

UNDER BIOLOGICAL CONTROL – ENHANCING MAIZE PRODUCTION IN DPR KOREA PARTNERSHIP RESULTS



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Editorial

The Asia Briefing Paper Series aims to inform the development practitioners and the (Swiss) public about new innovations, results and impacts of Swiss development cooperation in Asia. It shall particularly highlight past and present efforts to achieve aid effectiveness through partnerships between Swiss agencies and local partners.

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Results of Integrated Pest Management (IPM) in Maize in the DPRK

Agriculture is a major economic sector of the Democratic People's Republic of Korea (DPRK). Since the early nineties, it involved approximately one third of the economically active population and contributed an estimated 25% to the gross national product (GNP). Nonetheless, agricultural output has remained frustratingly low. Agricultural policy and structure have not effectively overcome production difficulties associated with the short growing season and pest damage. In addition, soil degradation over the last twenty years has even further reduced yields, resulting in food shortages despite the consistent use of agrochemicals in an effort to maintain production. Ensuring food security is a very high priority and sustainable crop production is receiving heightened attention and support from the North Korean Ministry of Agriculture (MoA).

Decreasing maize yields are of particular concern since maize is one of the most important staple cereal crops in the DPRK. In 2007 alone, it was sown on 495'000 hectares (almost 20% of the total arable surface). In an effort to increase maize yields, Switzerland is supporting the implementation of Integrated Pest Management (IPM) with its Pyongyang-based Korean partners, the Plant Protection Institute (PPI) of the Academy of Agricultural Sciences (AAS) and the Central Plant Protection Station (CPPS) of the MoA.

IPM is a pest management strategy that focuses on sustainable crop production by applying a combination of biological, cultural and chemical control measures. It gives precedence to non-chemical pest control measures, but employs the most environmentally friendly pesticides when required. The key element of this IPM approach in the DPRK is the mass release of *Trichogramma*, a parasitic wasp that protects the crop from a major insect pest, the Asian corn borer. Positive effects of reduced pesticide use is a marked decrease in farmer or consumer health hazards and negative environmental impacts.



Maize cultivation on a Cooperative Farm

Trichogramma wasps are released using a so-called inundative biological control approach. Very large numbers of the parasitic wasps are distributed every year in the field to maintain a high pressure on the maize pest. This must be repeated annually when huge numbers of the Asian corn borer colonise the maize fields early in the spring. At this time of the year, the number of wasps that have survived the winter is too small to keep the pest in check and therefore must be reinforced through additional releases of these natural enemies.

In the course of this Swiss-Korean collaboration, efficient Chinese *Trichogramma* mass production technology was introduced to the DPRK. Through a joint effort, the technology was adapted for use with low energy consumption, due to erratic energy supply, and to ensure sustainability under local conditions. Whenever possible, locally available material was used for the production facilities and the rearing process. Training was provided to local staff for the production and maintenance of the equipment.

So far, eight facilities were established, each of which contributes to the protection of 700 hectares of maize from pest damage. In total, the facilities produce and distribute 2'800 million *Trichogramma* wasps every year. The implementation of this IPM approach has resulted in a 25% maize yield increase (= 1.1 tons of maize grain/ha). This translates to 6'160 tons over the approximately 5'600 hectares treated.

The results of this joint programme have encouraged the DPRK government to consider a nationwide application, which could result in the production of an additional 500'000 tons of maize. This would contribute substantially to food security and also serve to meet Millennium Development Goal 1: halving hunger by 2015.

To back the DPRK MoA's nationwide dissemination plan, an important institutional strengthening and capacity building component was incorporated into the project.

CONTEXT

Agricultural policy and the rural economy are administered by the Ministry of Agriculture (MoA), which establishes agricultural priorities, oversees yearly national farm production plans and coordinates all government agricultural support.

Ninety percent of agricultural production in the DPRK is generated from approximately 3000 cooperative farms involving 6 million people. On average, a farm is manned by 1900-2000 people working 550-750 ha of arable land. Each cooperative farm works according to a production plan issued by the MoA that defines crop and yield requirements. Farms compile an annual work plan (AWP) detailing agricultural inputs, mechanised services and the labour needed to meet these requirements.

While implementation of the AWP is the responsibility of the Cooperative Farm Management Board, responsibility for meeting farm production targets actually lies with the cooperative farm work teams and sub-work teams (averaging around 100-115 and 15-20 people, respectively). These teams, which constitute the basic building blocks of the DPRK's rural socialism, consist of specialised technicians and general labourers who are organised around specific production tasks (e.g. vegetable production, fruit production, livestock management, farm equipment).

Over the last few decades, cooperative farm work teams have faced increasing difficulties in meeting their production targets. A decline in soil fertility has been identified as a major contributing factor, while insect pest damage further exacerbates the problem.

Maize is one of the most important, yet most severely affected, crops in the DPRK. Under optimal conditions, average yields of this staple can reach 6.5 t/ha. However, low soil fertility reduce this to 4.5-5 t/ha, while insect pest damage causes a further decline to 3.9 t/ha.

Maize as a staple food in DPRK

Maize products are an important source of calories and protein for human nutrition. In the DPRK, harvested maize is milled and used to prepare a large number of foods including noodles, cake and bread. Some of the by-products of milling can be used as a source of high quality edible oil, which is particularly scarce in the country. The crop is also extremely important as winter fodder for draught animals, which are necessary for the preparation of soil in spring.

One insect pest, the Asian corn borer, *Ostrinia furnacalis*, imposes the greatest losses in the DPRK's maize production. The larvae of this widespread moth feed inside the maize stem and later attack the cobs. Resulting yield losses of grain maize typically range from 10 to 30%, depending on the year and location, but extremely high damage levels of up to 80% can occur. Furthermore, this type of pest attack also leads to a reduction in the quantity of green material available for animal feed.

Traditional attempts to control the Asian corn borer in the DPRK are mostly chemically-oriented, involving the routine application of broad-spectrum synthetic pesticides during the pest's first generation. However, as the maize plants grow taller, this treatment becomes impossible as cooperative farms lack the sophisticated machinery required.

In an initiative to improve food security in the DPRK, this project focused on rapid and sustainable improvement in maize production. Integrated Pest Management (IPM) was introduced into the DPRK to increase yields in the short term and restore soil fertility in the long term, thus benefiting farmer, consumer and environmental health.



Damage by Asian corn borer larvae

INTEGRATED PEST MANAGEMENT: A SUSTAINABLE SOLUTION

Integrated Pest Management (IPM) is a dynamic pest control strategy involving a combination of biological, cultural and chemical control methods. It particularly emphasises the incorporation of methods to promote long-term pest prevention (insects, mites, weeds and diseases) while using pesticides only as a last resort to protect the health of farmers, consumers and the environment.

The IPM approach developed to improve general maize production in the DPRK included cultural control techniques, such as intercropping, crop rotation and the selection of plant varieties that are resistant or tolerant to local pests. Intercropping (growing two or more crops simultaneously in the same field) and crop rotation (growing a planned sequence of different crops on the same piece of land) ultimately have very similar aims: both encourage crop diversity within the farm system and help to maintain or even improve soil fertility. The three cultural techniques in combination minimise pest damage, promote the occurrence of natural enemies and help to improve crop yields.

Biological control was seen as a highly promising option for attaining long-term suppression of the Asian corn borer in the DPRK. Constituting a fundamental component of IPM, this strategy involves using natural enemies to reduce pests. Natural enemies include predators (which eat the pest), parasitoids (which develop on or in the pest and ultimately kill it) and pathogens (which inflict disease that kills the pest). Biological control is a process of augmenting the natural enemies of a pest, either by providing food or hiding places, or by releasing large numbers of a specific natural enemy in a pesticide-like application.



Asian corn borer

What is *Trichogramma*?

Trichogramma is a tiny insect (less than 1 mm in size) that is present in many agricultural and natural habitats. It lays its eggs into the eggs of larger insects, especially moths. Many moth caterpillars are well known as important pests of field crops, forests, and fruit trees.



After hatching, the *Trichogramma* larva absorbs the nutrients in the pest egg, ultimately killing the developing pest caterpillar. Once fully developed, the beneficial *Trichogramma* emerges (see right) and then searches for further pest insect eggs in which to lay its own eggs.

Insect specialists in the early 1900s began to mass rear *Trichogramma* for pest control. Today, several different species of *Trichogramma* are produced in private or government owned insectaries around the world.

Mass releases of a parasitic wasp became the major focus for Asian corn borer control in the DPRK maize production. This environmentally and economically sound technique not only offered a way of reducing or avoiding economic losses due to pest damage, but also presented an opportunity to reduce pesticide use and the associated negative impacts. *Trichogramma ostriniae* is already a well known and highly studied biological control agent of the Asian corn borer. Although tiny in size, this insect attacks the eggs and reduces populations of the destructive maize pest with remarkable efficiency. Following a demonstration of its commercial success in Europe and in China, *T. ostriniae* was deemed highly suitable for use within a biological control approach in the DPRK.

BENEFICIAL INSECTS: HIGH POTENTIAL TO INCREASE MAIZE YIELDS

Before mass releases of *Trichogramma* can be carried out in a maize field, large numbers of the parasitic wasp must be reared and prepared in a suitable form.

(1) Sufficient numbers of so-called host eggs must be available to rear the parasitic wasp. Adult moths are kept in cages to lay eggs, which are collected and provided to the beneficial *Trichogramma* wasps.

(2) The parasitic wasps lay their own eggs inside the host eggs. After hatching, the *Trichogramma* larvae remain inside the host eggs and start to develop.

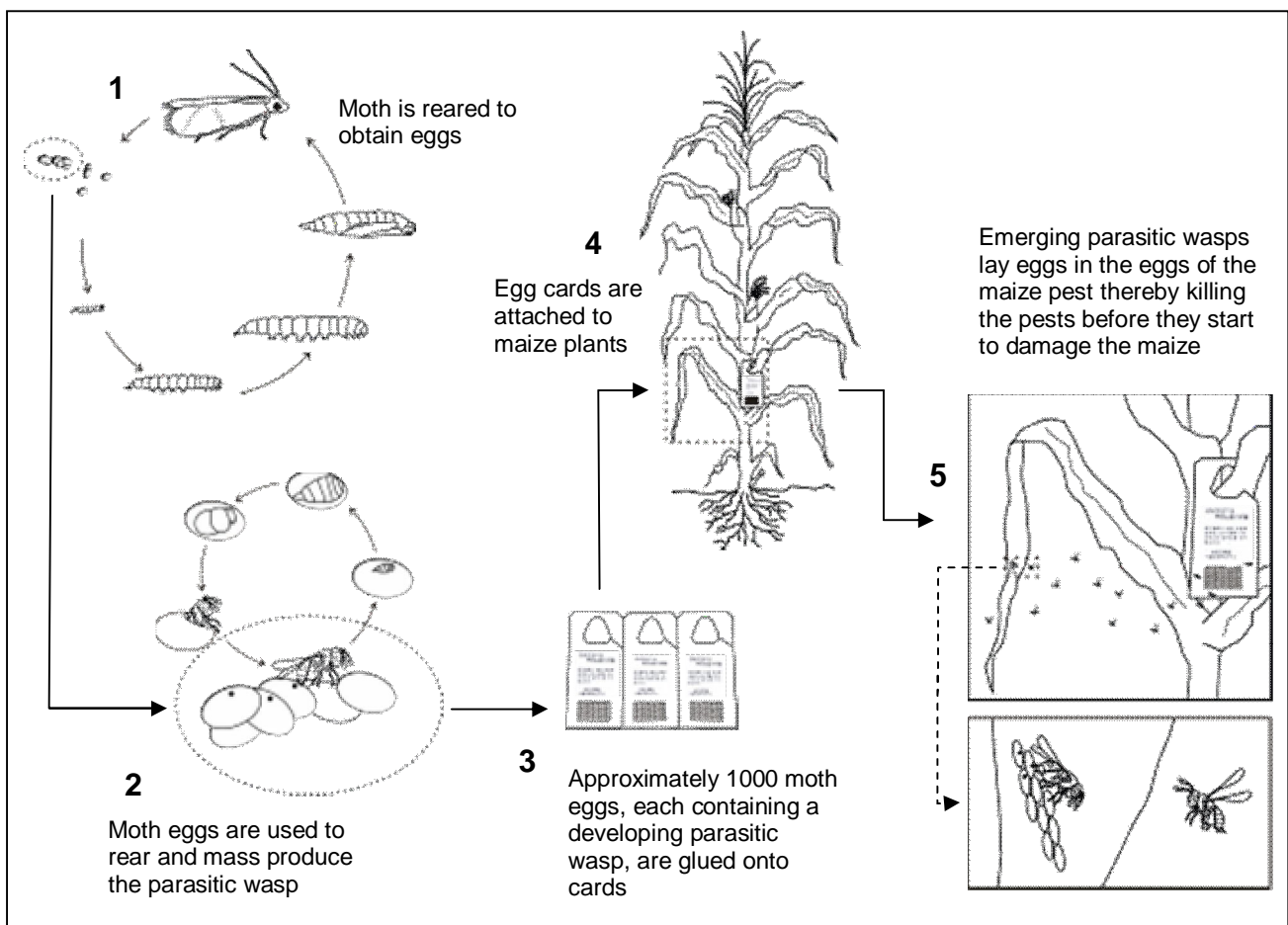
(3) The host eggs containing the developing beneficial insects are glued to paper cards.

(4) These egg cards are then attached to maize plants in the field when the Asian corn borer lays its eggs on the plants. The timing for this application needs to be accurate to ensure that the parasitic wasps emerge when the pest eggs are present in the field.

(5) If the timing is correct, the emerging *Trichogramma* will parasitize the pest eggs, thereby killing the pest insect before it is able to damage the maize.

The IPM approach using *Trichogramma* was tested on pilot farms in the DPRK. The average yield of grain maize from IPM plots was 28% higher than in the traditional cultivation system, demonstrating the effectiveness of these beneficial insects within an IPM framework. Furthermore, the abundance of Asian corn borer larvae in the IPM plots was decreased by almost 65%, which means less damage and more plant material for animal feed. Consistent results were obtained from several fields on three different cooperative farms over a period of two years.

Cooperative farm workers were impressed with the results and favour IPM as a more sustainable control approach to maize cultivation. This has motivated stakeholders to promote the establishment of *Trichogramma* rearing facilities for nationwide implementation of IPM.



PRODUCTION FACILITIES FOR BENEFICIAL INSECTS



Trichogramma production facility

With an effective production method for *Trichogramma* in place, additional facilities were needed to supply more cooperative farms with this beneficial insect.

Three experimental *Trichogramma* production facilities were established using Chinese designs and equipment, which were subsequently adapted to local DPRK conditions for the construction of a fourth facility. This pilot facility addressed problems associated with poor infrastructure and limited access to electricity. It incorporated locally-acquired equipment and permitted a reduction in electricity consumption by two-thirds. Following testing of the pilot facility, an additional four facilities were built according to the 'local design'. Strict quality control, in accordance with international recommendations, was also implemented to ensure production of high quality *Trichogramma* wasps.



Production staff and equipment

Each facility has a production team consisting of a manager, a technician and workers (6 staff per facility). To ensure sustainable management of each facility, a business plan was developed to specify the organisational structure, terms of references, calculations of annual inputs and outputs, costs of machinery maintenance and depreciation, a products distribution plan, etc. Taking into consideration the situation in the DPRK, the key feature of this plan is a barter system, which allows various essential inputs including barley and cole for the mass production of the parasitic wasp to be obtained.



Maize plant with egg card

With eight *Trichogramma* production facilities now established and each producing sufficient beneficial insects to supply 3-5 cooperative farms, dissemination of this biological control approach is already showing signs of success. From this year on, approximately 5'600 hectares of maize will be managed under this new system, increasing total maize grain yield by a predicted 6'200 tons annually.

Further expansion of the approach will enhance food availability in the DPRK, thereby contributing to improved national food security.



Intercropping maize – bean

CAPACITY BUILDING FOR SELF REPLICATION

Ensuring sustainability and self-perpetuation of the maize IPM approach in the DPRK has been a priority from the beginning. Such qualities are crucial for enabling widespread IPM implementation within a relatively short period of time. Capacity building of local and national project partners was thus foreseen to be fundamental to the project's success and comprised a major component of the project activities. Throughout the project, numerous stakeholders from various institutions have been recipients of efforts to broaden aptitude for various aspects of general IPM, especially with respect to maize production.

For example, activities with the Plant Protection Institute of the Academy of Agricultural Sciences (AAS-PPI) aimed to broaden their capacity for applied research and knowledge transfer with an initial focus on the production and release of biological control agents. The establishment of an experimental production facility gave scientists hands-on experience in mass producing *Trichogramma* parasitic wasps. With the support of Chinese production specialists, a *Trichogramma* Production Manual was developed and printed (in Korean and English), and is currently used by AAS-PPI to train county production staff. An additional training component assures that farmers develop a sound knowledge base in maize IPM, the application of *Trichogramma* and subsequent assessment of its impact in the maize field. AAS-PPI, along with its experimental production facility, has already demonstrated its important role as a resource and training centre.

The strengthening of production technology expertise was the main emphasis of capacity building activities with the Central Plant Protection Station (CPPS) of the MoA. An initial understanding of Chinese production technology design, together with experience of its implementation, was crucial for subsequent successful adaptation of the technology and equipment to suit local DPRK conditions. During the capacity building process, CPPS specialists acquired the skills and knowledge required to manufacture, maintain and manage production facilities.

Capacity building activities were conducted at the Pyongyang Agricultural University (PAU) to institutionalize IPM. In an effort to anchor the IPM concept within higher education, a series of IPM lectures were provided to university lecturers and post-doc students and used for the joint development of their own locally adapted lectures. A complete IPM curriculum, comprising both theoretical and practical aspects is now embedded within the university programme. Once the approach is approved by the Ministry of Education, universities and colleges at national,

provincial and county levels will all be able to offer an IPM course.

Policy-related issues have been the focus of capacity development activities at the MoA headquarters. Maize IPM, particularly the use of *Trichogramma*, is a high priority for the DPRK government. The current project activities have provided a model for nationwide implementation of maize IPM in the DPRK. Capacity building activities have therefore focussed on strengthening ownership, planning and logistical skills of relevant departments in order to support further dissemination of the IPM control strategy. In a joint effort with local maize specialists, an internationally compatible 'Guideline for Maize IPM in the DPRK' was developed as an accompanying measure to amplify nationwide IPM implementation.

Capacity Building activities instigated and implemented through the project

- § national expert group for IPM established and familiarised with international IPM standards during a study tour to Switzerland
- § two policy level workshops held with national expert groups to develop national IPM guidelines
- § continual transfer of knowledge through consultancies to enable partners to implement maize IPM
- § several two-week training courses held in China with *Trichogramma* production experts to transfer knowledge of successful Chinese commercial production system
- § three training courses for national production staff provided by local specialists; courses are ongoing and aim to train approximately 150 production staff
- § the DPRK technical scientific institute's capacity for carrying out technical backstopping for national production experts strengthened
- § ongoing Training of Trainers courses to prepare farm extension specialists for training of farmers
- § 50 one-week hands-on farmer training courses conducted on maize IPM implementation (more than 1'000 work team leaders reached during 2008/2009)
- § study tour to China for senior university staff to transfer knowledge on the structure and content of IPM curricula in an international context
- § 15 university professors and post doc lecturers brought into the position to deliver IPM lectures, and an IPM curriculum established at the university, which will also affect agricultural universities and colleges nationwide once approved at national level
- § IPM anchored at an elite agricultural university in the DPRK

PERSPECTIVES FOR THE FUTURE



Based on the encouraging results of these Swiss-funded activities, the DPRK government now considers maize IPM, particularly the use of *Trichogramma*, to be a high priority of the MoA. Since IPM implementation increased maize yield by at least 20% without intensifying production, the government is now planning to implement the IPM approach over 200'000 ha of maize production in the near future.

Funding from Switzerland and Europe is now being used to scale up the IPM approach to cover approximately 10% of the targeted area and provide a model for nationwide implementation of maize IPM in the DPRK. This important next step will support the establishment of an additional 20 low-tech, energy saving *Trichogramma* production facilities across three DPRK counties. As with the eight existing facilities, these County *Trichogramma* Production Facilities (CTRF) will likewise each deliver biological control products to 3-5 cooperative farms, thereby enabling a total of approximately 100 maize-producing cooperative farms to implement IPM. The result of this will be a potential 20% increase in maize yield over approximately 19'600 ha (considering that each facility has the capacity to provide sufficient *Trichogramma* for 700 ha of maize).

This Swiss and European co-funded initiative will continue to provide technical backstopping and capacity building to target groups at policy, institutional, extension and farm levels in order to ensure long-term self-reliance and sustainability of the IPM approach. These activities will focus on further dissemination of IPM, with an emphasis on the implementation of an appropriate quality control strategy and hands-on training of production facility staff and farmers.

A general facility quality control strategy, addressing both internal and external issues, will be developed together with all relevant stakeholders. Incorporated into this strategy will be a feedback loop from the farms that release the parasitic wasp back to the production facilities.

Relevant training will be given to the personnel of the 28 CTRF (28 x 6 employees = 168 personnel) and to at least one extension specialist from each of the 100 cooperative farms to ensure that all the sub-work teams (leaders and workers) involved in maize production are appropriately instructed in IPM implementation. Overall, this approach will disseminate IPM knowledge to more than 20'000 farmers across 100 cooperative farms.

The ultimate number of beneficiaries of the project is difficult to estimate, but certainly vast. The anticipated 20% (0.8 t per ha) increase in maize production across the area serviced by 28 production facilities will provide an additional yield of 15'680 t (= 19'600 ha x 0.8 t per ha). The initial beneficiaries of such an improvement will be the families of the farming communities, profiting from an increased stability in maize production, enhanced economic stability and improved food supply. With at least 1'500 people per farm, approximately 150'000 people across 100 farms will benefit directly from the provision of biological control agents for Asian corn borer control. After subsequent nationwide the enhanced food supply and improved nutritional health should reach far beyond the farms and their surrounding communities and be felt by all 23 million people of the DPRK.



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Photos: Manfred Grossrieder, Kang Song Il, Feng
Zhang, Dirk Babendreier

Further reading: www.cabi.org

Information on the structure of the agricultural
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