Food and Agriculture Organization of the United Nations

Commission for Controlling the Desert Locust in the Central Region

REPORT OF

THE INTER-REGIONAL TRAINING ON THE USE OF BIOPESTICIDES FOR LOCUST CONTROL

16-20 May 2022

Agadir, Morocco

Executive Summary

The interregional training on the use of biopesticides in locust control held in Agadir 16-20 May 2022. The training was organized jointly by NSPMD, Commissions for controlling the Desert Locust in Western (CLCPRO) and Central (CRC) Regions, Near East Plant Protection Organization (NEPPO) and Moroccan National Anti-Locust Center (CNLAA), with the participation of the biopesticide producing company (Eléphant Vert). Eighteen participants from fifteen countries, hosting locust-breeding areas: Algeria, Chad, Egypt, Ethiopia, Kenya, Libya, Mali, Morocco, Mauritania, Niger, Oman, Saudi Arabia, Somalia, Sudan and Yemen, in addition to FAO's experts took part in the training.

The theoretical part was delivered in the form of PPT presentations dealing with general knowledge of locust control alternatives based on entomopathogenic fungi, the experience of their experimental and operational use in different countries. Specific attention was given to the status of the biopesticide registrations in different countries and ULV spraying techniques. Each country presented its experience in biopesticides according to the outline that had previously been requested by the organizers.

The practical part took place a) in the CNLAA laboratory on the techniques for testing the germination of Metarhizium acridum spores, b) in the CNLAA car park premises, on the method of preparing the mixture of biopesticide spores with diesel and the calibration of spraying devices (Micro Ulva+ hand-held sprayer, Micron AU8000 motorized knapsack sprayer and vehicle-mounted sprayers such as Ulvamast as well as manual and electronic Micron AU8115), c) in the field where simulation treatment exercises were carried out.

During the event, the trainees acquired both theoretical and practical knowledge on all aspects of handling, transporting, storing and applying the biopesticide, *Metarhizium acridum*. Specific attention was given to methods of fungal spore viability assessment, mixing the biopesticide with diesel before application and parameters of Ultra-Low Volume (ULV) spraying with the biopesticide product. Lessons learned from successful biopesticide operational use and barrier treatments with Insect Growth Regulator (IGR) in Somalia during the recent Desert Locust approach were shared with the participants.

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Abbreviations and acronyms

APV	Autorisation Provisoire de Vente
CILSS	Comité Permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel
CLCPRO	Commission for Controlling the Desert Locust in the Western Region
CNLA	Centre National de Lutte Antiacridienne (Mauritania)
CNLAA	Centre National de Lutte Antiacridienne (Maroc)
CRC	Commission for Controlling the Desert Locust in the Central Region
CSP	Comité Sahélien des Pesticides
DGPC	Direction Générale de la Protection Civile
EV	Eléphant Vert
FAO	Food and Agriculture Organization of the United Nations
NEPPO	Near East Plant Protection Organisation (NEPPO)
NSP	Plant Production and Protection Division FAO
ULV	Ultra Low Volume
UNLA	Unité Nationale de Lutte Antiacridienne
UV	Ultra-Violet

1. Introduction

The Interregional training on the use of biopesticides for locust control was held in Agadir, Morocco, from 16 to 20 May 2022 in collaboration between FAO, the Commission for Controlling the Desert Locust in the Western Region (CLCPRO), the Commission for Controlling the Desert Locust in the Central Region (CRC), the Near East Plant Protection Organization (NEPPO), and the National Locust Control Center of Morocco (CNLAA).

This training was attended by 18 participants from 15 countries belonging to FAO regional Desert Locust commissions (mainly frontline countries): CLCPRO (Algeria, Libya, Mali, Morocco, Mauritania, Niger, Chad) and CRC (Saudi Arabia, Egypt, Ethiopia, Oman, Sudan, Yemen) in addition to Kenya and Somalia. Eritrea had been invited but its representative could not join the training.

The event was also attended by the head of FAO Locusts and Transboundary Plant Pests and Diseases, Plant Production and Protection Division (NSP), the Executive Secretary of CLCPRO, the Executive Secretary of CRC, the Executive Director of NEPPO, the FAO Agriculture Officer/ Locust Management (NSP), FAO consultants and EV representatives. The list of participants is presented in Annex 2.

This training I s part of the efforts undertaken by FAO and its Commissions for controlling the Desert locust to promote the use of biopesticides in locust control, as a safer and essential alternative to conventional pesticides, allowing the implementation of the preventive strategy of the Desert locust control. It aims to share knowledge, experiences and lessons learned on the use of biopesticides, promote their registration and train participants on handling and field application of biopesticides.

2. Opening ceremony

The Opening ceremony took place in the conference hall of the Anezi Tower hotel, Agadir on 16 May 2022. Mr Shoki Al Dobai, Team Leader, “Locusts and Transboundary Plant Pests and Diseases” Team (NSPMD) opened the Training on behalf of FAO and the Executive Secretaries of the Desert Locust Commissions (Mr Mohamed Lemine Hamouny and Mr Mamoon Alawi) of CLCPRO and CRC respectively with thanking the partners, who supported this event, in particular the National Anti-Locust Control Center of Morocco (CNLAA) and the Near East Plant Protection Organization (NEPPO). He stressed that the holding of this event contributes to the promotion of the use of biopesticides, as less toxic alternatives for Desert Locust control, in the context of a preventive strategy. He described as a “success story” the use of the biopesticide in Somalia during the recent upsurge of the Desert Locust and underlined that the Training would be a great opportunity to share experiences and lessons learned with the concerned countries.

In his speech, Mr Mekki Choubani, Executive Director of NEPPO, expressed his gratitude to the Government of Morocco for hosting this important event. He then highlighted the essential role of the FAO regional Commissions in controlling the Desert Locust, particularly in strengthening the capacities of member countries in order to ensure full success in preventive control, the only sustainable strategy of controlling the Desert Locust.

On behalf of the Government of Morocco, Colonel Abdelmajid Kati, representative of the Director General of Civil Protection, welcomed the participants. He praised the efforts made by the organizers of this event for the development and implementation of new sustainable and environmentally friendly alternatives in locust control, whose effectiveness has been proven on several occasions. At the end of his speech, he reiterated his welcome to the participants and wished full success to the Training.

3. Organization and Training Program

The training had been organized in such a way as to combine both theoretical and practical aspects while giving practice most of the time available. The main trainer was Mr Said Lagnaoui, FAO International Consultant on spraying technology, assisted by Mr Alexandre Latchininsky, Agricultural Officer/Locust Management, NSPMD, Mr Heath McRae, FAO International Consultant on biopesticides, and Mr Mohamed Jaafar, Director of the National Center for Locust Control of Mauritania. Mr Said Ghaout, senior locust management expert, acted as moderator of the training on the basis of the five-day training program, presented in Annex 1.

The training was given in French and English, since the participants were from two regions speaking or understanding one of these two languages; which was a challenge overcome thanks to the applied pedagogical method and simultaneous translation provided.

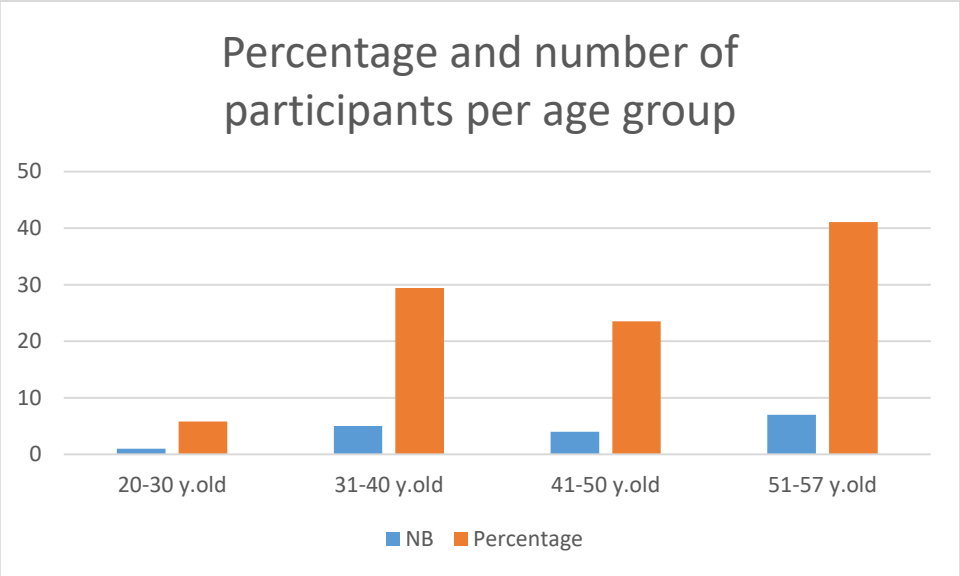
The theoretical part was delivered in the form of Powerpoint presentations dealing with general knowledge of locust control alternatives based on entomopathogenic fungi, the experience of their experimental and operational use in different countries. Specific attention was given to the status of the biopesticide registrations in different countries and ULV spraying techniques. Each country presented its experience in biopesticides according to the outline that had previously been requested by the organizers.

The practical part took place a) in the CNLAA laboratory on the techniques for testing the germination of *Metarhizium acridum* spores, b) in the CNLAA car park premises, on the method of preparing the mixture of biopesticide spores with diesel and the calibration of spraying devices (Micro Ulva+ hand-held sprayer, Micron AU8000 motorized knapsack sprayer and vehicle-mounted sprayers such as Ulvamast as well as manual and electronic Micron AU8115), c) in the field where simulation treatment exercises were carried out.

Two FAO videos on the use of biopesticides in locust control were also presented.

4. Profile of the participants

The level of education of the participants is high. Among the 18 participants, 15 hold a university degree (Bachelor (5), Master (2), Engineer (8)) and 3 have a technician's degree. The youngest is 27 years old and the oldest is 57 years old. The distribution by age group is shown in the following graph:



The participants come either from the national locust control units (UNLA) or from the Plant Protection (PV) services of the countries concerned. They all have experience in locust control (from 1 to 34 years of experience) and have received training in pesticide spraying techniques in the past. Only two of them (representatives of Somalia and Chad) have already received training on the use of biopesticides.

5. Summary of the training

5.1 Biological control of locusts (Alexandre Latchininsky)

Biopesticides present an ecologically acceptable and safe, low-toxicity alternative to conventional pesticides. Among naturally occurring entomopathogenic microorganisms, it is a fungus *Metarhizium acridum* which is used for locust control. It provokes an epidemic disease among the treated insects. Commercially available biopesticide products are based on different isolates of *Metarhizium acridum* fungus: **Green Muscle**® (isolate IMI 330189) and **Novacrid**® (isolate EVCH077). Both are manufactured by Éléphant Vert Company. The formulation is the dry technical powder of fungal spores in vacuum-sealed bags of 500 g each. Each gram of the powder contains $5x10^{10}$ spores of *Metarhizium acridum.* Before the application, the contents of the bags are mixed with diesel oil. To apply the biopesticide, Ultra-Low Volume (ULV) sprayers are used. These include aircraft, vehicle-mounted, knapsack or hand-held sprayers. The recommended dose rate is 50 g of the biopesticide product mixed with one liter of diesel oil per hectare.

When *Metarhizium acridum* spores come into contact with the locust exoskeleton, they germinate and penetrate inside by pressure and enzymatic action. The fungus multiplies and competes with the host for water and nutrients. The locusts are weakened in three to four days, reducing feeding and dying from seven days onwards. The fungus continues to produce spores on the cadavers, which thus becomes a new source of contamination. Maximum mortality occurs two to three weeks after treatment. Both hoppers and adults are susceptible to the biopesticide.

Metarhizium acridum is highly specific to locusts and grasshoppers. It kills only these insects and does not affect honeybees and other beneficial non-target arthropods. It is not toxic to humans or animals such as birds, fish, reptiles, amphibians etc. The biopesticide requires standard Personal Protective

Equipment (usually, a face mask is sufficient) and can be applied with the same ULV sprayers as the chemical pesticides.

However, *Metarhizium acridum* acts slower than the majority of chemical pesticides. It requires particular temperature and humidity conditions for storage and transportation. Spore viability should be checked before each application. When mixing with diesel oil, the solution should be mixed thoroughly to avoid clogging the sprayer's filters. Mortality assessment in the field requires a special procedure of collecting the treated locusts and monitoring them in cages for up to three weeks.

Metarhizium acridum is a great tool for the preventive strategy to control the Desert Locust, particularly when it is necessary to treat initial, small groups of hoppers to prevent them from forming dense and huge hopper bands.

It is essential to understand the advantages and drawbacks of the biopesticide in order to promote its adoption and operational use against the Desert Locust.

5.3 Production and development process of the biopesticide (Elephant Vert)

Éléphant vert (EV) was created in 2012, as an international group totally focused on sustainable agriculture, putting research at the service of the development of new biocontrol solutions. In 2014, EV began with the launch of the production site for organic amendments and fertilizers in Meknes (Morocco) and Segou (Mali). Subsidiaries were then created in France (2015), Senegal (2016) and Côte d'Ivoire (2017).

In 2019, EV obtained certification for the first 100% proprietary biocontrol product Novacrid® (*Metarhizium acridum* EVCH077) produced in Meknes, Morocco. EV also produces the other strain of *Metarhizium acridum* IMI 330189, which has been used for a long time and marketed under the name Green Muscle®.

In his presentation, the representative of EV explained to the participants the stages of product development from the strain isolation and purification, mass production of spores by solid fermentation, quality control of the resulting formulation, packaging and storage of the product. World-wide registration status and operational use of the biopesticide were presented.

The advantages of Novacrid® have been highlighted as follows:

• *Cost effectiveness:*
Very low application rate: from 25 g/ha to 75 g/ha, which makes the biopesticide economically competitive with some conventional insecticides
One to two applications per season: significant savings in ULV spraying and aerial treatments
• *Efficiency :*
It is effective and specific to locusts and grasshoppers
Up to 100% observed mortality
• *Safety*
Safe for human health (operators and local population)
Harmless to the environment (water, soil, bees, other non-target organisms, predatory birds).

5.4 Somalia success story in the use of the biopesticide against the Desert Locust during the recent upsurge (Heath McRae)

Desert Locust swarms invaded Somalia and Ethiopia from Oman and Yemen in early 2019. Unprecedented cyclone activity in 2019 and 2020 produced ideal breeding conditions, and the development of Desert Locust swarms at a scale not seen for 25 years in the region.

Due to Somalia's economy being primarily based on nomadic and small-holding pastoralism with an estimated 45 million goats, sheep and camels in the country, and the Desert Locust found in the same ecosystem as livestock, the correct product choice was vital.

In late 2019, FAO and the Somalia government committed to the sole use of the biopesticide Metarhizium (Novacrid) and the addition of the Insect Growth Regulator (IGR) Teflubenzuron later in 2020 to enhance the hopper band control.

During 2020, with the assistance of FAO, the Somalia governmental aerial and ground control teams treated 130,000 ha of Desert Locust hopper bands with the biopesticide Novacrid.

On November 22, 2020, Cyclone Gati produced an amount equaling two years of rain in just two days across the northern Somalia region, creating ideal breeding conditions and resulting in the Desert Locust upsurge continuing into 2021.

To overcome the upsurge in 2021, almost 190,000 ha of hopper band affected area were barrier treated with an IGR Teflubenzuron 30 g of active ingredient (a.i.) / litre, greatly reducing the number and size of swarms. These barrier treatments against hoppers were followed with biopesticide operations against immature swarms. Two hundred and fifty swarms covering 80,000 ha were successfully treated with the biopesticide Novacrid at 50g a.i. / litre, applied at 1 litre per ha. Reports of very few swarms migrating from Somalia to neighboring countries by the end of 2021 highlighted the success of the 2021 operations.

Efficacy assessments during 2021 provided excellent results for both the IGR barrier treatments on hopper bands and the biopesticide on immature swarms.

In both cage and field trials with the biopesticide Novacrid, 50% mortality was recorded in 9 days and 83% mortality 14 days' post-treatment.

Efficacy assessments of the IGR application at 300-m barrier spacing provided 90-98% mortality between 4 and 10 days and at 500-m barrier spacing - 98% within 11 days after treatment.

The successful operations carried out in Somalia, especially during 2021 showed that large scale control using a combination of the biopesticide *Metarhizium* and a low toxicity IGR can provide results equivalent to those of conventional pesticides but with the benefit of a much lower impact on the environment and risk to human and animal health.

5.4 Mauritania's experience in the use of biopesticides (Mohamed El Hacen Javaar)

Mauritania, as a frontline country, actively participates in efforts to promote biological control of the Desert Locust, as a preventive strategy. The first experimental trial of *Metarhizium* (Green Muscle) was conducted in 2006 in the field under natural and operational conditions leading to complete elimination of hopper bands and persistence of action for four days after treatment.

Other tests were carried out in 2009 for the validation of five new formulations of Green Muscle within the framework of the implementation of the FAO CGP/INT/964/IFA project. The results were as follows:

I) virulent formulations under laboratory conditions,
II) effective under semi-natural conditions and
III) stable under ambient storage conditions.

In 2014, a test on the stability of the biopesticide for long-term storage was carried out and the results gave a viability of the spores of >90% during 4 years of storage at 4°C (last germination test in 2018).

In 2016, a PhD thesis was presented by Mr Mohamed Etheimine from Mauritania, entitled “Study of the factors influencing the stability, effectiveness and persistence of *Metarhizium acridum* in biological control against the Desert Locust in operational conditions”. The work led to the following results:

(i) Efficient and stable formulations (six months of storage in the room at room temperature: 21 to 39°C and three years in refrigeration conditions (-2 to 15°C),

(ii) Biopesticide efficacious even in sparse vegetation conditions. Efficacity and persistence increased when the vegetation was denser.

(iii) Possibility of the biopesticide use in barrier treatments was demonstrated.

In addition, in 2016, the operational use of *Metarhizium acridum* led to a 60 to 70% reduction in the initial density of treated hoppers in the field, while in cages mortality reached 80% after 10 days. As for the viability of the spores, it was not affected despite the fact that the product remained in the field under natural conditions for one month.

In 2019, the operational use of the biopesticide in an area of crops infested with young adults and solitaro-transiens hoppers reduced the Desert Locust populations by 50 to 60%.

In 2020, a wide operational use of the biopesticide was carried out on 320 ha, especially in difficult-to-access biotopes, compared to 160 ha treated with Chlorpyrifos.

The problems encountered relate to the sedimentation of the product causing the clogging of the pipes and the pump in addition to the long time required to carry out the mixing.

5.5 Country experiences and lessons learned in the use of biopesticides

Representatives of the countries were invited to share their experience on the use of biopesticides. The main information that was deduced from their presentations is as follows:

Algeria: Experimental tests of the biopesticide Novacrid® were carried out in 2016 with very encouraging results. However, the product is still not registered in Algeria but the procedures are underway to obtain its registration soon.

Saudi Arabia: Biopesticides are not yet registered but the decision-makers in charge of locust control are aware of the role they can play as alternatives to conventional pesticides to reduce their impact on human health and the environment. Measures are underway to make them available for locust control.

Egypt: Promising trials have been carried out with *Metarhizium acridum* but the product is not yet registered.

*Ethiopia***:** The registration procedure is in progress. *Metarhizium acridum* trials were carried out in 2021 with good results. No operational use of biopesticides occurred during the recent Desert Locust upsurge.

Libya: Biopesticides are not registered for locust control.

Mali: The biopesticide based on *Metarhizium acridum* has a Provisional Sales Authorization (APV) from the Sahelian Pesticides Committee (CSP). However, Mali has no experience in the operational use of the biopesticide due to a lack of targets. It was used only for training purposes.

Morocco: *Metarhizium acridum* (Novacrid®) is registered in Morocco until 22/12/2025. The tests that led to its registration were very conclusive. Its operational use is not yet effective but it is planned as part of the preventive control means against the Desert Locust and Moroccan Locust. Currently, Morocco has no stock of *M. acridum*.

Mauritania: As a member of CILSS, *Metarhizium acridum* is therefore registered in the country until the end of May 2022 but it can continue to be used until the CSP meets to decide what's next (extension or discontinuation of use). In 2020, Mauritania successfully treated 325 ha infested with Desert Locust hoppers using *Metarhizium acridum*. The biopesticide stock available at the CNLA is 316kg.

Niger: The provisional authorization for sale (APV) of *Metarhizium acridum* (Novacrid®) issued by the CSP is also valid in Niger as a member of CILSS. Several trials were conducted on the Desert Locust and grasshoppers (*Oedaleus senegalensis*) in 2013, 2014, 2016 and 2017 leading to very promising results. In terms of operational use of *M. acridum*, during the 2017/2018 campaign, a total of 450 ha were treated against grasshoppers.

Kenya: The product is not registered in Kenya but trials have been carried out on a pilot basis against fifth hopper instar of the Desert Locust. Monitoring the effectiveness (%) in the field was difficult because many treated hoppers were either cannibalized, eaten by predators or had moved. To overcome these challenges, cage mortality control was performed. Mortality reached 80% after seventeen days in the cage. Infected hoppers reduced their feeding and movement. Since Desert Locust is not common in the country, manufacturers of biopesticides are reluctant to register them for Desert Locust only as they believe they are not economically viable.

Oman: The biopesticide is not yet registered. Officials are convinced of the advantages and interest of their use in locust control.

Somalia: *Metarhizium acridium* is not registered but due to the importance of pastoral resources and beekeeping in the country, the government decided to use it operationally and on a large scale during the Desert Locust upsurge in 2020 and 2021. At the end of 2020, the IGR Teflubenzuron 30 ULV also started to be used with good results.

Sudan: Biopesticide trials have been conducted with promising results. However, the product is not yet registered.

Chad: The Novacrid® biopesticide is registred in the CILSS space and therefore in Chad. Different doses of Green Muscle® were tested under semi-controlled conditions on Desert Locust hoppers in Abéché in 2008/2009 with encouraging results. Chad has 170 kg of Novacrid® provided by CLCPRO as part of prevention against a possible resurgence of the Desert Locust.

Yemen: *Metarhizium acridum* is not registered in Yemen. However, the country has 600 kg of the biopesticide in stock, received as part of the FAO emergency plan to deal with the upsurge of the Desert Locust in 2020-2021

5.6 Module on the use of biopesticides in locust control (Said Lagnaoui)

The consultant started his presentation by explaining the context that favoured the development of the promotion of biopesticides. He highlighted the importance of the preventive control strategy advocated by the FAO and successfully carried out against several outbreaks of the Desert Locust in the Western Region since the 2003-2005 invasion.

He also recalled FAO's efforts to ensure full success preventive control strategy through, among other things, the encouragement and support for operational research of enthomopathogenic fungus strains which ultimately led to the discovery of *Metarhizium acridum* isolates now used in biopesticides.

He then described the product Novacrid® based on the fungus *Metarhizium acridum* EV CH077 and explained its mode of action by contact and not by ingestion. He insisted on the control of the viability of the spores of the fungus before any use and described the method and the steps to follow for this purpose.

The methods of storage and transport have been explained. The different ways of preparing the mixture of spores with diesel, as a solvent, were demonstrated based on illustrations/photos. The required dose rates and treatment conditions were explained as well as the protective measures to take during the preparation of the mixture and during the treatments.

5.7 Module on key principles and parameters of ULV spraying (Said Lagnaoui)

In its second module, the consultant presented the spraying equipment available for biopesticides, and then the basic principles of ULV spraying. The procedures to be followed to ensure good spraying have been detailed, with particular emphasis on the preliminary calculations of the flow rate and the drift of the spray droplets. The explanations also concerned the calibration of ULV treatment devices, namely how to calculate the flow rate of the device, the forward speed and the spray width. The conditions required to carry out ULV treatments as well as the methods of controlling the quality of the treatments through the collection of droplets on oleo-sensitive papers, were also described.

5.8 Practical exercise on spore germination tests

A practical exercise on the germination tests of *M. acridum* fungus spores was organized at the CNLAA laboratory. Spores of *Metarhizium acridum* EV CH077 were thus deposited in Petri dishes containing an artificial media and left to germinate. The counting of spores having germinated in mycelium (compared to those which have not) was carried out the next day under a microscope to define the rate of germination.

5.9 Practical exercise on calibration techniques of the sprayers

A practical session was carried out in the CNLAA car park premises during which the material learned during the theoretical presentations, on the techniques for calibrating ULV sprayers, was put into practice by the participants during an entire day. The session began with the preparation of the mixture of biopesticide spores with diesel, respecting the steps and the advice given beforehand. The participants practiced calibrating the flow rates of the treatment devices (Micro ulva+, motorized knapsack sprayer equipped with Micron AU8000 head, vehicle-mounted sprayers Ulvamast and Micron AU8115 Manual version).

5.10 Simulation of biopesticide treatment in the field

A simulation of a treatment using the biopesticide was carried out in the field south Agadir (Ait Melloul region). All the necessary logistics had been put in place to carry out the said simulation. Two vehicles equipped with Micron AU8115M sprayed the product after calibrating the devices.

The collection of the droplets on oil-sensitive papers, placed on the treated plot, allowed the participants to see and appreciate the quality of the spraying under the weather conditions at the time of the spraying, which were characterized by a light wind unfavorable for good spraying. Participants practiced counting droplets on oleo-sensitive paper.

5.11 Information session on Insect Growth Regulators (IGR) (Alexandre Latchininsky and Heath McRae)

An information session on insect growth regulators (IGR), as another alternative for locust control, was presented to the participants.

Insect Growth Regulators (IGRs) are a lower toxicity alternative to conventional pesticides, such as organophosphates and pyrethroids. They belong to a chemical group of benzoyl-urea insecticides. IGRs work only by ingestion, NOT by contact. They are sprayed over the vegetation, which is eaten by locusts. IGRs can maintain their toxicity on the vegetation for up to four weeks (depending on the dose rate). Their mode of action is an interference with the chitin formation during the process of insect molting, so the insects are killed during molting. IGRs are effective only against hoppers and will not kill adults.

Advantages of the IGRs: they have very low human toxicity and very low toxicity to mammals, birds, reptiles etc., they are relatively low toxic to non-target arthropods and safe for honeybees.

Disadvantages of the IGRs: they have slow action – mortality starts about a week after application; they are not suitable if fast crop protection is needed, they work only against hoppers and inefficient on adults and they are highly toxic for aquatic invertebrates so cannot be used near water.

Because of their prolonged toxic action, IGRs can be applied not only in a blanket coverage but in barriers. Such barriers are placed on the way (in front) of moving hopper bands. This was operationally used against Desert Locust hoppers in Somalia.

Detailed presentation on the successful barrier treatments with an IGR against the Desert Locust in Somalia concluded the session.

6. Summary of discussions

The discussions mainly concerned the following points:
Registration of biopesticides: Registration is deemed slow for various reasons including, among others, a) the reservations of decision-makers on the introduction of pathogens whose behavior in the environment and local ecosystems is not known, b) preference for fast-acting shock products for fear of upsurge or invasion and crop damage, c) political pressure to quickly eliminate any locust reports threatening the food security of populations, d) lack of awareness of authorities and decision-makers on the advantages of using biopesticides and c) the periodic nature of locust infestations which makes the biopesticide market unprofitable and economically unsustainable for manufacturers of biopesticides intended for locust control.

Registration is a slow and expensive process. Once the product is approved and in the absence of an order during a period of calm, it happens that the registration comes to an end without the producer receiving purchase orders, as is the case recently in South Africa.

Mixing biopesticides with solvent: the preparation of the mixture of fungal spores with diesel is deemed complex, time-consuming and cumbersome in terms of logistics. Participants wondered if it would be possible to have a ready-to-use formulation to save time and effort. The question of finding a substitute for diesel was raised since diesel can be used for other purposes outside of locust control operations.

The representative of Somalia affirmed that cases of phytotoxicity of the vegetation treated with the biopesticide mixed with diesel oil had been observed and he attributed this to the effect of diesel oil which, in a dusty environment, forms a surface layer of grains of sand on the plant, thus hindering photosynthesis. This observation should be verified by experiments because in principle it should not happen if the calibration of the sprayers and the correct dosage of the mixture are carried out according to the rules.

Availability of biopesticides: Some participants raised, as a constraint, the non-availability of biopesticides at the right time. To overcome this constraint, it was suggested to build up security stocks, especially in frontline countries where the possibilities of use are more frequent in the context of preventive control operations against the Desert Locust. The representative of EV reported that the company has a production capacity of 700 kg/month of Green Muscle and 1 ton/month of Novacrid. For orders of more than one ton, it is necessary to organize the delivery times according to the production schedule (availability and capacities). He also pointed out that the company has a storage capacity of 3 tonnes at 4°C for a maximum one year, which suggests the possibility of using the company as a bank of biopesticides.

Storage and transportation conditions for biopesticides: country representatives highlighted the lack of appropriate infrastructure and equipment for the storage of biopesticides under the required conditions. The equipment, often dilapidated when it exists, and the recurring problem of electrical load shedding do not ensure proper conservation of organic products. The conditions of their transport also leave much to be desired. To improve this situation, the representatives of the countries requested the support of the FAO and the regional commissions for controlling the Desert Locust CLCPRO and CRC; which assured them of their willingness to provide the necessary assistance to meet the needs.

Spore viability: The biopesticide is composed of living organism in the form of spores. It is therefore essential to check the viability of the spores before each use by carrying out germination tests.

The difficulty of performing such tests in the field was raised. The participants wondered if it was possible to find a simple and easy method to carry out these tests in the field. The idea of having a portable kit for germination testing was suggested and the representative of the company producing the biopesticide took note to check the feasibility of the proposal.

Use of biopesticide against swarms: Biopesticide treatments carried out on a large scale in Somalia were not limited to hopper bands but also concerned swarms; which raised questions from the participants about the effectiveness of the treatments against the adults as they move. The great mobility of the swarms makes it difficult to control or assess mortality after treatment since the effect of the fungi on the insect is not immediate. The feasibility of such interventions seems possible only on settled young swarms which have just completed their last moult and whose wings are not sufficiently hardened to fly over long distances or on mature swarms in copulation and/or laying eggs, forced to stay on the ground for a few days.

Sprayers dedicated to biopesticides: the usefulness of having a range of sprayers specifically dedicated to spraying biopesticides was discussed. Although efficient, the sprayers currently available -essentially produced by a single firm- are intended for ULV treatments but are not equipped with an agitator or a system which makes it possible to ensure the maintenance of a good homogeneity of the spores in the mixture and avoid their sedimentation and the clogging of the spraying system. The representative of EV pointed out that his company has no expertise in this area and that the solution must be sought from the manufacturers of sprayers.

7. Participants Assessment

Feedback and an evaluation of the training were made by the trainees using an anonymous form inviting the participants to rate the questions according to a classification from insufficient to very good (see appendix 3). The results are summarized as follows:

- Knowledge/expectations: eighty-nine (89%) percent rated the knowledge acquired as very good and eleven (11%) percent as good. All participants considered expectations met (very good 94% and good 6%).
- Content of the training: 88% rated the program content as very good and 12% as good. They also appreciated the teaching methods (78% very good and 22% good) as well as the exchange between participants and trainers (82% very good and 18% good).
- Organization: The trainees were accommodated at Anezi Tower Hotel, Agadir, 53% indicated that the venue and the accommodation were very good, 41 % rated the accommodation as good while 6% (one person) considered the accommodation as medium. They also appreciated the means deployed (91% very good and 9% good).

In view of the above evaluation, it should be concluded that the training was very useful; the results would of course be reflected in future successful locust operations using biopesticides.

8. Conclusions and recommendations

8.1 Conclusions

The organization of the interregional training on the use of biopesticides bringing together member countries of the two regional FAO Commissions for the controlling of the Desert Locust, CLCPRO and CRC (especially those on the frontline) was a commendable and fully successful initiative.

It also denotes the good collaboration and cooperation between the two commissions, particularly in building the capacities of member countries through sharing and exchanging of experiences.

The challenge of organizing it in two languages, French and English, was successfully overcome thanks to the applied pedagogical method and simultaneous translation provided.

According to the participants, expressed through the evaluation of the training submitted to them, their aspirations have been fulfilled, namely the acquisition of know-how and the improvement of knowledge on the operational use of biopesticides. They deemed the general organization of the training to be very satisfactory.

The participants have appropriated the techniques of spraying biopesticides and are now able to transfer the knowledge acquired to their colleagues through national trainings so as to ensure the sustainability of the achievements. All participants are convinced of the advantages that biopesticides offer to effectively control locusts without harming human health and the environment in general.

8.2 Recommendations

At the end of the training, the participants made the following recommendations:

Recommendations	To be implemented by
Operations-Registration	
1. Speed-up registration of *Metarhizium acridum* in order to make the product available for operational use against locust infestations, especially those located in environmentally sensitive areas.	Countries, Biopesticide producer
2. Establish, in each country, teams specialized in the use of biopesticides and appoint a national focal point in charge of biopesticide use.	Countries
3. Create and maintain a strategic stock of biopesticides in the frontline countries concerned by the Desert Locust to use them as a priority whenever conditions allow.	Countries, FAO Commissions
4. Acquire the necessary equipment to ensure the storage, packaging and transportation of biopesticides under the required conditions.	Countries, FAO Commissions
5. Prioritize frontline countries, concerned by Desert Locust, in supporting the registration of biopesticides for use in locust control.	FAO Commissions Biopesticide producer
6. Produce and share guidelines on the use of biopesticides in locust control to all concerned countries.	Biopesticide producer, FAO Commissions
7. Keep the regional commissions (CLCPRO and CRC) informed of the progress of biopesticide registrations in member countries and benefit from their support if necessary.	Countries, FAO Commissions
Training	
8. Continue to organize, on a regular basis, regional trainings on all aspects of the use of biopesticidesincluding monitoring and evaluation of treatments' efficacy.	FAO Commissions
9. Support countries to train specialized control teams in the use of biopesticides to ensure optimal efficacy.	FAO Commissions
10. Include, in the national training plan of each country, the organization, annually, of national trainings on the use of biopesticides.	Countries

Communication – Awareness raising	
11. Pursue advocacy for the gradual integration of the use of *Metarhizium acridum* within the framework of preventive actions against the Desert Locust.	Countries, FAO Commissions
12. Raise awareness among the institutions concerned, political authorities and decision-makers about the usefulness and the advantages and benefits of biopesticides.	Countries, FAO Commissions
13. Take advantage of the various events organized in the fields of agriculture, public health and the environment (such as the celebration of World Food Day etc.) to present and promote the successes obtained with biopesticides.	Countries, FAO/ Commissions
Research and development	
14. Improve the current formulation of *Metarhizium acridum* to facilitate its use, particularly the solvent, in order to avoid the problem of sedimentation and clogging of spraying equipment	Biopecticide producer
15. Develop a ready and easy-to-use formulation of *Metarhizium acridum* that can replace the current one which requires complex mixing operations and heavy logistics	Biopecticide producer
16. Carry out research to elucidate the influence of UV light on spore viability and propose solutions to avoid the risk of product deterioration under its influence.	Biopecticide producer
17. Design and supply a spore germination test kit that can be easily transported to the field for on-site testing prior to each spray operation with biopesticides to assess spore viability**.**	Biopecticide producer

The recommendations were endorsed by all the participants.

CLOSING SESSION

During the closing session, Mr. Shoki Al Dobai thanked all participants for their fruitful participation, discussions and hard work which resulted in 17 important recommendations. He thanked the Regional Commissions CLCPROC and CRC, NEPO and CNLAA for their excellent organization and preparation of the training. He also thanked the trainers, the moderator and the translation team for the tremendous efforts which resulted in the success of this training. And finally, he wished everyone a safe journey home.

At the end, each participant received an FAO certificate of the training followed and USB keys containing all the didactic material of the training.

ACKNOWLEDGEMENTS

Thanks are due to the Government of Morocco for hosting the event and to FAO, its commissions (CRC and CLCPRO), NEPPO, CNLAA and EV for organizing and supporting, as partners, this interregional training as well as for the trainers. Acknowledgement extended to the efforts of all CNLAA staff for their tireless efforts, which made the event a pleasure and a great success.

This report was prepared by Said Ghaout, Senior Locust Management Expert, acting as moderator of this training.

Annex 1. Training programme

TIME	ITEMS –	DOCUMENTS	PRESENTER/MODERATOR
DAY 1: (16 May Monday, 09.00 – 17:00)			
08:30 – 09:00	**Registration of the participants**		
SESSION 1 (Morning Session)		**Session venue – Anezi Tower Hotel**	
9:00 - 09:40	**1. Official opening of the event**		FAO Representatives (Shoki AlDobai) NEPPO Representative (Mekki Chouibani) Moroccan Government Representative (Cl Abdelmajid Kati)
	2. FAOs' advocacy video (the use of biopesticides in locust control)		
09:40 – 10:00	**Coffee break (+ Group Photo)**		
10:00 – 10:10	**3. Introduction of Participants**		
10:10 – 10:25	**4. Biological control of locust (history, development and bio-agents) /**		Alexandre Latchininsky
10:25 – 11:30	**5. Countries experience and lessons learned on the use of biopesticides** (5 minutes each country) /		Participants
11:30 – 11:45	**6. Somalia success story in the use of the biopesticide in DL upsurge control /**		Heath MCrae
11:45 – 12:00	**7. Mauritania experience in the use of biopesticide /**		Jaavar Mohamed El Hacen
12:00 – 12:30	**8. General discussion on success, challenges and lessons learned /**		All /tous les participants
12:30 – 13:00	**9. Review the technical profile of participants /**		Said Ghaout

13:00 – 14:30	**Lunch break**		
SESSION 2 (Afternoon Session)		**Session venue – Anezi Tower Hotel**	
14:30 – 15:30	**10. Biopesticide training module 1.** Context and the development of the biopesticide use in locust control . - Mode of action - Spore viability (germination assessment) - Storage and transportation - Applications dose - Mixing options, application methods and spray volumes - Environmental , health and safety measures - Non-target effects		Said Lagnaoui
15:30 – 15:45	**Coffee break-**		
15:45 – 17:00	**11. Biopesticide training module 2** - Application equipment - Treatment conditions - Mortality control assessment		Said Lagnaoui
17:00	**End of the day activity**		

TIME	ITEMS	DOCUMENTS	PRESENTER
DAY 2: (17 May Tuesday, 09.00 – 17:00)			
SESSION 3 (Morning Session)		**Session venue– Anezi Tower Hotel**	
09:00 – 10:00	**1. Production and development process of the biopesticide** - Production capacity and facilities at countries level - Product registration and challenges		Expert from Elephant Vert
10:00 – 10:30	**Coffee break –**		

10:30 – 12:30	**2. Key principles and parameters of ULV spraying**		Said Lagnaoui
12:30 – 14:00	**Lunch break**		
SESSION 4 (Afternoon Session)		**Session venue – National Locust Control Center (CNLA)**	
14:30 – 16:00	**3. Germination test**		Trainer/participants
16:00 – 17:00	**4. DL Centre facilities visit**		
17:00	**End of the day activity**		

TIME	ITEMS	DOCUMENTS	PRESENTER
DAY 4: (19 May Thursday, 09.00 – 17:00)			
SESSION 7 (Morning Session)		**Session venue – Lieu :Field**	
08:00 – 12:30	**1. Field simulation of the biopesticide spraying with different type of sprayers**		Trainer/participants
	Coffee break		
12:30 – 14:30	**Lunch break**		
SESSION 8 (Afernoon Session)		**Session venue : Anezi Tower Hotel**	
14:30 – 16:00	**1. Review of the mortality monitoring protocol /**	Locust Biopesticide Field Efficacy Trials Guidelines	Trainer/participants
16:00 – 16:15	**Coffee break**		
16:15 – 17:00	**2. FAO technical video on the operational use of the biopestictide in locust control**		
17:00	**End of the day activity**		

TIME	ITEMS	DOCUMENTS	PRESENTER
DAY 5: (20 May Friday, 09.00 – 13:00)			
09:00 – 10:30	**1. Open discussion recommendations and next steps**		All
10:30-11:00	**Coffee break**		
11:00 – 12:00	**Information session: Other alternatives for locust control**		
12:00 – 12:30	**2. Training evaluation**		Participants
12:30 – 12:45	**3. Certificates for participants /**		
12:45-13:00	**4. Closure of the meeting /**		

Annex 2. Participant list

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Annex 3. Evaluation form

THEMES		APPRECIATION			
		Insufficient *Insuffisant*	**Medium** *Moyen*	**Good** *Bien*	**Very Good** *Très bien*
1- OBJECTIVES *OBJECTIFS*	**Did the topics of this training meet your expectations?** *Les thèmes de cette formation ont-t-ils répondu à vos attentes ?*				
	Do you think that the knowledge you have acquired will improve your work? *Pensez-vous que les connaissances acquises amélioreront votre travail ?*				
2- CONTENT OF THE TRAINING *CONTENU DE LA FORMATION*	**How do you rate the content of the training?** *Comment jugez-vous le contenu de la formation ?*				
	Was the announced program respected? *Le programme annoncé a-t-il été respecté?*				
	Were the teaching methods appreciated? *Les méthodes pédagogiques présentées sont-elles appréciées ?*				
	Were the exchanges between participants and trainers enriching?				

	Les échanges entre participants et formateurs étaient-ils enrichissants ?				
3- ORGANISATION	**Do the means deployed seem appropriate to you?** ***Les moyens déployés vous semblent-ils appropriés ?***				
	Were the program times suitable? ***Les horaires de programmation convenaient-ils ?***				
	How do you rate the accommodation conditions? ***Comment juger-vous les conditions d'hébergement et d'alimentation ?***				

Any specific comments or suggestions?:……