular vegetables after potato in Bangladesh. Tomato is mainly grown during rabi season but some varieties are also cultivate in summer season in Bangladesh. It is grown worldwide either in the field, green houses or net houses. It is one of the most important protective crops. Tomato provides an excellent amount of vitamin C, mineral manganese and vitamin E. Moreover, lycopene in tomato is a powerful anti-oxidant and reduces the risk of prostate cancer (Hossain *et al.*, 2004). Among the winter vegetable crops grown in Bangladesh, tomato ranks fourth in respect of production and third in respect of areas (Anonymous, 1999). Tomato is cultivated in an area of 23886.63 hectares with total production of 190 thousand tons and average productivity of 32.20 ton per acre (BBS, 2012).

A huge number of insect pests are reported to ravage the tomato fields and among them, tomato fruit borers (TFB) are of much significance and causes extensive damage to fruits. Among fruit borers, *Helicoverpa armigera* (Hubner) is responsible for considerable losses in quantity as well as quality of tomato fruits (Meena and Raju, 2015).

H. armigera is a cosmopolitan and ployphagous insect pest that causes a yield loss up to 70% (Dhandapani *et al.*, 2003). Most of the tomato growers of our country are exclusively rely on different chemical/conventional insecticides to control *H. armigera* and many sucking insect pests. Tomato being a vegetable crop, use of conventional insecticides leaves considerable toxic residues on tomato fruits which causes serious health hazards. In addition, indiscriminate uses of various synthetic insecticides adversely affect the population of natural enemies i.e. predators, parasitoids and pathogens in tomato ecosystem (Mossa *et al*., 2018). To combat such adverse effects from insecticides uses, in recent years, farmers are encouraged to apply different biorational insecticides which pretend to be more target specific and safer for natural enemies as well as environements (Chakrabarty and Sarker, 2011; Islam *et al*., 2016).

In the search for safer insecticides technologies, i.e. more selective mode of action and reduced risks for non-target organisms and the environment, progress has been made in the last few years for the development of natural and synthetic compounds through fermentation of soil bacteria viz. *Streptomyces*, *Saccharopolyspora* etc. capable of controlling insects potentially without interfering the biodiversity of beneficial arthropods. Emamectin benzoate and Abamectins are two bacterial fermented biopesticides derived from soil bacteria, *Streptomyces avermitilis* and widely used for controlling different sucking and borer insects as well as mites (Mossa *et al*., 2018). In addition, Spinosad, a derivative of the soil actinomycete (*Saccharopolyspora spinosa*), is the most widely used biorational pesticide against different vegetables like tomato, brinjal, bean etc.

Many laboratory and field investigations were made to ascertain the effect of biorational pesticides on the abundances of beneficial arthropods like ladybird beetle, carabid beetle, mirid bugs, spiders etc (Galven *et al*., 2005; Ahmed *et al*., 2015) however the safety of soil fermented biopesticides to the predatory arthropods in tomato ecosystem are scantly investigated. In the present study, the compatibility of three bacterial fermented biopesticides viz. Suspend 5 SG (Emamectin Benzoate), Ambush 1.8 EC (Abamectin) and Tracer 45 SC (Spinosad) with three prevailing predators namely ladybird beetle, carabid beetle and, lynx spiders was evaluated in a tomato ecosystem. All these predators are highly efficacious for predating whitefly, aphid, jassids etc and play significant role in biological control approach (Koch, 2003; Rajeswaran *et al*., 2005). Therefore, the present study was undertaken to find out the compatibility of selected biopesticides with different predatory arthropods in tomato ecosystem.

Materials and Methods

Experimental site and soil

The experiment was conducted at Bangladesh Agricultural University research farm during rabi season of 2017-18 to evaluate the toxic effects of Emamectin Benzoate (Suspend 5SG), Spinosad (Libsen 45 SC) and Abamectin (Ambush 1.8 EC) on the abundances of three predators like ladybird beetle, lynx spiders and carabid beetle in *H. armigera* infesting tomato field. The soil of the field experiment area was under Old Brahmaputra Alluvial Tract under the Agro Ecological Zone 9 (UNDP and FAO, 1988) with non-calcareous dark grey flood plain soil. Soil contains 10, 80 and 10% sand, silt and clay respectively with the bulk density 1.3g cm^{-3}, total pore volume (TPV) of 50%, and pH of 6.7 at 0-15 cm depth.

Experimental design, plot preparation and seedlings transplantation

The experiment was laid out following randomized complete block design (RCBD) with seven treatments including control and three replications of each. The experimental field was about 20 m x 9 m size while each of the plot size was 4 m^2. The experimental field was prepared through ploughing and cross ploughing for several times to obtain desirable final tilts which were followed by laddering and spading. Fertilizers and manures were applied as recommended by Rashid (1993) for tomato at the rate of 15 ton cowdung, 150 kg Urea, 100 kg TSP and 50 kg MoP/ha respectively. After that the healthy and disease free seedlings of 30 days old were then transplanted in the experimental plots. Two adjacent unit plots and blocks were separated by 60 cm and 80 cm apart, respectively. VF-Roma was selected as the experimental variety. Then healthy and disease free seedlings of 30 days old were then transplanted in the experimental plots.

Tested insecticides

The field experiment was consisted of seven treatments including three insecticides. Treatments were: T_1- Suspend 5 SG (Emamectin Benzoate) @ 1.0 g/L, T_2: Suspend 5 SG (Emamectin Benzoate) @

1.5 g/L, T_3: Libsen 45 SC (Spinosad) @ 0.25 ml/L, T_4: Libsen 45 SC (Spinosad) @ 0.50 ml/L, T_5: Ambush 1.8EC (Abamectin) @ 2.0 ml/L, T_6: Ambush 1.8EC (Abamectin) @ 3.0 ml/L, T_7: Untreated control. All the insecticides were sprayed once infestation appears and a total of four sprays were given at 10 days interval. Spraying of insecticides were done in the morning using a high clearance sprayer equipped with a compressed air charged spray system calibrated to deliver 10 gpa through TX-6 hollow cone nozzles (2/row).

Methods of recording observations

After spraying each insecticide predators were counted at 7 days later and a total three counts were made. For each counting, three plants were randomly selected from each plot and predators were then visually counted from three plants. Then, a mean value was found out for that plot. Finally, a cumulative mean value was calculated from three plots and expressed as number of predators per plant. Moreover, percent decrease of predators over control was calculated using the following formula:

$$\text{Percent decrease} = \frac{C - T}{C} \times 100$$

Here,

C = Mean number of predators in control condition

T = Mean number of predators in treated condition

Statistical analyses

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance (ANOVA) was done with the help of computer package MSTAT. The mean differences among the treatments were adjudged with Duncan's Multiple Range Test (DMRT) and Least Significant Difference (LSD) when necessary.

Results

Abundances of ladybird beetle in biopesticides treated tomato field

Emamectin Benzoate (Suspend 5SG) and Abamectin (Ambush 1.8EC) were found almost safe to ladybird beetles (LBB) in *H. armigera* infesting tomato field as LBB populations were not changed significantly with that of untreated control (Table-1 & Fig.1A). In contrast, Spinosad (Libsen 45 SC), an important bacterial fermented biopesticides that showed moderate toxicity to LBB populations. Specifically, a cumulative mean of 6.38 LBB/plant was found when tomato plants were left untreated and importantly 5-6 LBBs/plant were also found when plants were sprayed with either Suspend 5SG or Ambush 1.8 EC using two concentrations of each. On the other hand, number of LBBs were reduced to 3.0 to 3.8 per plant when tomato field was treated with Libsen 45 SC @ 0.25 to 0.50 ml/L. Results also showed that approximately 40.28-50.50% LBB populations were died or reduced over control due to the application of Libsen 45SC (Fig. 1A) while only 11.12-22.10% or 1.70-14.50% populations were reduced when tomato plants were treated with either Suspend 5SG or Ambush 1.8 EC respectively (Fig.1A).

Table-1: Abundances of ladybird beetle in *H. armigera* infesting tomato field following treated with selected biopesticides

Treatments	Mean number of ladybird beetle per plant			Cumulative mean
	7 days after 1st spray	7 days after 2nd spray	7 days after 3rd spray	
Suspend 5 SG @ 1.0 g/L	5.56a	6.23a	5.23a	5.67a
Suspend 5 SG @ 1.5 g/L	5.01a	5.21a	6.19a	5.47a
Libsen 45 SC @ 0.25 ml/L	4.52b	3.34b	3.56b	3.81b
Libsen 45 SC @ 0.50 ml/L	4.16b	3.13b	2.70c	3.03c
Ambush 1.8 EC @ 2.0 ml/L	6.23a	5.89a	6.71a	6.27a
Ambush 1.8 EC @ 3.0 ml/L	5.12a	5.00a	6.23a	5.45a
Control	6.01a	7.23a	5.90a	6.38a
Level of significance	*	*	*	*
CV (%)	7.88	10.23	10.01	12.11

In a column, means followed by similar letter(s) are not significantly different at 5% level of probability. *P<0.05.

Abundances of carabid beetle in biopesticides treated tomato field

Toxic effect of Suspend 5 SG, Libsen 45 SC and Ambush 1.8 EC on the abundances of carabid beetle in *H. armigera* infesting tomato field has been shown in table-2 and figure 1B. Like as ladybird beetle, similar trend was found in case of abundances of carabid beetle. Approximately, a cumulative mean of 4-4.5 carabid beetle/plant was counted in Suspend 5 SG or Ambush 1.8 EC treated tomato field and these populations were found statistically insignificant in comparison with control populations (4.85/plant). Results also revealed that 12.37-17.73% and 7.62-16.49% carabid populations were reduced over control when tomato plants were treated with either Suspend 5 SG and Ambush 1.8 EC respectively. Like as previous results, Libsen 45 SC clearly showed toxicity to carabid beetle. A cumulative mean of 2.36 and 3.51 carabid beetle/plant was counted from Libsen 45 SC treated plot with the doses of 0.25 and 0.50 ml/L respectively. Moreover, 27.62% and 51.34% carabid populations were reduced when plants were treated with Libsen 45 SC @ 0.25 ml/L or 0.50 ml/L respectively (Table-2 & Fig.1B).

Table-2: Abundances of carabid beetle in tomato field following treated with selected biopesticides.

Treatments	Mean number of carabid beetle/m^2			Cumulative mean
	7 days after 1st spray	7 days after 2nd spray	7 days after 3rd spray	
Suspend 5 SG @ 1.0 g/L	4.31a	4.23a	4.21a	4.25a
Suspend 5 SG @ 1.5 g/L	4.00a	3.98a	4.01a	3.99a
Libsen 45 SC @ 0.25 ml/L	3.82b	3.74b	3.52b	3.51b
Libsen 45 SC @ 0.50 ml/L	2.76c	2.23c	2.10c	2.36c
Ambush 1.8 EC @ 2.0 ml/L	4.23a	5.81a	3.98a	4.47a
Ambush 1.8 EC @ 3.0 ml/L	3.81a	4.12a	4.23a	4.05a
Control	4.44a	5.21a	4.90a	4.85a
Level of significance	*	*	*	*
CV (%)	6.71	8.81	10.21	9.12

In a column, means followed by similar letter(s) are not significantly different at 5% level of probability. *P<0.05.

Abundances of lynx spiders in biopesticides treated tomato field

Like as ladybird beetle and carabid beetle, similar trend was found for lynx spiders reduction in Emamectin Benzoate (Suspend 5SG), Abamectin (Ambush 1.8EC) and Libsen 45 SC (Spinosad) treated plots (Table-3 & Fig.1C). Cumulative mean value showed that approximately 3-4 lynx spiders/plant were counted when tomato plants were treated with either Suspend 5SG or Ambush 1.8EC and it was comparable with untreated control. However, 5.54% and 12.13% or 3.69% and 11.87% lynx spider populations were reduced over control when tomato field was treated with either Suspend 5SG @ 1.0 & 1.5g/L or Ambush 2.0 & 3.0 ml/L respectively. In contrast, 2.07-2.87 lynx spiders/plant were counted in Libsen 45 SC treated plot that was approximately 30 to 45% reduction over control considering lower to higher doses (Fig.1C).

Table-3: Abundances of lynx spiders in tomato field following treated with selected biopesticides.

Treatments	Mean number of lynx spiders per plant			Cumulative mean
	7 days after 1st spray	7 days after 2nd spray	7 days after 3rd spray	
Suspend 5 SG @ 1.0 g/L	3.51a	4.00a	3.23a	3.58a
Suspend 5 SG @ 1.5 g/L	3.00a	3.89a	3.11a	3.33a
Libsen 45 SC @ 0.25 ml/L	2.70b	2.74b	2.56b	2.87b
Libsen 45 SC @ 0.50 ml/L	2.56b	2.00c	1.67b	2.07c
Ambush 1.8 EC @ 2.0 ml/L	3.13a	4.11a	3.71a	3.65a
Ambush 1.8 EC @ 3.0 ml/L	2.98a	3.89a	3.23a	3.34a
Control	3.25a	4.23a	3.90a	3.79a
Level of significance	*	*	*	*
CV (%)	6.78	10.34	11.23	10.01

In a column, means followed by similar letter(s) are not significantly different at 5% level of probability. *P<0.05.

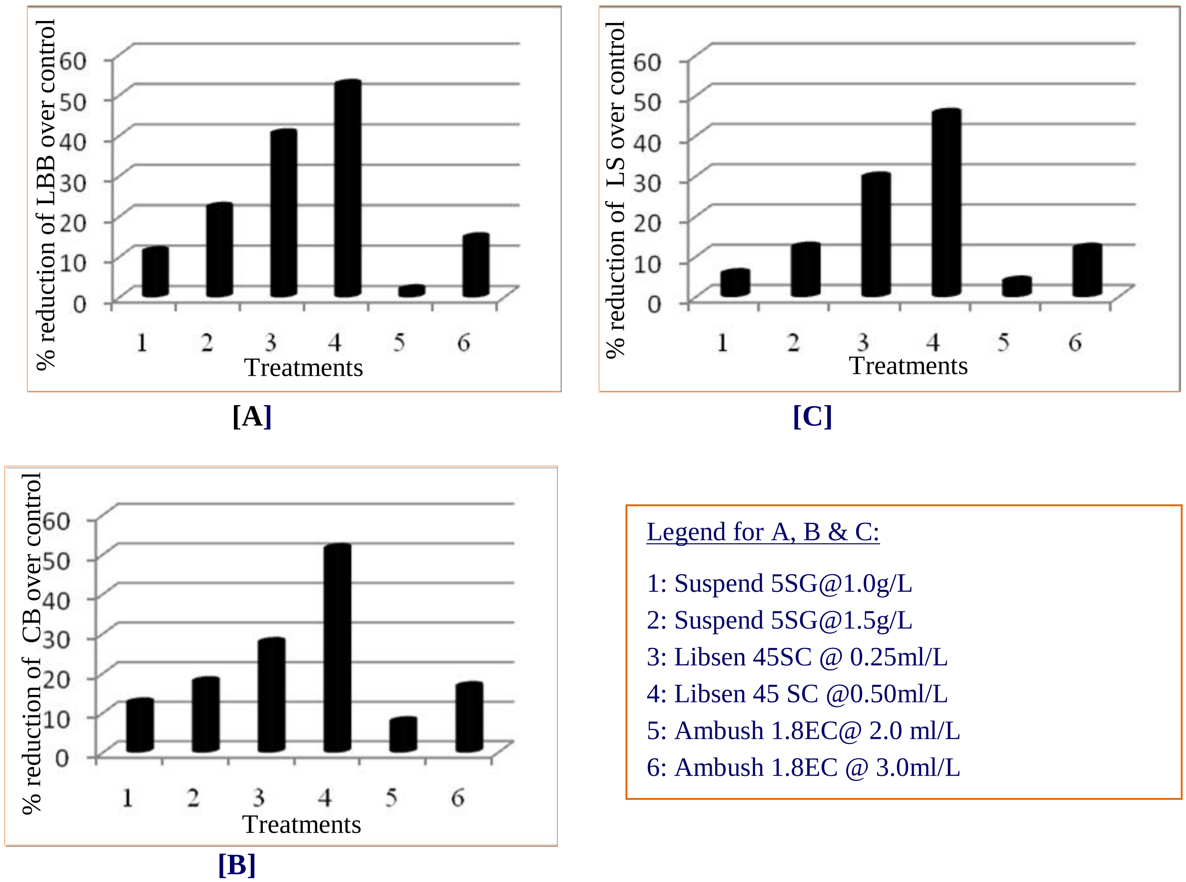

Fig.1: Percent reduction of ladybird beetle (LBB) [A], carabid beetle (CB) [B] and Lynx Spiders [C] over control in *Helicoverpa armigera* infesting tomato field when tomato plants were treated with Suspend 5SG @1.0 & 1.5 g/L (Emamectin benzoate), Libsen 45 SC @ 0.25 and 0.50 ml/L (Spinosad) and Ambush 1.8EC @ 2.0 and 3.0 ml/L (Abamectin).

Discussion

Bacterial fermented biopesticides *viz*. Emamectin Benzoate, Abamectin and Spinosad are potential alternative to broad-spectrum conventional insecticides and generally considered to be harmless compounds against predatory arthropods. In the present study, the toxic effect of Emamectin Benzoate (Suspend 5SG), Abamectin (Ambush 1.8EC) and Spinosad (Libsen 45 SC) were tested on the abundances of three predatory arthropods like ladybird beetle, carabid beetle and lynx spiders in the *Helicoverpa armigera* infesting tomato field. The present study aimed mainly to explore whether the compounds alternative to conventional insecticides could be used to control *H. armigera* on tomato while being innocuous to ladybird beetle, carabid beetle and lynx spiders.

Our present study clearly showed that emamectin benzoate was found very less toxic to all tested predatory arthropods. In untreated condition, 6.38 ladybird beetles were found per tomato plant and this numbers were not changed significantly even tomato plants are sprayed with Emamectin Benzoate at the field recommended or even higher doses (5.67/plant @ 1.5 g/L, 5.47/plant @ 1.0g/L). Moreover, non-toxic effect of Emamectin Benzoate was also found in case of lynx spiders and carabid beetle abundances. The non-adverse effects of Emamectin Benzoate on different predatory arthropods have been reported in many studies (Islam and Sarder, 1997; Mollah *et al*., 2013). In contrast, Tiwari and Prasad (2011) have reported that Emamectin Benzoate can cause significant levels of mortality to some species of coccinellid and spider predators, but this may depend on concentration, amount of drift residues and other unidentified factors. The Abamectin, an another important bacterial fermented biopesticide, found to be safer than Emamectin Benzoate regarding predator abundances. It has been reported elsewhere that there is no negative effect of Abamectin on natural enemies after an application for 7 days (Mossa *et al*., 2018). On the other hand, some other studies have reported very low toxicity of Abamectin to predator species when direct spraying was done (Bengochea *et al*., 2010, Bengochea *et al*., 2013).

Spinosad (Libsen 45 SC) is a mixture of tetracyclic-macrolide compounds produced by a soil actinomycete and has been classified as a biopesticides. Spinosad is highly active against lepidoptera and is reported to be practically nontoxic-toxic to natural enemies. Our present study showed that Spinosad (Libsen 45 SC) was found moderately toxic to ladybird beetles, carabid beetles and spiders populations as 30-50% predators were died following exposure to Spinosad @ 0.25-0.50 ml/L. Our present results are in close agreement with previous findings that Spinosad is not a safe and innocuous compound to different natural enemies. Elzen *et al*. (2000) reported that contact bioassay of Spinosad at the recommended field rate caused 19-65% mortality in the parasitoid, *Catolaccus grandis* (Burks). Moreover, field rate of Spinosad caused about 35% and 45% mortality of lynx spiders and ladybird beetles respectively when sprayed in rice field (Ahmed *et al*., 2015; Galven *et al*., 2005).

Conclusion

Our present findings showed that Emamectin Benzoate and Abamectin are found safe or compatible with ladybird beetle, carabid beetle and lynx spiders at the field recommended rate or even higher the field rate. On the other hand, Spinosad caused to 30-50% mortality at the field recommended rate or higher rate. Based on the present findings it could be concluded that Emamectin Benzoate (Suspend 5 SG @ 1.0 & 1.5 g/L) and Abamectin (Ambush 1.8 EC @ 2.0 and 3.0 ml/L) could be incorporated in IPM program safely. The Spinosad, a popular biopesticides in recent time, should be applied carefully against crop pests considering its lethality or incompatibility with important natural enemies.

Acknowledgments

The author gratefully acknowledges the funding authority, the Ministry of Science and Technology (MOST), Peoples Republic of Bangladesh for providing the fund to conduct this research work successfully in the FY 2017-2018.

Conflict of interest

The authors declare no conflict of interest.

References

Ahmed, Z., Ahmad, M., Rehman, A., Iqbal, M.F., Latif, M., Hussain, M. and Farooq, M. 2015. Efficacy of Biopesticides and spinosad on spiders faunain rice. *International Journal of Current Research in Chemistry and Pharmaceutical Sciences*, 2(2):51-54.

Anonymous. 1999. Statistical Year Book of Agricultural Statistics of Bangladesh. Statistics Division, Ministry of Planning, Govt. of the Peoples Republic of Bangladesh, Dhaka. P.125.

BBS (Bangladesh Bureau of Statistics). 2012. Statistical year book of Bangladesh, Statistical Division, Ministry of Planning, Govt. of the Peoples Republic of Bangladesh, Dhaka. P.38.

Bengochea, P., Hernando, S., Saelices, R., Adán, A., Budia, F., González-Núñez, M., Viñuela, E., & Medina, P. 2010. Side effects of kaolin on natural enemies found on olive crops. *IOBC/WPRS Bulletin*, 55, 61–67.

Bengochea, P., Amor, F., Saelices, R., Hernando, S., Budia, F., Adán, A., & Medina, P. 2013. Kaolin and copper-based products applications: ecotoxicology on four natural enemies. *Chemosphere*, 91, 1189–1195.

Chakrabarty, S. and Sarker, P.K. 2011. Management of *Leucinodes orbonalis* Guenee on eggplant during the rainy season in India. *Journal of Plant Protection Research*, 51(4):325-328.

Dhandapani, N.U., Shekhar, R. and Murugan, M. 2003. Bio-intensive pest management (BIPM) in major vegetable crops. An Indian Perspective. *Food Agricultural Environment*, 2003; 1:333-339.

Elzen, G. W., Maldonado, S. N., and Rojas, M. G. 2000. Lethal and sublethal effects of selected insecticides and an insect growth regulator on the boll weevil (Coleoptera:Curculionidae) ectopara162 Cisneros et al. sitoid *Catolaccus grandis* (Hymenoptera:Pteromalidae). *Journal of Economic Entomology*, 93, 300–303

Galven, T.L., Koch, R.L. and Hutchison, W.D. 2005. Effects of spinosad and indoxacarb on survival, development and reproduction of the multicolored Asian lady beetle (Coleoptera:Coccinellidae). *Biological control*, 34(1):108-114.

Hussain, B. and Bilal, S. 2007. Efficacy of different insecticides on tomato fruit borer, *Helicoverpa armigera*. *Journal of Entomology*, 4:64-67.

Islam, T., Das, G. and Uddin, M.M. 2016. Field evaluation of promising biorational pesticides against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. *Journal of Biopesticides*, 9(2):113-118.

Islam, A.T.M.F. and M.A. Sardar, 1997. Toxic effects of insecticides on bean aphid, Aphis craccivora Koch and its predator *Menochilus sexmachulatus* F. (Coleoptera: Coccinellidae). Bangladesh Journal of Entomology, 8(1 and 2): 21-29.

Koch, R.L. 2003. The multicolored Asian lady beetle, Harmonia axyridis: a review of its biology, uses in biological control, and non-target impacts. Journal of Insect Science, 3(1):1-16.

Meena, L.K. and Raju, S.V.S. 2015. Efficacy of insecticides against fruit borer, *Helicoverpa armigera* (Hubner) on tomato. *Indian Journal of Entomology*, 77(2):201-202.

Mollah, M.I., Rahman, M. and Alam, Z. 2013. Effect of Insecticides on Lady Bird Beetle (Coleoptera: Coccinellidae) in Country Bean Field. Middle-East Journal of Scientific Research, 7(11): 1607-1610.

Mossa, A.T.H., Mohafrash, S.M.M. and Chandrasekaran N. 2018. Safety of Natural Insecticides: Toxic Effects on Experimental Animals. *BioMed Research International*. 2018 (2): 17.

Rajeswaran, J., Duraimurugan, P. and Shanmigam, P.S. 2005. Role of spiders in agriculture and horticulture ecosystem. Journal of Food Agriculture and Environment, 3(3/4):147-152.

Rashid, M.M. 1993. Shabji Biggan, Bangla Academy, Dhaka.

Tiwari, G. and Prasad, C.S. 2011. Effect of Insecticides, Bio-pesticides and Botanicals on the Population of Natural Enemies in Brinjal Ecosystem. *International Journal of Plant Research*, 24(2):40-44.

UNDP, FAO, 1988. Land Resource Apprisal of Bangladesh for Agricultural Development Report 2. Agro-ecological regions of Bangladesh, BARC/UNDP. New Airport road, Farmgate, Dhaka-1207. PP. 212-221.

Access this Article in Online	
	Website: www.ijarbs.com
Quick Response Code	Subject: Entomology
DOI:10.22192/ijarbs.2021.08.02.020	

How to cite this article:

Gopal Das, Mst Rokeya Khatun and Md. Eftekhar Uddin. (2021). Abundances of different arthropod predators in bacterial fermented biopesticides treated tomato field. Int. J. Adv. Res. Biol. Sci. 8(2): 161-167.
DOI: http://dx.doi.org/10.22192/ijarbs.2021.08.02.020