Towards biocontrol-based IPM for the diamondback moth in eastern and southern Africa

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Abstract

Effective chemical control of the diamondback moth (DBM), the key insect pest of crucifers in Eastern and Southern Africa, has become difficult. DBM has developed resistance to common insecticides and farmers increasingly use insecticide cocktails and spray more frequently. This is resulting in rising production costs, environmental contamination, health risks and high residues in produce. The recorded level of parasitism of indigenous parasitoids, including those of the genus *Diadegma*, is low compared with south-east Asia and South Africa. To enhance effective, economical and environmentally acceptable control of the pest, an IPM programme, based on the improved biological control of DBM, was initiated. This project tries to achieve improvements through a collaborative regional research effort in various steps: collection of basic information on distribution and efficiency of the indigenous natural enemy complex in Ethiopia, Kenya, Uganda and Tanzania; study of the taxonomy and bionomics of local parasitoids in comparison to parasitoids of proven value in south-east Asia and South Africa; importation, multiplication and release of superior parasitoids from Asia with support of the Asian Vegetable Research and Development Center (AVRDC) or South Africa. The organisational and operational set-up of the project is described.

Introduction

The main crucifer species grown in the Eastern and Southern African region (Ethiopia, Kenya, Tanzania, Uganda, Malawi, Zambia, Zimbabwe and Mozambique) are rape (*Brassica carinata* A. Br. and *Brassica napus* L.), kale (*B. oleracea* L. var. *acephala*), Chinese cabbage (*Brassica chinensis* L.) and cauliflower (*B. oleracea* L. var. *botrytis*). These vegetables are grown mainly for home consumption and domestic markets. They are valuable as relish in many homesteads, providing necessary dietary vitamins and minerals in a maize-based diet, as well as a source of cash for small scale farmers, particularly women and youths, in rural and peri-urban areas. However, production is often constrained by damage caused by a range of pests. Of the major pests, the diamondback moth (DBM), *Plutella xylostella* (L.) and aphids (*Brevicoryne brassicae* L., *Lipaphis erysimi* Davis and *Myzus persicae* Sulzer) have been identified as the most damaging (Nyambo & Pekke 1995, Adane-Kassa & Abate 1995, Oduor *et al.* 1996, Seif & Löhr 1998) in the region.

To date, farmers in Africa depend solely on the use of insecticides, which are often applied on a calendar basis to control these pests, and it is becoming increasingly difficult and uneconomic to achieve effective control. DBM has developed resistance to a wide range of the insecticides commonly used (Mingochi *et al.* 1995; Kibata 1996; B. Nyambo, personal communication). In addition, incidence of turnip mosaic virus, which is transmitted by aphids, has been on the increase in the region in recent years (D. Mingochi, personal communication; A.A. Seif, personal communication). As a result, many farmers have resorted to the use and application of insecticide cocktails as well as increased spraying frequency in order to achieve control of DBM and aphids (Kibata 1996). This has led to an increase in the level of contamination of the farm environment, high pesticide residues in the produce as well as health risks to farm workers and increased cost of production.

To address the problem, a regional workshop in 1995 tried to identify knowledge gaps in the management of the major pests of crucifers and set regional research priorities (Nyambo *et al.* 1996). Three activities were given priority, as these would provide the much-needed basic information to formulate suitable IPM options to reduce over dependency on chemical insecticides. Among these activities was a study of the seasonality of DBM and aphids including an inventory of their indigenous natural enemies in Kenya, Malawi, Mozambique, Tanzania, Uganda, Zambia and Zimbabwe.

Few DBM parasitoids were recorded in the participating countries in these studies. These included *Diadegma* spp. and *Oomyzus sokolowskii* (Kurdjumov). However, their combined level of parasitism did not exceed 14.5% at any of the study sites except at Henderson-Zimbabwe where *O. sokolowskii* caused 40% parasitism in one single collection (Seif & Löhr 1998). A follow-up regional workshop in May 1998...
discussed the research results and identified opportunities for future regional research activities (Seif & Löhr 1998). From the results, it was evident that DBM is the major insect pest of cruciferous vegetables in the region. Consequently, the workshop recommended that the issue of DBM and its natural enemy complex should be given more emphasis in future research activities in the region to generate more basic information as preparation for a classical biocontrol initiative against DBM. In particular, it was felt that more information is needed to explain why DBM parasitism by *Diadegma* spp. which has proven such a success in Asia, was so low at all study sites. To answer this question, more work on the taxonomy and biology of *Diadegma* was felt to be a prerequisite.

Judging from the experience in Asia with the implementation of biocontrol-based IPM approaches (Ooi 1990, Poelking 1990, Talekar *et al.* 1990, Biever 1996, Eusebio & Morallo-Rejesus 1996, Iga 1997), there is good potential in eastern and southern Africa to manage DBM with parasitoids as most of the production is also in the highlands. The aim of the project is to contribute to this process.

**Expected results**

ICIPE developed a project in cooperation with the national research institutions of the four partner countries. The proposal was submitted to the competitive grant facility for international agricultural research of the German Ministry of Cooperation and Development and awarded funding in early 2001. The following results are expected after the first project phase of three years:

- Baseline information on the indigenous natural enemies of DBM complemented through additional collections in collaborating countries
- Taxonomic status of the genus *Diadegma* in Africa is clarified and documented
- Comparative biological studies of the African and Asian DBM parasitoids conducted and promising strains for a classical biocontrol programme identified
- Classical DBM biocontrol pilot programme initiated in Kenya
- Exploration for additional pupal DBM parasites conducted in areas of DBM origin

Overall project coordination and management is based at ICIPE. The integration of AVRDC into the project ensures that maximum advantage is taken from its vast experience in a similar project in Asia. Major aspects of AVRDC involvement are the provision of parasitoids of proven quality from Asia and the coordination of exploration for additional pupal parasitoids in the areas of origin of DBM in partnership with the United States Department of Agriculture Biocontrol Station in Montpellier/France (Table 1).

The NARS second scientists as PhD students for the basic scientific studies suggested in the project, contribute with further collection of information about pests and local natural enemies and implement, with support from ICIPE and AVRDC, the importation, release and monitoring programme of the envisaged biocontrol programme. This will first be done in Kenya and later, in a second phase of the project, be extended to all countries in the region with an interest in cabbage production. An annual project coordination meeting is the main forum for planning and review of the regional project activities.

The project covers the crop and pests at the regional level and brings in both local and international expertise to alleviate a problem that has not been addressed by any country in the region. Cooperation should optimise use of scarce resources, avoid unnecessary duplication of efforts, enhance multi-disciplinary and team effort and enhance capacity and capability within NARS in eastern and southern Africa.
The management of diamondback moth and other crucifer pests

Table 1. Principal collaborators in the DBM biocontrol project in East Africa

<table>
<thead>
<tr>
<th>Country</th>
<th>Institution</th>
<th>Responsibilities</th>
<th>Scientist involved</th>
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<tbody>
<tr>
<td>Kenya</td>
<td>ICIPE Horticultural Pests Programme</td>
<td>Overall coordination; molecular taxonomic methods; studies of indigenous parasitoids; introduction of exotic parasitoids; pilot site Taita Hills; impact analysis Survey Eastern &amp; Central Kenya; pilot site Limuru; pilot release and monitoring Survey Western Kenya; pilot site Kisii; pilot release and monitoring</td>
<td>Dr. B. Löhr</td>
</tr>
<tr>
<td></td>
<td>KARI National Biocontrol Programme, Muguga</td>
<td></td>
<td>Dr. F. Nang’ayo</td>
</tr>
<tr>
<td></td>
<td>KARI Regional Research Centre, Kisii</td>
<td></td>
<td>Mr. Oscar Magenya</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>EARO, Nazareth Research Station</td>
<td>National survey for indigenous parasitoids, pilot site studies, long-term population dynamics of DBM</td>
<td>Mr. Gashawbeza Ayalew</td>
</tr>
<tr>
<td>Tanzania</td>
<td>Plant Protection Division, Biocontrol Unit, Kibaha; German-Tanzanian IPM Project, Arusha</td>
<td>National survey for indigenous parasitoids, pilot site studies, pilot introduction</td>
<td>Mr. Oscar Mfugale Mr. William Mwaiko</td>
</tr>
<tr>
<td>Uganda</td>
<td>NARO Biocontrol Unit Namulonge Makerere University Kampala</td>
<td>National survey for indigenous parasitoids, pilot site studies</td>
<td>Dr. James Ogwang Ms. Florence Nagawa</td>
</tr>
<tr>
<td>South Africa</td>
<td>Plant Protection Research Institute, Pretoria</td>
<td>Studies of temperature adaptability of Cotesia plutellae, provide C. plutellae to Kenya</td>
<td>Dr. Rami Kfir, Mr. Robert Nofemela</td>
</tr>
<tr>
<td>Taiwan</td>
<td>AVRDC Taiwan</td>
<td>Provide Diadegma semicaudatum and C. plutellae to Kenya; introduce and test heat-tolerant parasitoids</td>
<td>Dr. N.S. Talekar</td>
</tr>
<tr>
<td>France</td>
<td>USDA European Biological Control Laboratory (EBCL), Montpellier</td>
<td>Explore for more heat-tolerant parasitoids</td>
<td>Dr. Alan Kirk</td>
</tr>
</tbody>
</table>

AVRDC Asian Vegetable research and Development Center, Taiwan; EARO: Ethiopian Agricultural Research Organisation; KARI: Kenyan Agricultural Research Institute; NARO National Agricultural Research Organisation (Uganda)

Surveys for indigenous natural enemies

A training course for key national project collaborators was organised jointly by AVRDC and ICIPE in April 2001 in order to standardise methodology and research procedures at the beginning of the project to ensure proper data collection, preservation of specimens for identification and collation of information. Work plans and budgets for surveys and collections were also developed.

NARS collaborators in Ethiopia, Kenya, Tanzania and Uganda initiated national surveys and collections of DBM and its natural enemies in September 2001. Survey work is advanced in Ethiopia, Kenya and Tanzania and will be finished in all partner countries by May 2002. All relevant information is compiled in a database at ICIPE. Parasitoids are also curated and stored at ICIPE until identification is complete. So far, the surveys have not yielded any significant new parasitoids and confirmed the scarcity and ineffectiveness of local parasitoids. *D. mollipla, O. sokolowskii, Itoplectis* sp. and a few *C. plutellae* were the species collected so far. Overall parasitism rates were mostly below 10%. The Ichneumonidae were limited to highland conditions, *O. sokolowskii* and *C. plutellae* to warmer growing conditions (Löhr, unpublished survey data).
DBM moths collected from unparasitised larvae and/or pupae are also preserved and kept at ICIPE. The material may be very important for future studies on the diversity of the pest. Recent studies on other supposedly cosmopolitan species have shown that what appeared to be one species was actually a complex of closely related species (Munroe 1973) and this can have significant consequences for biological control efforts. Chang et al. (1997) have shown that in an area as limited as Hawaii, there is considerable variation in DBM and this can be expected to be much greater in the huge area covered by the proposed project.

Taxonomic status of the genus Diadegma in Africa

The genus Diadegma, the most efficient and widespread group of DBM parasitoids world-wide, has been recorded in Kenya, Tanzania, Uganda and South Africa (Seif & Löhr 1998, Kfir 1997). However, parasitism rates are generally low. Data from earlier field surveys in Kenya, Malawi and Tanzania showed low parasitism by a parasitoid initially identified as D. semiclausum (5–11.3%, 15% and 14.5% respectively) (Seif & Löhr 1998). There were some doubts about the correctness of this identification and Azidah et al. (2000) grouped all African DBM parasitoids of the genus under the species name of Diadegma molipla (Holmgren), originally described as a potato tuber moth parasitoid. Doubts about the identity of the species persist as the genus Diadegma is not fully described (Fitton & Walker 1990, Kfir 1997) and there seems to be variability in the material collected so far (R. Sithole, pers. communication; B. Wagener, pers. communication). Therefore, classical and molecular taxonomic methods are used in the project to clarify the taxonomic status of the local African Diadegma spp.

Classical biocontrol of DBM for East Africa

There are three obvious candidates for introduction into East Africa: D. semiclausum, C. plutellae and Diadromus collaris Gravenhorst. The former was used widely in south-east Asia with good results and should perform equally well in the similar growing conditions of the east African highlands. A good complementary parasitoid for the same agro-ecological zone should be D. collaris which is completely absent from East Africa, even though it seems to be relatively common in South Africa (Kfir 1997). Cotesia plutellae is also relatively rare in East Africa. Parasitism rates observed in hundreds of collections in areas suitable for this species were very low in Kenya (Nang’ayo, Magenya, Gathu and Löhr, unpublished survey data) and the species was not found in Tanzania (Mwaiko, unpublished survey data). This contrasts with the situation of very high parasitism rates in the lowveld of South Africa (Kfir 1997) and makes the species a good candidate for introduction in semi-arid areas of East Africa. Studies on the temperature adaptability of the species are currently ongoing in South Africa. Another source for this species will be AVRDC Taiwan.

In preparation for an assessment of the impact of introduced parasitoid species, four pilot sites were established for detailed field studies of the population dynamics of DBM and its natural enemies. Pilot releases will be made into these sites after one year of continuous observations is completed. Establishment and impact of the released parasitoids will be assessed in these fields. In addition, a baseline study for an economic impact assessment is in preparation.

Exploration for additional parasitoids

AVRDC and European Biological Control Laboratory will work together to explore for parasitoids, especially pupal parasitoids, of DBM in the Mediterranean area, where the pest is believed to have originated (Talekar & Shelton 1993). DBM damage on crucifers in Europe is minimal because of the presence of a wide range of parasitoids in the continent. In Moldavia-Romania alone, almost 30 species of parasitoids have been listed and these reduce the DBM populations below economic damage levels (Mustata 1992). Discussions are under way with Prof. Mustata to revisit and reanalyse the historical data and initiate season-long collections in the Moldavia region to establish changes in parasitoid species composition with changing temperatures throughout the season.

Additional natural enemies are collected by EBCL staff on their regular collection missions. The collected parasitoids are shipped to AVRDC where they are purified, tested for their effectiveness under tropical lowland conditions and multiplied. These natural enemies will be maintained at AVRDC and made available for introduction in the project countries as well as any other interested countries in Asia.

References


