A novel nematode-based biocontrol solution for farmers against the fall armyworm

Background: Native to the Americas, the fall armyworm (FAW), *Spodoptera frugiperda* (JE Smith), has recently invaded Africa and Asia and is rapidly becoming one of the leading threats to food security on these continents[1] (Fig. 1). The caterpillars can feed on a large variety of staple crops[2], but are particularly destructive to maize, one of the most widely grown crops in the world[3]. FAW causes billions (US$) worth of yield losses annually and threatens the livelihoods of millions of farmers[1]. The rapid global spread of FAW has led to an enormous increase in the use of chemical insecticides in maize production[4], potentially causing serious negative impacts on public health, beneficial organisms and the environment[5]. Safer and more sustainable alternatives to control this highly destructive pest are urgently needed.

Figure 1: Plants damaged by FAW.

Objective: My PhD project is a collaborative effort between the University of Neuchatel (UniNE), Rwanda Agriculture and Animal Resources Development Board (RAB) and the Centre for Agricultural Bioscience International (CABI). It aims at developing an innovative control method against FAW, specifically designed for small-holder farmers, using entomopathogenic nematodes (EPN) as biological control agents.

Figure 2: Preparation of the EPN-gel formulation.

EPN are tiny soil-dwelling roundworms naturally present in soils worldwide[6]. They are strict parasites of insects and have been used to control insect pests for decades[7]. EPN can be isolated from soil samples and mass-produced, allowing developing countries to produce biological control products locally[8,9]. Importantly, EPN are safe for farmers and consumers, with minimal risk to the environment[10]. They are extremely virulent to lepidopterans, such as the caterpillars of FAW[11]. EPN are sensitive to UV radiation and desiccation and are therefore seldomly used against leaf-feeding insect pests[12]. However, FAW caterpillars mostly feed well-hidden in the wrapped leaves of the whorl, where the EPN will be largely protected. To further shield the EPN from harmful abiotic factors, we incorporated them into an affordable, easy-to-produce gel formulation (Fig. 2). The formulated EPN can be readily applied into the whorl of vegetative maize plants to control FAW (Fig. 3).

Results: Using EPN we isolated from Rwandan soils, we have shown in laboratory and field experiments that our approach can effectively control FAW[13]. In the laboratory we artificially infested maize plants with FAW caterpillars and then applied EPN formulated either in water, a commercial surfactant-polymer-formulation (SPF) or gel. All treatments significantly reduced FAW survival and plant damage (Fig. 4). These results also held true under realistic farming conditions (Fig. 5). In several trials involving farmers' fields in Rwanda, just one application with a low dose of EPN formulated in the gel was as effective as a conventional dose of the contact insecticide, cypermethrin. The gel was the most suitable formulation for EPN to reduce FAW infestation under field conditions.

Figure 3: Application of EPN formulated in a protective gel into the whorl of a maize plant.

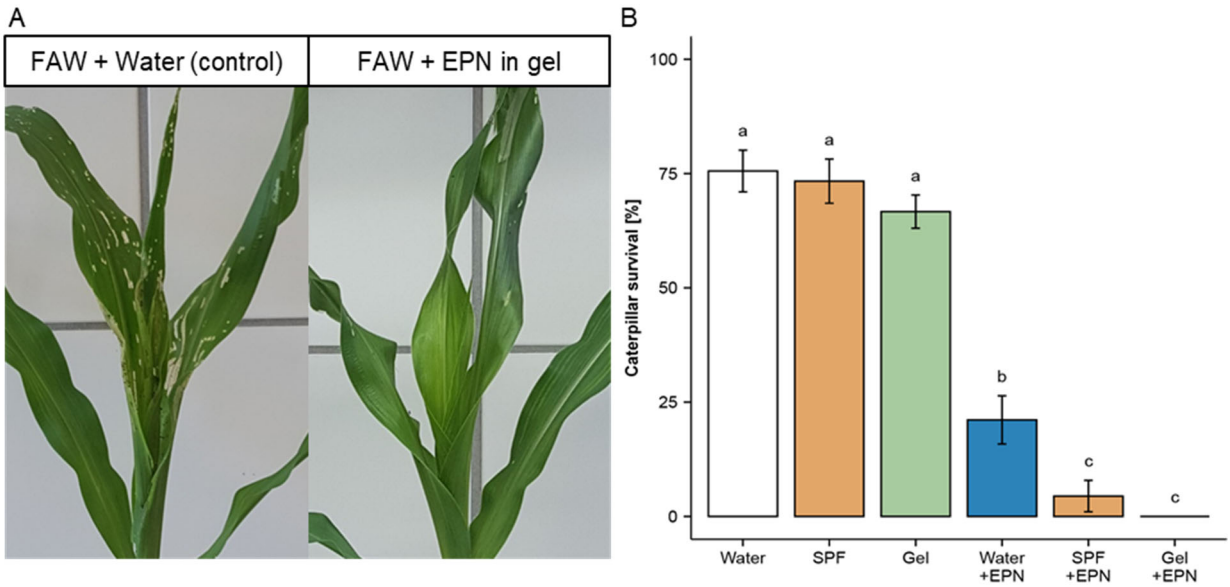

Figure 4: Plant damage (B) and caterpillar survival (A) six days post treatment with formulated EPN.

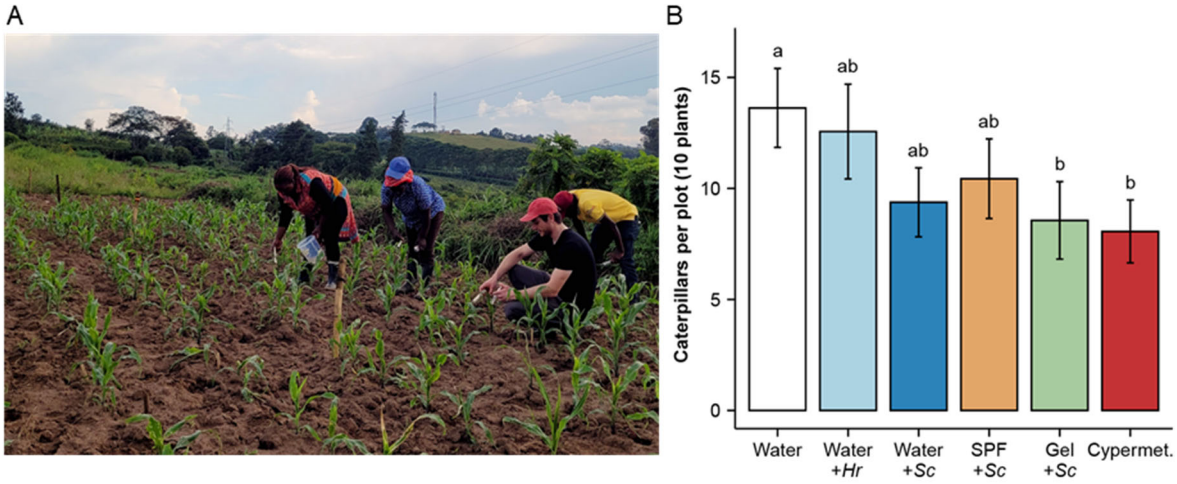

Figure 5: Application of formulated EPN (A); FAW infestation levels ten days after treatment with formulated EPN or with the pesticide cypermethrin. *Hr* and *Sc* indicate two different species of Rwandan EPN, *Heterorhabditis ruandica* and *Steinernema carpocapsae*. Cypermet.: chemical insecticide, cypermethrin, used as positive control.

Our results represent a proof-of-principle that clearly shows that appropriately formulated EPN hold great potential to control FAW. Formulated EPN can be as effective as a commonly used chemical insecticide, while reducing the non-target effect on other organisms and being safe for farmers and the environment.
We are currently investigating whether repeated applications of formulated EPN can further reduce FAW infestation and plant damage over an entire maize growing season. Preliminary results are very promising and may translate into an increased grain yield.

Prospects: We envision that, provided specific training, small-holder farmers could produce and formulate native EPN and use a locally developed control option against the FAW, without relying on external sources. Moreover, local agro-industries could upscale mass production of EPN as biocontrol products, and further develop the EPN-formulation to meet the specific needs of larger scale maize cropping systems. We believe that our research represents a major step forward in the development of a safe, sustainable and effective control method for the FAW on maize, using native biological control agents.

For further information, please visit: https://www.unine.ch/farce/home/membres/patrick-fallet.html

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