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Short Presentation of the Studies on Microbial Metabolites as Eco Friendly Insecticides against *Halicoverpa armigera*

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A B S T R A C T

Today crop pests have become a major concern for the farmers across the world. *Helicoverpa armigera* commonly known as Gram Pod-Borer is an economic important insect pest of gram crop, which was used to be treated with chemical insecticides. Due to misuse and overuse of these chemical insecticides, resistance is being developed in many insects resulting in increased survival rate of the insect pests. There is an urgent need for alternatives of these chemical insecticides. Bio-insecticides are eco-friendly insect/pest control which is obtained from naturally occurring substances (biochemicals), microbes and plants. Before developing a new insecticide, the scenario of *H. armigera* and its bio-control should be presented with the help of some prior studies. This paper describes the national and international research work based on the microbial pesticide/ insecticides against *H. armigera*.

Introduction

Agriculture is the backbone of Indian economy which has gone through immense changes in the second half of the twentieth century. Adoption of technologies, high yielding varieties, and agrochemicals between 1960 to 2000 lead to 'The Green Revolution' increasing the crop yield per hectare. Today crop pests have become a major concern for the farmers across the world. *Helicoverpa armigera* is commonly known as Gram Pod-Borer.

Productivity of Gram crop is strongly affected by *H. armigera*, which damages 90-95% crop during favorable weather conditions, due to its high fecundity, migratory and polyphagus nature, and its resistance to insecticides. Yield losses of 400 kg/ha caused by the Pod-borer have been reported, with damage to pods ranging from 30-40% to 90-95% (Dhaliwal *et al.*, 2010). Economic damage is the greatest in cotton and vegetables.

Use of chemical pesticides has played a positive role in increasing agricultural productivity and in making India self-sufficient in food grain production. Due to misuse and overuse of these chemical insecticides, resistance has developed in many insects resulting in increased survival rate of the insect pests. There is an urgent need for alternatives of these chemical pesticides. Bio-pesticides are eco-friendly pesticides which are obtained from naturally occurring substances (biochemicals), microbes and plants. The potential benefits to agriculture and public health programs through the use of biopesticides are considerable. Through the use broader use of biopesticides, agriculture and health programs can be beneficially affected. However, in India, some of the biopesticides like *Bacillus thuringiensis* (*Bt*), nucleopolyhedroviruses (NPV), neembased pesticides, *Trichoderma* etc. have already been registered and are being used.

Farmers are faced with increasing problems of controlling insecticide resistant *Helicoverpa*. Excessive use of pesticides led to the creation of new strains of pests resistant to synthetic insecticides as well as to the available bio-pesticides like *Bt.* cry proteins. The resistance development is often related to receptors modification that involves the mechanisms and targets of action. Due to the results of resistance, there is an urgent need to synthesize novel compounds with insecticidal activity against Pod-borer.

Studies related to *Halicoverpa armigera* and their biocontrol

National status

Pest infestation in different regions and different crops has been demonstrated with several studies. Many researchers studied the harmful effects of *Halicoverpa armigera* on different crops. Some of them are as follows:

Dinesh *et al.,* (2017) evaluated the yield losses caused by *Helicoverpa armigera* (Hubner) infesting Chickpea. The loss estimation due to insect pests on Chickpea showed that mean plant height under treated conditions were 1.10 and 1.11 times greater than when unprotected. The mean number of pods was 1.25 and 1.32 times more when the crop was protected. Mean number of damaged pods was 5.44 and 5.12 times more and the mean percent pod damage was 6.76 and 6.86 times greater under unprotected conditions. Similarly, the mean seed per pod was 1.68 and 1.70 times more in protected plots than in unprotected plots. Mean yield/plant (g) and mean yield/plot (g) were 2.09 and 2.19 and 1.43 and 1.45 times greater when the crop was protected. On the basis of yield, avoidable losses of 29.93% and 31.28% were recorded due to *H. armigera* infestation in Chickpea variety GNG 1581.

Patra *et al.,* (2016) reported the extent of the crop losses in Pigeon pea (Var: Bahar) due to pest complexes during the 2009-10 and 2010-11 growing seasons. A total of 41 insect species, consisting of 11 Coleoptera, 13 Hemiptera, 3 Orthoptera, 1 Diptera, 1 Thysanoptera, 11 Lepidoptera, and 1 Hymenoptera were recorded. Results revealed that pod-boring insects (*H. armigera*, *L. boeticus*, *A. clavipes* and *M. obtusa*) caused major crop losses to pigeon pea. The national status of the production of bio-pesticides in the proposed area can be reviewed with the help of earlier research. The strategies being used/worked out in India have been reported as follows:

Gopalakrishnan *et al.,* (2017) isolated and identified a toxic metabolite that can be used against *H. armigera* from a previously characterised *Streptomyces* species (strain CAI-155). The purified metabolite showed 70–78% mortality for 2nd instar *H. armigera* larvae by diet impregnation assay, detached leaf assay, and greenhouse assay. The LD_{50}

and LD_{90} values of the purified metabolite were 627 and 2276 ppm, respectively. They proposed that this novel metabolite can be exploited for pest management in future.

Sreekanth *et al.,* (2012) evaluated the efficacy of different biopesticides against the Gram Pod-borer, *Helicoverpa armigera* (Hubner) and the Legume Pod-borer, *Maruca vitrata* (Geyer) on Pigeon pea. The per cent inflorescence damage due to Legume Pod-borer was lowest in spinosad 45% SC at 73 g a.i/ha (4.74%), followed by *Bacillus thuringiensis*-1 at 1.5 kg/ha (10.52%) and *Beauveria bassiana* SC formulation at 300 mg/Lt (14.15%) with 80.9%, 57.6%, and 42.9% reduction over controls, respectively.

The pod damage due to *M. vitrata* was the lowest in spinosad (17.38%), followed by Bt.-1 (27.57%), and *B. bassiana* SC formulation at 300 mg/lt (33.82%) compared with the controls (45.84%) with 62.1%, 39.9%, and 26.2% reduction over controls, respectively.

Anshul *et al.,* (2013) prepared methanolic extract of powdered *A. annua* leaves and different compounds isolated from the extract for toxicity and inhibition/ disruption of growth and development of the African Pod-borer, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae).

The methanol extract severely affected 100% of the larva treated Larvae gained very little weight, some larvae died, some formed larval-pupal intermediates, and a few abnormal adults (adultoids) emerged.

Patel *et al.,* (2011) conducted an experiment on molecular characterization of novel serovars of *Bacillus thuringiensis* isolates from India. Novel *Bacillus thuringiensis* isolates GS4, GN24 and UP1 were isolated and characterized by determination of serotyping, insecticidal protein by SDS-PAGE, plasmid composition, cry gene content and insect toxicity. Isolate GS4 was toxic to lepidopteran insect larvae of *Helicoverpa armigera*, but UP1 did not showed any toxicity.

International status

There is a global effort to identify and produce bio-pesticides using microorganisms or plant extracts. The international status of this is represented by the following journal articles:

Arasu *et al.,* (2013) conducted an experiment in collaboration with Saudi Arabia, Korea and India. They studied antifeedant, larvicidal, and growth inhibitory bioactivities of a novel polyketide metabolite isolated from *Streptomyces* sp. AP-123 against *Helicoverpa armigera* and *Spodoptera litura*. They found the polyketide metabolite presented significant antifeedant activities against *H. armigera* (78.51%) and *S. litura* (70.75%) at 1000 ppm concentration. The metabolite also exhibited high larvicidal activities against *H. armigera* (63.11%) and *S. litura* (58.22%) and the LC_{50} values were 645.25 ppm for *H. armigera* and 806.54 ppm for *S. litura*.

Mahmudunnabi *et al.,* (2013) developed the biorational-based integrated pest management package against the Pod-borer, *H. armigera* Hubner infesting Chickpea.

They conducted an experiment in Bangladesh during rabi 2012-13 to evaluate different biorational based IPM packages viz., IPM package 1 (P1) comprising pheromone trapping of *H. armigera* along with sequential release of the biocontrol agents *Trichograma evanescens* at gm/ha/week + *Bracon hebetor* at 1 jar (1000-1200 adults)/ha/week, and spraying of *Bacillus thuringiensis* (Bt) at 0.4g/litre of water; IPM package 2 (P2) consists of pheromone trapping in addition to sequential release of bio-control agents and spraying of *Helicoverpa* nuclear polyhedrosis virus (HNPV) at 0.1g/L of water against this pest attacking Chickpea. Results indicated that the IPM package (P2) revealed the best performance reducing 68.20% pod damage over control and provided significantly the highest yield (1832.20 kg/ha).

Wubneh (2016) worked on the biological control of Chickpea Pod-borer, *Helicoverpa armigera Hubner* in Ethiopia. According to his study, most natural populations of *H. armigera* have at least some degree of infection by species-specific NPVs. When the degree of NPV infection can be enhanced, *H. armigera* larval population can be decimated, without deleterious effects on any other organisms.

Sun *et al.,* (2006) conducted an experiment entitled as modelling biological control with wild-type and genetically modified baculoviruses in the *Helicoverpa armigera*–cotton system in China and Netherland. They developed comprehensive model to simulate virus epizootics in a stage structured insect population and analyse scenarios for the biological control of cotton bollworm (CBW), *Helicoverpa armigera*, in cotton, using wild-type or genetically modified baculoviruses.

In simulations on dosage and timing of a wild-type strain and a genetic recombinant of *H. armigera* single nucleocapsid nucleopolyhedrovirus (HaSNPV), the economic injury level was not exceeded against a prevailing population of 12 larvae per m^2 when virus was applied 10 times during the season. They suggested that the model may be used as a decision tool for evaluating virus application strategies in interaction with virus genotype and climatic conditions that affect the phenology and population dynamics of CBW.

Some groups of researchers studied the resistance in insect against the available bio-pesticides as follows:

Chakroun *et al.,* (2016) presented a study on the characterization of the resistance to Vip3Aa in *Helicoverpa armigera* from Australia and the role of midgut processing and receptor binding. They discussed that insect resistant cotton and maize expressing the Bt Vip3Aa protein were recently commercialized, though not yet in Australia. They found that, although relatively high, the frequency of alleles for resistance to Vip3Aa in field populations of *H. armigera* in Australia did not increase over the past four seasons until 2014/15. According to this study Vip3Aa-resistance did not confer cross-resistance to Cry1Ac or Cry2Ab. Vip3Aa was labelled with ^{125}I and used to show specific binding to *H. armigera* brush-border membrane vesicles (BBMV). Binding was of high affinity (*Kd* = 25 and 19 nM for susceptible and resistant insects, respectively) and the concentration of binding sites was high (*Rt* = 140 pmol/mg for both). Despite the narrow-spectrum resistance, binding of ^{125}I-labeled Vip3Aa to BBMV of resistant and susceptible insects was not significantly different. Proteolytic conversion of Vip3Aa protoxin into the activated toxin rendered the same products, though it was significantly slower in resistant insects.

Agriculture is the back bone of all developing countries and it's at high risk due to biotic as well as abiotic stress. Insects cause major loss in food crops and country has to suffer a lot. *Halicoverpa armigera* is an economic important insect which destroys the Chick pea crop badly. Chemical pesticides played a vital role following by their negative impact on environment as well as on human health.

Microbes are the rich sources of metabolites with their unique properties. With the help of these microbial isolated, bio insecticides are being manufactured and they are safe as well as eco-friendly. As these are novel compounds, so the chances of existing resistance are also low.

Future aspects

The make aim to draw a thought in this direction is to reveal the need of new potent strains of bacteria as bio pesticides. As the future aspect of my presentation, a new bacterial culture is to be identified followed by bioformulation against *Helicoverpa armigera.*

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