

# **Feed the Future: Innovation Lab for Integrated Pest Management**

## **Trip Report**

**Event:** Training Workshop on Biological Control of the Fall Armyworm (FAW) in Africa and Asia: Scouting for Parasitoids, Mass Rearing of Egg Parasitoids, and Augmentative Release Techniques

**Country Visited:** Niger

**Dates of Travel:** July 19, 2019 to July 29, 2019

### **Travelers' Names and Affiliations:**

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2. **Rajiv Das Rajbhandari**, SPPO, Central Plant Protections Lab, MOALD
3. **Ajaya Shree Ratna Bajracharya** Senior Scientist, Entomology Division, NARC Khumaltar, Lalitpur, Nepal.
4. **Ghanshyam Bhandari, Scientists**, National Maize Research Program/ NARC, Chitwan

### **Purpose of Trip:**

The purpose of this workshop is to assess and learn methods in field collection, mass rearing, and release of indigenous biological control agents of the fall armyworm including egg and larval parasitoids in the fields.

To learn and practice field collection of natural enemies of the FAW, as well as mass rearing and release of indigenous egg and larval parasitoids for biological control of the fall armyworm in the fields. The training included both theoretical, lab, and field practices.

**Sites Visited:** ICRISAT, Niamey and Sandore, Niger

### **Description of Activities/Observations:**

Fall Armyworm (FAW) *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), is a devastating voracious pest of agricultural crops with native origin in the Americas. After a century of closed history in America, it accidentally landed in Africa in 2016, successfully wreaking havoc in over 40 countries. It has now travelled around Asia and was reported in India in May 2018, ravaging agricultural crops, especially maize. Nepal, a neighbor to India, is a small country in South East Asia where maize is a staple. A joint effort has been made by all

the stakeholders and agriculture-related organizations in Nepal to come up with strong action plans for combatting the pest. A plan involving even the small-scale farmers is being considered in order to come up with safer, accessible, effective, and sustainable solutions against FAW. Long-term and sustainable solutions to FAW spread should follow an integrated pest management (IPM) approach. IPM includes regular pest monitoring and use of two or more control options in a compatible manner. Biological control is one of the components of the IPM approach. Recently, two egg parasitoids, *Trichogramma* and *Telenomus*, were identified in Africa and it is expected that these parasitoids also might be available in Asia. Information on the occurrence and rates of parasitism of indigenous natural enemies has a paramount importance in designing biological control of FAW either through conservation of native natural enemies or augmentative release. This training was technical and designed for national researchers, extension agents, and technicians to gain practical, hands-on experiences in field collection, lab mass rearing, and mass release of indigenous egg parasitoids of the FAW. The details of the training activities accomplished and observed during the travel are highlighted below:

### **Day 1: July 19, 2019:**

All the nominated participants (listed above) from the Nepal travelled from the Tribhuvan International Airport at 11:00 PM to travel to Niger Via Doha (2:10 am flight from Kathmandu), Casablanca, Morocco—with a final destination in Niamey. The details of the Itinerary are as below:

### **Day 2 &3, July 20-21,2019:**

- Departure from Kathmandu TIA to Doha in Qatar Airways in 2:10 am flight on July 20, 2019. The team reached to Doha, Hamad International Airport at 4:25am (local time);
- The next flight departure from Doha to Casablanca, Morocco was at 8:40 AM in Qatar Airways and reached Casablanca, Morocco at 2:30PM (local time)
- Departure from Casablanca, Morocco to Niamey, Niger was at 10:25 PM in Royal Air Morocco and reached Niamey at 2:00AM (local time). The ICRISAT Staff (Mr. Tondi) picked us up from the Airport and brought us to ICRISAT Training Center, Niamey. The entirety of participants reached ICRISAT, Niamey, Niger at 4:00 am.
- The participating members from Nepal were accommodated at the ICRISAT Training and visiting center (TVC) in Niamey, Niger.
- The whole day was spent at ICRISAT office and was interacted with the staff and received an overview on the logistics for the training. On the same day, we met with Dr. Muniappan Rangswamy from VT/IPMIL. Updates about the travel and ongoing IPMIL activities from Nepal.

## **Day 4 to 8, July 22-26, 2019:**

**TRAINING OVERVIEW:** The training course was held at the ICRISAT Sadore Research Station, situated 40 km South of Niamey, Niger. All the participants were accommodated at the ICRISAT Training and visiting center (TVC) in Niamey.

All four participants from Nepal participated in a six day long training workshop on Biological Control of the Fall Armyworm (FAW) in Africa and Asia: Scouting for Parasitoids, Mass Rearing of Egg Parasitoids, and Augmentative Release Techniques, organized by International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in collaboration with University of Maradi, Niger and Institut National de la Recherche Agronomique du Niger (INRAN) from July 22-26,2019 at ICRISAT, Sadore, Niger. The training was supported by FAO, FtF-IPMIL, CGIAR- Research program on Grain Legumes and Dryland Cereals (GLDC).

### **July 22, 2019 (Monday)**

#### **Day 1 Training: (theoretic/lecture):**

- Participants from ICRISAT, TVC travelled to the ICRISAT Sadore Research Station, situated 40 km South of Niamey, Niger at 8:00 am and reached to the Sadore Research station at 9:00am.
- The first day of the training started from 9:00am with welcome remarks from Dr. Malick Ba, Country Representative, ICRISAT, Niger, followed by the objective of the training by Dr. Muniappan Rangaswamy, IPMIL Director, VT.
- Introduction sessions were carried out with all the 15 countries' participants.
- Reports on status and control of FAW from different participating countries.
- After the introductions, all 15 country member representatives presented their reports on the status and controls of FAW in respective countries. The following countries were presented: Cameroun, Nepal, Benin, Ghana, Togo, Cambodia, Mali, Vietnam, Cote d'Ivoire, Burkina Faso, Senegal, Sudan, Bangladesh, DRC and Niger.
- The country updates showed that much of the work on the FAW management was done in Africa. Some of the work on the biological control has been successful and needs to replicate those learning in respective countries too. Some of the updates presented from different countries are summarized below:
  - Fall armyworm is in Asia and Africa.
  - It has not reached Africa north of Sahara desert, Europe, Central Asia, some Arabian countries, central Asia, Australia, New Zealand and Pacific Islands.
  - How to manage is the main question – the one that is effective, economical, and socially acceptable that has less adverse impact on human health and environment.

- Approaches must be scientific and evidence based.
- Biological control is one of the best options for Integrated Pest management.
- Some effective natural enemies have already been found in Asia and Africa.
- Need to explore for more natural enemies in the FAW invaded territories.
- Classical biological control in Asia and Africa has limited options. Exploration of FAW natural enemies in the Americas has been thoroughly done.
- Conservation and augmentative biological controls are the currently available best options.
- Conservation biological control – preservation of locally occurring natural enemies – use of less toxic pesticides to preserve them.
- Augmentative biological control – production and release of effective natural enemies – local or introduced ones.
- Currently the natural enemies are *Telenomus remus* and *Trichogramma* spp.
- In this workshop, we learned how to mass produce natural enemies in lab and release them in the field.
- When we go back to our country, survey and find local parasitoids and predators of FAW, especially egg parasitoids, *Trichogramma* and *Telenomus*, and get them identified by a specialist in respective countries.
- Secure and set up adequate laboratory space and human support and start rearing *Trichogramma* and *Telenomus*.
- Group photo along with the entire group of participating members along with the resource person was done.
- After the coffee break, Technical sessions were carried by the resource person from ICRISAT, IPMIL and University Dan Dicko de Maradi

### **General information on FAW bio-ecology: Session by Dr. Muni**

- Dr. Muniappan Rangaswamy presented on the General Information on FAW: Taxonomy, origin, related species, distribution, spread, monitoring and pheromone traps;
- Dr. Malick Ba, presented on the General information of FAW management which included: mechanical control, cultural control, host plant resistance, biological control;
- General information on biological control (conservation, classical, augmentative/inundative): **Session by Dr. Muni**
  - Similarly, Dr. Muni presented on the General information on Biological control which included conservation , Classical, augmentative, inoculative and inundative methods of controls;
- Case study of successful augmentative biological control of the millet head miner in the Sahel: **Session by Dr. Baoua**
- Update on FAW natural enemies encountered in Africa and Asia: **Session by Dr. Muni and Mr. Laouali Amadou**
- Mass production of *Trichogramma* and *Telenomus*: **Practical Session by Mr. Laouali Amadou**

- Best laboratory practices for parasitoid mass rearing: **Practical Session by Mr. Laouali Amadou**

**July 23-24, 2019 (Tuesday & Wednesday): Day 2 and Day 3 of the training:**

- Day 2 of the training was more focused on the production and maintenance of *Corcyra* and FAW cultures.
- Similarly, Day 3 of the training was focused on the production of *Habrobracon hebetor* and its release bags.

In order to accomplish the above activities, all the participants were split into 4 small groups to practice the following. Each group had 6-7 members, separating English and French speakers. All the practical sessions were lead by the resource person along with the PhD Scholars.

**Preparation of FAW artificial diet was prepared using the following ingredients**

- **Pack A:** Agar-----24grams
- **Pack B:** Sucrose, Cellulose(fiber), saltmix, Methyl paraben, Sorbic acid, Cholesterol, Aureomycin, Vitamin E Acetate, Wheat Germ, Stabilized casein, Linseed Oil, Raw corn oil-----126.9 grams
- **Pack C:** Potassiumhydroxide Solution-----4.8grams
- **Pack D:** Vitamins(Vitamin Mix, Diet Fortification, Ascorbic acid-----12.9grams

**Mass production of FAW using artificial and natural diets**

Mass rearing of FAW is required as some of its natural enemies depend on the host (FAW) number. The lab practice covers mass rearing of FAW using artificial diets and this includes colony initiation, egg collection and sterilization, media preparation and dispensing, inoculation of diets with first instars neonates, pupae collection and harvesting, and pairing of adult moths (oviposition). It also includes rearing FAW using natural host maize and Castor leaves.

**Mass rearing of Rice moth , *Corcyra cephalonica***

The purpose of multiplying Rice moth *Corcyra cephalonica* is to multiply the egg parasitoid *Trichogrammatids* on factitious host *Corcyra cephalonica* eggs. This includes rearing *Corcyra cephalonica* in a lab for colony establishment as well as rearing *Corcyra cephalonica* for *Trichogrammatids* mass production. This lab session includes selection of natural diets of Rice moth (pearl millet bran), inoculation of diet with egg or larvae, organizing lab materials required, oviposition and egg harvesting, collection of newly emerged adult moths and sexing them.

### **Mass production of *Trichogramma* using *Corcyra* eggs**

This covers sexing *Trichogramma* wasps, exposing the Rice moth (*Corcyra*) eggs to *Trichogramma* wasps, preparing glue cards, pouring the eggs on cards painted with glue, preparation of honey solution for the wasps, release of *Trichogramma* to the eggs glued to the card, removal of exposed cards, labelling and incubating the parasitized eggs.

### **Mass production of *Telenomus* using FAW eggs**

Collection of FAW eggs from lab mass reared FAW colony in the rearing cages, examining egg masses for parasitism using hand lens (compare both eggs with parasite and without parasite for better understanding of the differences; parasitized FAW eggs turn deep black compared to unparasitized FAW eggs). Eggs are irradiated in a dark chamber under UV light 4 W tube (UVP, USA, 254 nm) for 45mn at a distance of 3 cm. Irradiation is needed to kill the embryo to avoid emergence of larvae and give more time to Trichogrammatid for parasitism. Keeping the UV treated egg masses at room temperature for 10 days to observe for *T. remus* adult emergence, allow mating for two days before exposing fresh FAW egg masses for parasitism, exposing fresh FAW egg masses to *T. remus*.

### **Preparation of parasitoid tricho-cards for field releases**

- White-colored cardboard are cut in small rectangular pieces
- A card of 7.5 cm x 2.5 cm is used for 125 eggs of *C. cephalonica*
- The card is covered with a thin layer of non-toxic glue (Arabic gum or white chicken eggs ).
- The glue is spread on the card using a brush
- A corner of the card is left not glued for honey droplets to be placed for Trichogrammatid adult
- The eggs cards can be stored in the refrigerator at 4°C for 2-5 days for accumulation of eggs prior to infestation by Trichogrammatids
- However, as storage period increased, the parasitism rate declined as compared to freshly laid eggs

### **Infestation of eggs with *Trichogrammatids***

- Prior to infestation, a drop of honey is placed at the corner of the card to feed the adult parasitoid.
- This increases parasitoid lifespan and fertility.
- The egg cards are inserted into glass tubes and infested with 6 mated Trichogrammatids females for 2 days.

- After 2 days, the parasitoids can be given a new batch of egg cards for parasitism and so forth.
- However, the ratio of host eggs: number of parasitoid varied from species to species.
- Once parasitoid culture is established, several egg cards can be put together in a large container, containing another piece of cardboard with newly emerged adult parasitoids and a droplet of honey for feeding.
- For *T. armigera* in 1-liter container, we inserted 2 cards of 14,000 eggs with 500 females for 6d. The females are given another set of eggs for remaining 6d of their life.
- About 3-4 days after card placement, the parasitized eggs turn dark, providing a qualitative evaluation of the rate of parasitism.
- If for some reason the parasitism rate is smaller, eliminate the hatched larvae (it happens when irradiation failed).
- New generation will start emerging after 7-8 days.

### **Quality control and care in rearing**

- Have separate rooms for host culture and parasitoid culture to avoid contamination in the breeding environment.
- For control of parasitism quality, take three 100-egg samples from a card and record the number of parasitized eggs, the wasp emergence percentage, and the sex ratio (number of females divided by the total number of insects emerged).
- To avoid interruption in the insect flow of both the host and the parasitoid, maintain strict control of the asepsis conditions at the breeding sites.
- When hygiene conditions are not adequate, a predatory mite can be found and, consequently, compromising the parasitoid production.

### **Mass rearing of *Habrobracon hebetor*, a polyphagous larval parasitoid**

- Colony of *H. hebetor* has been established and maintained in the laboratory on an alternate host, the rice moth, *Corcyra cephalonica* at the ICRISAT, IER, INERA, ISRA and INRAN facilities.
- *C. cephalonica* is reared on a mixture of millet flour and millet grains

Collect the *corcyra* cocoons into jars/vials separately, observe for adult ***Habrobracon hebetor*** emergence, introduce honey solution into the jars or vials for adult feeding. Transfer 2<sup>nd</sup> instar FAW larvae to the cage (second instars are preferred by this parasitoid), introduce fresh maize leaves inside the cage for larvae to feed, introduce about 10 pairs of *Habrobracon hebetor* into the cage using aspirator for about 200 FAW larvae, expose them for 24 hrs during which the larval parasitoid, *Habrobracon hebetor*, stings/oviposits into the FAW larvae. Collect the stung larval instars 24 hrs. after exposure and keep them in a Petri dish, provide them with fresh

maize leaves and change the leaves every 2 days, observe for white fluffy cocoons 6-7 days after exposure, harvest the cocoons and keep them in adult emergence cage; the cycle of exposure continues until the required population is attained.

Participants will be assigned to the following four groups for lab practical exercises. Each of the group was having 6-7 members with separating the English and French speakers. All the practical sessions were lead by the resource person along with the PhD Scholars. The details of the group and their title of lab work is given in below table.

<b>Date/Days</b>	<b>Title of Practical</b>	<b>AM</b>	<b>PM</b>
<b>July 23,2019 Tuesday</b>	Preparation of artificial diets for FAW mass rearing	Group 1	Group 2
	Rearing Rice moth	Group 2	Group 3
	Rearing <i>Trichogrammatoid</i>	Group 3	Group 4
	Rearing <i>Telenomus</i> and <i>Corcyra</i>	Group 4	Group 1
<b>July 24,2019 Wednesday</b>	Preparation of artificial diets for FAW mass rearing	Group 3	Group 4
	Rearing Rice moth	Group 4	Group 1
	Rearing <i>Trichogramma</i>	Group 1	Group 2
	Rearing <i>Telenomus</i>	Group 2	Group 3

**July 25, 2019 (Thursday): Day 4 of the training:**

- Practice scouting for eggs and larvae parasitoids of FAW (sorghum and maize planted for the purpose on ICRISAT Sadore campus)
- Practice field release of egg parasitoids
- Revisit lab practices

**July 26, 2019 (Friday): Day 5 of the training:**

In the morning, participants will be arranged in four groups and will be given time to go to the lab to practice any of the procedures they think that they would like to repeat for better understanding. In the afternoon, there was a wrap-up session and conclusion of the training sessions.

In the afternoon at 3:00PM all the participants from Sadore ICRISAT Lab returned back to TVC, Niamey ICRISAT.

**Training Completions Certificates Distributions:**

At the TVC, ICRISAT, Niamey, all the participants were provided with the Training completion Certificates to all the trainees. The Certificates were handed by a resource person, Dr. Muni, Dr. Malick and Dr. Baoua, respectively, and wishing safe departure to all the participants.

**July 27-29, 2019 (Saturday, Sunday and Monday):** In the morning the ICRISAT managed the sightseeing in Niger. Visited the Museum at Niamey and at the late night travelled back to Niamey Airport from the TVC. All of the four participants travelled back to Nepal in following flight below:

- The departure flight from Niamey, Niger to Casablanca, Morocco was at 3:10 AM in Royal Air Maroc and reached Casablanca, Morocco at 6: 40 am (local time)
- Departure from Casablanca, Morocco was at 2:40 AM in Royal Air Maroc and reached to Doha, Hamad International Airport at 10:50PM (local time).
- Similarly the departure flight from Doha, Hamad International Airport was at 2:40 am and reached to Kathmandu Airport at 10:15am.

### Training Activities Conducted:

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Biological Training on Management of FAW	July 22-26	National researchers, extension agents and technicians	21	6	ICRISAT, IPMIL	To learn how to produce and release the biological parasitoids and artificial diets for FAW managements

### Suggestions, Recommendations, and/or Follow-up Items:

- Follow up on the training learning on respective country;
- Figure out best scaling up options engaging the private sectors, public (research and extension), cooperatives, Farmers groups, Community Business Facilitators etc.
- Follow up with the respective country government on implementation to produce and release the parasitoids in the fields.
- Develop long-lasting collaboration with the participating countries' fellow trainees.
- Survey FAW infested fields for natural enemies (egg, larval, and pupal) recruited by it.
- Exchange visits on successful scale up and dissemination programs on biological control
- The duration for the training should be extended additional 2-3 days;
- Training Modules on the Biological controls should be published in English languages, should be provided to each country's trainees so that they can translate in respective language for training to the private sectors too,
- Mobilization of trainees to use what was learned to train other government staffs and extension professionals, private sector/agrovets for management of FAW in Nepal

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\*The blue colour name indicates the Resource person for the training