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Research Article Advances in Agriculture, Horticulture and Entomology AAHE-119
ISSN 2690-1900

Assessment of Bio-Pesticides against Fall Armyworm Management in Nepal

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Received Date: April 16, 2020; **Accepted Date:** April 27, 2020; **Published Date:** May 08, 2020

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Abstract

Fall Armyworm (FAW) (Spodopterfrugiperda), a native to Americas, is a devastating insect of especially maize and rice. For the first time, it was reported in Nepal in May, 2018 in Nawalparasi District. Since then it has spread and established in other provinces in other crops. As first and foremost step, farmers are using synthetic pesticide to control disease and pests since long. This is mainly because of the lack of alternative control measures. However, its ill effect, especially due to inappropriate use and use of hazardous pesticides has caused several health and environmental issue among several others. Biopesticides are the best alternative of synthetic pesticide and it is urgent to assess effective biopesticides against FAW suitable for Nepal. The paper attempts to review the globally practiced biopesticides against FAW. The result showed that among registered 12 biopesticides, several were found effective against FAW and more especially neem based pesticides and Bt are the most effective.

Keywords: Bio pesticides; Fall Armyworm; Hazards; Incidence

Introduction

The world is expecting 9 billion people by 2050 and agriculture is facing pressure to feed these populations. Moreover, climate change is pounding sever impact on agriculture. Several literatures are indicating increasing pressure of disease pest on agriculture linking with climate change.

Fall Armyworm (FAW, Spodopterfrugiperda) is native of the tropical and sub-tropical regions of the Americas (Bateman M., et al., 2018; Prasanna, Huesing, Eddy, & Peschke, 2018). FAW moths have both a migratory habit and a more localized dispersal habit, which can migrate over 500 km before oviposition (Prasanna, Huesing, Eddy, & Peschke, 2018). It is polyphagous insect which can feed on more than 80 species and spreads rapidly. It causes damage to the leaves and ears, which reduces plant development and consequently grain yield (Roel, et al., 2010). Maize yield loss due to FAW was reported up to 34% (Lima, Silva, Oliveira, Silva, & Freitas, 2010). However, 20% of production losses was reported when defoliation occurs around flowering of Maize (Polanczyk, da Silva, & Fiuza, 2000). In 2018, it was detected in India which has alleviated the level of risk in Nepal too (GC, Dhungel, Ghimire, Devkota, & GC, 2019). It is because, during the right wind pattern, FAW can have a flight of 1,600 km in 30 hours as per the record (Prasanna, Huesing, Eddy, & Peschke, 2018). In May 2018, it reached southern India (Shylesha et al., 2018) and was reported from Nepal in May 2019 (Bajracharya et al., 2019). It is a polyphagous pest, but maize is its preference.The use of bio-pesticides is not a nascent plant protection technique, which was the major option before invention of synthetic chemical pesticide (Roel, et al., 2010). There is lack of consensus while defining biopesticides (Bateman M. L., et al., 2018). The application of chemical pesticides has manifold effect on human health and environment. In Nepal, farmers are mostly using broad

spectrum pesticides and more importantly due to wrong selection of pesticides, it is inviting several hazards (GC, 2015). The application of bio-pesticides is a promising alternative to control FAW (de Lima, de Oliveira, Junior, Marques, & Correia, 2010).

Biological Control

Biological control or bio- control, is defined as "the use of living organisms (and viruses) to suppress the population density or impact of specific pest organisms, making it less abundant or less damaging than it would otherwise be" (Eilenberget al. 2001). The use of micro-organisms such as bacteria, fungi, nematodes, virus, protozoa that can cause disease in insects have also reached commercial scale and some organisations have attracted a lot of interest due to their control potential and their ability to multiply in vitro. Several fungi such as B. brongniartii, B. bassiana, M. anisopliae, viruses such as nuclear polyhederosis virus (NPV), baculoviruses, and nematodes (Steinernema, and Heterorhabditis) and insect parasitoids are the major recent research focus. The major advantages of using microbial agents are narrow host range, high virulence, safety for non-target organisms, compatibility with some fungicides and many other types of pesticides, ease of production with local materials and application without using costly equipment.

Methodology

In order to assess the potentiality of bio-pesticides against FAW, two steps exploration was carried out. At the first step, a list of registered bio-pesticides was prepared. Then in the second step, extensive literature review was done to assess the effective bio-pesticides experimented from around the world against FAW. The long list of potential effective bio-pesticides against FAW was prepared and appropriate potential bio-pesticides for Nepal was proposed. A general recommendation was provided for those bio-pesticides found effect against FAW which are registered in Nepal. A conceptual framework of the methodology is presented in **Figure 1**.

The data were accessed by using mainly two search portals. They are "Directory of Open Access Journals" (DOAJ, https://doaj.org/) and Google Scholar (https://scholar.google.com). The list of registered biopesticides was accessed from the website of Plant Quarantine and Pesticide Management Center (http://npponepal.gov.np/downloadsdetail/2/2018/39799637/) of Nepal which is responsible for registration and deregistration of pesticides in Nepal.

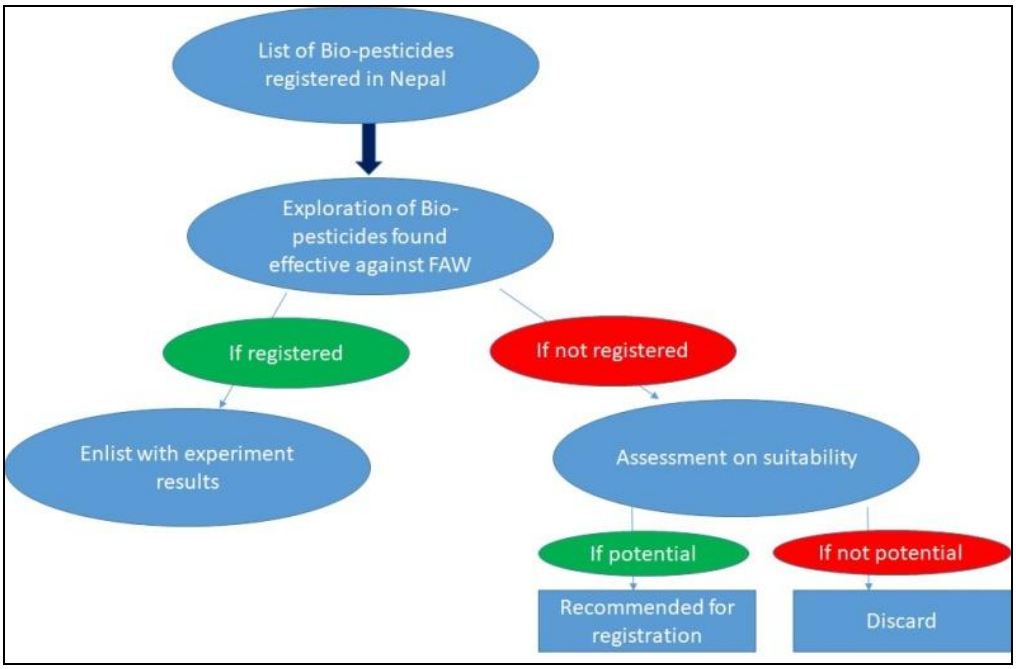

Figure 1: Conceptual framework of the study.

Results and Discussion

In Nepal, Plant Quarantine and Pesticide Management Center, under the Ministry of Agriculture and Livestock Development is responsible for registration and deregistration of pesticides along with other authorities related to the pesticides. According to the center, there are 12 Registered Bio-pesticides in Nepal. The list is presented in **(Table 1)**.

SN	Common Name
1	Azadirachtin
2	Bacillus amaloliquefaciens D 203
3	Bacillus subtilis
4	Bacillus thuringiensis
5	Beauveriabassiana
6	Metarhiziumanisopliae
7	Nuclear Polyhedrosis Virus
8	Paecilomyceslilacinus
9	Pseudomonas fluorescens
10	Trichodermaharzianum
11	Trichodermaviride
12	Verticilliumlecanii
Source: Plant Quarantine and Pesticide Management Center, 2019	

Table 1: List of biopesticides registered in Nepal.

Azadirachtin

Neem (Azadirachtaindica) is found one of the most effective natural alternatives to chemical synthetic insecticides (Prates, Viana, & Waquil, 2003). It has low toxicity for mammals and is efficient even in low concentrations (Roel, et al., 2010). It can control more than 430 insects with the advantage of being food and environmental safe (Roel, et al., 2010). Neem causes several effects like repellence, halting of development and ecdysis, development delay, fertility and fecundity reduction, behavioral and physiological changes leading to potential death (Roel, et al., 2010). LC50 of neem leaves aqueous extract against fall armyworm was found 2.67 mg mL-1 (Prates, Viana, & Waquil, 2003).

In one study, Deltamethrin and neem based pesticides (neem extract and neem oil) were found equally effective (Lima, Silva, Oliveira, Silva, & Freitas, 2010). The neem oil at concentration of 0.4% was observed with total mortality of the first instars larvae of FAW and degeneration of epithelial lining of midgut was observed at concentration of 0.006%, 0.05% and 0.4% of neem oil (Roel, et al., 2010). Newly hatched larvae of up to 24 hours old were found more susceptible to 5 and 10 mL or g/L of Neemseto (commercial formulation of neem) than 10 days larvae (de Lima, de Oliveira, Junior, Marques, & Correia, 2010). The aqueous extract of neem leaves and spraying adjuvants caused lethal effect on FAW larvae after three days of application caused mortality up to 100% and inhibit the larval development (Viana & Prates, 2003).

Bacillius Thuringiensis (Bt)

Bacillus thuringiensis (Bt) is a Gram-positive bacterium naturally occur in soil, water and grain dust (Valicente, Tuelher, Leite, Freire, & Vieira, 2010). Application of sprays containing insecticidal proteins from Bacillus thuringiensis (Bt) in agriculture for pest management has history of decades (Schnepf, et al., 1998; Brar, Verma, Tyagi, & Valero, 2006). It is the most famous biopesticide around the world and account for 90% of all biopesticides sold in the world (Valicente, Tuelher, Leite, Freire, & Vieira, 2010). FAW can be controlled by using Bt(Dequech, Fiuza, da Silva, & Zumba, 2007), besides the lethal effect on hosts, the entomopathogen may alter physiology which hinder insects' feeding intake and reproduction (Polanczyk and Alves, 2005). The use of Bt is attracting attention against FAW considering its efficiency and low impact on natural enemies (Polanczyk, da Silva, & Fiuza, 2000). Bt produces a spore-crystal complex which is responsible for its biocide characteristic (Capalbo, Valicente, Moraes, & Pelizer, 2001). Newly hatched larvae of up to 24 hours old were found more susceptible to 5 and 10 mL or g/L of Xentari (commercial formulation of Bacillus thuringiensis subsp. aiawai) (de Lima, de Oliveira, Junior, Marques, & Correia, 2010). Btaizawai HD 68 strains were found the most effective which has caused the mortality of FAW upto 100% followed by Btthuringiensis 4412 (80%) and Btkurstaki (70%) (Polanczyk, da Silva, & Fiuza, 2000). The differences in toxicity of these strains to FAW may be related to the composition of crystals and their toxic potential (Polanczyk, da Silva, & Fiuza, 2000).

Metarhizium Anisopliae

Metarhiziumanisoplie is formerly known as Entomopthoraanisopliae, is a fungus that grows naturally in soils and insect body throughout the world and causes diseases in various insects by acting as a parasite, it thus belongs to the entomopathogenic fungi. It has been exploited as biocontrol agents to number of countries. Metarhiziumis one of the best known genera of entomopathogenic fungi, commonly known as "green muscardine fungus" due to the green colour of the sporulating colonies andis applied as spores or mycelia in various formulations. The fungus was first isolated from the wheat chafer Anisopliaaustriaca by Metschnikoff in 1879 and named Entomophthoraanisopliae. In Nepal, GC and Keller (2002) isolated and identified , M. anisopliae (green muscardine fungus) and B. bassiana (white muscardine fungus) were isolated from white grubs' cadavers, Galleria bait method (GBM) and selective medium through soil dilution plating. Mass production has been carried out by the private sector, Agri-care Nepal.

Beauveria Bassiana

To control FAW, one of the alternatives is based on microbial agents having low environmental impact and high specificity and efficiency in reducing ability of insect to injure host plants (Carneiro, et al., 2008). Beauveriabassianawas found equally effective like synthetic chemical pesticides like fipronil and thiametoxan(Martins , Toscano , Tomquelski , & Maruyama , 2009). However, Beauveriabassianahas several strains among not all of them were found effective pathogenicity to FAW and it can be evaluated using RAPD markers (Carneiro, et al., 2008). The susceptibility of FAW

larvae to B. bassianahas been demonstrated in late 1990s (Jaime Molina-Ochoa, 2003).

Nuclear Polyhedrosis Virus (Npv)

Nuclear Polyhedrosis Virus (NPV) is one genus among the Baculoviruses (Rowley, Farrar Jr, Blackburn, & Harrison, 2010). NPV is one of the effective alternatives against FAW (de Romero, Romero, Gomez, & Willink, 2009). The mean lethal time of NPV isolated from several geographic region in Americas was found 8.3 to 10 days (Gomez, Moscardi, & Sosa-Gomez, 1999). Similarly, FAW larvae death rate was found rise with increasing viral concentrations, while susceptibility of larvae decreased with insect age and LC50(lethal concentration for 50% of the tested sample) for three and five days-old larvae were found 7.6*104 and 4.5*105 polyhedral/ml respectively (de Romero, Romero, Gomez, & Willink, 2009).

Insect Parasitoid

One of the major parasitoid of FAW is Campoletisflavicincta(Dequech, Fiuza, da Silva, & Zumba, 2007). Trichogrammachilonis Ishii is native to southern Asia. Nepal Agriculture Research Council (NARC) has found FAW egg parasitiods in Nepal. The specimens collected in Nepal were 99-100% identical to multiple specimens in GenBank. Rearing and field release of T. chilonis are underway in NARC in the hosts insect of rice moth (Corcyra cephalonica:Stainton (Lep.:Pyralidae) in the involvement of Department of Agriculture, USAID, iDE and other institutions.

Future Recommendations

Biopesticides are the best alternative of synthetic pesticide considering environmental and health hazards along with costs. However, effectiveness of biopesticides is the major issue to replace synthetic pesticides. Since, various studies have proven similar or superior effectiveness against FAW to synthetic pesticides; it has presented itself as a promising alternative. FAW being a devastative polyphagous and having potential to migrate rapid, concern of food security due to FAW is at heart of discussion. Among 12 registered biopesticides in Nepal, most of them are found effective to control FAW in several parts of the world. Neem-based pesticides and Bt were found most effective among other. However, before recommending plant protection measure, in-country experiment is highly desirable. Therefore, considering these facts, rapid experiments and research trails are deemed necessary to prevent farmers against FAW which could serious threat overall food security of the country and the region. Biocontrol agents have great promise for use as biological control agents against different insects. However, their infectivity is quite different depending on the host, associated environment, production methods and application techniques. Use of biopesticides owes significant important in a country like Nepal where there is likelihood of the mis-use of chemical pesticides and pest flair back in the future. FAW has already been established in Nepal and its impact on food security is alarming. It is high time to search novel means of pest control at a time of Covid-19 pandemic against the possible crisis of food caused by FAW.

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Citation: *Dhoj YGC, Ghimire K, Arun GC (2020) Assessment of Bio-Pesticides against Fall Armyworm Management in Nepal. Adv Agri Horti and Ento: AAHE-119.*