

INTEGRATED PEST MANAGEMENT IN CENTRAL ASIA

Proceedings of the Central Asia Region Integrated
Pest Management Stakeholders Forum

Dushanbe, Tajikistan. May 27 - 29, 2007

Sponsored by the USAID IPM-Collaborative Research Support Program (CRSP)



Proceedings Edited by:

Dr. Karim M. Mare dia and Dr. Dieudonné N. Baributsa

Central Asia IPM CRSP Program, Michigan State University



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Participants to the Central Asia Region IPM Forum, Dushanbe-Tajikistan; May 27-29, 2007.



Opening remarks by Dr. Robert Hedlund from USAID, Washington, D.C., U.S.A.



Forum participants visiting a private biolaboratory in Tajikistan

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Foreword

The Central Asia region was isolated from the rest of the world for more than 50 years during the former Soviet Union era. Central Asia is a center of diversity for many important crops, providing excellent opportunities for IPM and sustainable agriculture. Government policies are moving toward diversification of agriculture to meet the challenges of local food security, environmental quality, and natural resource management. To achieve this, countries in Central Asia are also looking for ecologically based, environmentally friendly approaches for crop production including Integrated Pest Management (IPM) programs that rely less on chemical inputs and are sustainable.

In this context, through the funding from the USAID sponsored IPM Collaborative Research Support Program (CRSP) at Virginia Tech University and Michigan State University in collaboration with University of California-Davis, the International Center for Agricultural Research in the Dry Areas (ICARDA), and other institutions in the Central Asia region are implementing a multi-year ecologically-based collaborative research and capacity building program in IPM. This regional program is implemented through a Project Facilitation Unit (PFU) of the Consultative Group on International Agricultural Research (CGIAR) based at ICARDA Regional office in Tashkent, Uzbekistan. The project has three components: enhance the efficiency and product lines of biolaboratories, enhance biological control of pests through landscape ecology/ habitat management, and strengthen IPM outreach and education.

As a part of the regional networking and information sharing process, a regional IPM Forum was held in Dushanbe, Tajikistan from May 27 – 29, 2007. The goal of this regional forum was to share the knowledge and experiences of IPM CRSP projects and other national and international programs with IPM stakeholders in the region. More than 50 participants, including policymakers, researchers, representatives of international research centers and NGOs from four Central Asian countries (Kazakhstan, Tajikistan, Uzbekistan, and Kyrgyzstan) attended this forum. The key recommendations that emerged from this forum are included in this proceeding. The need for a long-term regional IPM program, continued networking and information exchange, and expansion of IPM programs to vegetable crops was greatly emphasized.

The Forum served as an excellent platform for networking and knowledge sharing among IPM specialists in the region and the international IPM community. We hope this proceeding will serve as a useful resource for enhancing the use and integration of new approaches for IPM programs in the Central Asia Region.

With Best Wishes,

Karim M. Maredia
Program Director,
Central Asia IPM CRSP Program
Michigan State University
East Lansing, U.S.A.

Welcoming Remarks

Dear participants!

On behalf of the Ministry of Agriculture and Environment Protection of the Republic of Tajikistan and the Academy of Agricultural Sciences of Tajikistan I would like to welcome all of you to our Forum and wish you a pleasant stay in Dushanbe.

After the collapse of Soviet Union, Tajikistan farmers faced various problems. Currently one of the major problems in increasing agricultural production in our country is pest control. Annually, 30—40% of crop yields are lost due to pest damage. The evidence is that in Tajikistan alone more than 100,000 ha of agricultural crops were attacked by locusts in 2006-2007. In this context, there is a need for increased use/adoption of Integrated Pest Management to control agricultural pests.

The implementation of the Central Asia IPM CRSP Project in Tajikistan is a valuable contribution to increase researchers' knowledge on conducting state-of-the-art research and development of the pest control methods. Successful implementation of the IPM CRSP project activities would trigger an increase in crop production, which is one of the main visions of Tajikistan Poverty Reduction Strategy and solving the food security problems.

I believe this Forum and its key recommendations on IPM would definitely help strengthen partnership and collaboration between the researchers of Central Asia and other countries.

I am sure that the fruitful cooperation of Central Asian researchers with the International Research Centers such as ICARDA and Michigan State University gives an impulse in exchanging experiences and implementation of progressive pest control methods in agriculture within our region.

I wish the participants to this Forum fruitful work and success in maintaining sustainable agriculture development and strengthening of cooperation in the area of a science in our countries.

Dr. Tolib Nabiev
Academician
President of Academy of Agricultural Science
Ministry of Agriculture and Natural Protection

Key Note Address

—*Dr. Robert Hedlund, USAID, Washington, D.C., U.S.A.*

Dr. Tolib Nabiev, President of Tajik Academy of Agricultural Sciences, Dr. Karim Maredia, Leader of the Central Asia project of the Integrated Pest Management Collaborative Research Support Program, esteemed colleagues and participants from Central Asian Republics, ICARDA and U.S. universities, it is my honor and pleasure to welcome you here on behalf of the United States Agency for International Development and its IPM CRSP. We very much appreciate the support given to this workshop by our hosts here in Tajikistan. USAID is very pleased that this project was proposed through the IPM CRSP and that such an impressive group of collaborators has been assembled.

The goals and objectives of the Central Asia IPM CRSP project focus on collaborative research, outreach, and capacity building in IPM in Central Asia region with the following objectives:

- ◆ Help improve the efficiency and expand product lines of more than 800 biolaboratories in the region.
- ◆ Initiate research in landscape ecology to enhance biodiversity and biological pest management in the Central Asia region.
- ◆ Enhance the capacity of IPM specialists from the Central Asia region to provide leadership for promoting ecologically-based IPM research and outreach programs.
- ◆ Develop and integrate ecologically-based IPM information into educational packages in crop management programs in the region through training the trainers approach.
- ◆ Synergize interaction among scientists and institutions in the region through networking among IPM specialists and institutions and with the international IPM community.
- ◆ Integrate socio-economic and gender issues in the program.

To achieve these objectives, the project is focusing on three major components: 1) enhancing the efficiency and product lines of biolaboratories through collaborative research with UC-Davis, 2) Enhancing biological control of pests through collaborative research focusing on landscape ecology/habitat management, and 3) Strengthening of IPM outreach/education programs through collaborative linkages with MSU, UC-Davis and other local NGOs and universities.

Project Partners In Central Asia Region Include:

- ◆ Implementation is enhanced through the Project Facilitation Unit (PFU)-Tashkent, International Center for Agricultural Research in the Dry Areas (ICARDA)-Uzbekistan
- ◆ Advisory Training Center of Rural Advisory Service (ATC-RAS)-Kyrgyzstan
- ◆ Uzbek Institute for Plant Protection (IPP)-Uzbekistan
- ◆ Private Biolaboratory in Samarqand-Uzbekistan
- ◆ Botanical Research Institute of Academy of Sciences- Kyrgyzstan
- ◆ Bio-soil research Institute of Academy of Sciences-Kyrgyzstan
- ◆ Institute of Zoology and Parasitology Academy of Sciences-Tajikistan
- ◆ Tajik State Agrarian University Tajikistan

In the past couple of days I have seen significant impact of CRSP activities here in Tajikistan. With such a large contingent of competent partners, I look forward to hearing about your progress and plans throughout the region. Thank you for your participation and support.

Summary of Recommendations by the Stakeholders

–Dr. Karim Maredia and Dr. Dieudonné Baributsa

Through an open and interactive discussion, the stakeholders made the following recommendations for enhancing and implementing IPM programs in the Central Asia region.

- ◆ Need for a Long-term Regional IPM Program: Develop a well-coordinated, long-term regional IPM Program in collaboration with all the stakeholders in the Central Asia region.
- ◆ Foster Interactions among IPM Stakeholders: Organize regular meetings of IPM specialists, policy makers, researchers, NGO personnel and other key stakeholders to develop and implement action plans relevant to the region.
- ◆ Expand ICARDA's IPM Activities: Request ICARDA to expand their IPM program activities to include Tajikistan and Kyrgyzstan and seek ICARDA's support for the dissemination of local findings on entomophages and invasive pest species.
- ◆ Develop and implement IPM Programs beyond cotton crops: Develop IPM programs for vegetable crops and non-conventional techniques for pest control that are affordable to farmers.
- ◆ Development of a Biolabs Network: Maintain contact and form collaborative network of biolabs for supplying biological control agents to farmers/extension centers across the region.
- ◆ Expand University educational curriculum: Provide in-service training programs and vocational training to university faculty focusing on ecologically-based IPM. Develop and provide training materials for Farmer Field Schools (FFS) and Training of Trainers (ToT).
- ◆ Develop simple and rapid methods for virus detection: Expedite joint R&D efforts to build capacity for research on virus diseases detection and management.
- ◆ English Language Training: English is not the native and official language of communication. Support local programs that provide English language training to IPM researchers and educators.
- ◆ Habitat management for enhancing Biological Control: Develop joint a proposal on the use of natural habitats for enhancing natural enemies and biological control of Sunn pest (ICARDA, NARS of West and Central Asia and MSU).
- ◆ Enhance research and extension linkages: Enhance research and extension linkages for transferring new knowledge and technologies efficiently to farmers. Include participation of NGOs and farmers associations.
- ◆ Regional IPM Data Network: Considering that the Central Asian countries have many pest problems in common, develop a regional network for exchanging research results.
- ◆ Publications and Information Sharing: Publish and make available newsletters and quarterly publications on IPM to share research results among various stakeholders working on various aspects of IPM, and support local scientists to publish their research findings in international journals.

Ecologically-Based Participatory and Collaborative Research and Capacity Building in Integrated Pest Management Program in the Central Asia Region¹

—*Karim Maredia and Dieudonné Baributsa*

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Summary

Michigan State University (MSU) and the University of California (UC)-Davis, in collaboration with the International Center for Agricultural Research in the Dry Areas (ICARDA) and various National Agricultural Research Institutions and Universities in Central Asia are implementing a regional Integrated Pest Management (IPM) Program. This program was designed based on the priorities and the needs identified by stakeholders through a regional IPM forum organized in Tashkent, Uzbekistan in May 2005. The project takes an integrated and participatory approach and includes two collaborative research projects and an IPM outreach and education component. The first research project focuses on enhancing efficiency and product lines of Central Asian biolaboratories. The second project is on landscape ecology and enhancing biological control of pests. The IPM outreach and educational component is targeting IPM specialists working with farmers, NGOs, and local universities. A three-member team of IPM specialists from the Central Asia region is based at ICARDA's regional office in Tashkent to implement the activities of this project. To foster networking, a directory of IPM specialists from the region has been developed and distributed. In addition, the project has provided memberships in the International Association for the Plant Protection Sciences (IAPPS) to IPM specialists from Central Asia. The overall goal is to build a team and a regional network of IPM specialists and stakeholders that can continue to provide leadership in IPM research, education, and outreach in the region using ecologically-based and innovative IPM approaches.

Background On Agricultural Development Issues In Central Asia

After more than 50 years of isolation, countries in the Central Asia region (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) are transitioning from the centrally planned economy of the former Soviet Union to a market-oriented system (Babu and Pinstrop-Andersen, 2000). Agriculture is expected to play a key role in the economic revitalization of the region. During the Soviet Union era, countries in the Central Asia followed a broad policy of regionally based agriculture production that promoted monoculture through state-owned farms. The institutional linkages and collaborations were generally very weak.

The policy reforms during the past 15 years have led to land reforms from state ownership to private enterprises. In addition, the agricultural policies of these countries are moving away from monoculture systems to more diversified systems to meet the challenges of local food security, environmental quality, and natural resource management. With the agrarian reforms, farmers who are starting up their own farms need technical assistance and institutional support with enterprise development and crop diversification to restore sustainability, which has been severely damaged by the large-scale monocropping approach of the Soviet era.

As agriculture is expected to play a key role in the economic revitalization of the region, this transition requires a well-organized and technically competent agricultural research, education, and outreach system to assist farmers who are emerging as private farm owners

¹The Regional IPM Program in Central Asia is funded through a grant to Michigan State University from the USAID IPM Collaborative Research Support Program (CRSP) managed by the Virginia Tech University in the USA.

(Sulaiman and Hall, 2004). The practice of monoculture (e.g. cotton and wheat) during the Soviet era was accompanied by heavy reliance on applications of chemical pesticides to help manage crop pests. While pesticides were extensively used in Central Asian countries during the 1950s-70s, their use declined due to development of resistance, recognition of pesticide pollution and the loss of naturally occurring entomophages (biological control agents) (Sugonyaev 1994). Since independence in 1991, economic challenges have further limited pesticide use in Central Asia and promoted a strong tradition of large-scale rearing and mass release of natural enemies to control key pests. Many governments are enacting programs that promote the use of environmentally friendly technologies and new IPM and crop management approaches to reduce reliance on the excessive use of chemical pesticides (Quamar, 2002).

Ecologically-based IPM that relies on biological control can play an important role in reducing losses due to pests, minimizing reliance on chemical pest control and thereby fostering the long-term sustainability of agro-ecosystems. Biolaboratories that produced large-scale biological control agents for pest control in cotton during the Soviet era still exist and shape the positive attitude of scientists and policymakers toward IPM in the region (Walter-Echols, 2005). These biolaboratories are run either by the government or by private owners. Currently, the parasitoids *Trichogramma* spp., *Habrobracon hebetor* and *Chrysoperla carnea*—the green lacewing—reared in the extensive network of biolaboratories are the primary entomophages being produced for release. Various institutions working on these species would like to expand their current research activities to improve the efficiency of rearing methods and introduce new biological agents to diversify their product lines.

There is increasing recognition among biological control researchers and practitioners worldwide that conservation

of natural enemies via landscape management is a key to ecologically-based IPM systems (Landis *et al.*, 2000). Insect natural enemies (predators and parasites) frequently require plant-based resources such as pollen, nectar, and shelter to enhance their survival and fecundity in agricultural landscapes. However, agricultural systems often lack the non-crop habitats that provide these resources. Increasingly, research on landscape ecology is focusing on finding native plants for their use in habitat management that is compatible with other functions in the agricultural landscape. Carefully selected native plants may be incorporated into agricultural landscapes to assess their attractiveness to natural enemies and biological control of crop pests in agricultural production systems.

In the former Soviet Union, agricultural extension was designed for large-scale farms run by the government. The transition from collectives to private holdings requires a new approach in disseminating agricultural information to newly formed individual farms and self-managed cooperatives. Participatory training methods in which farmers are in the center of learning are most appropriate to empower farmers with skills and knowledge to help them make their own decisions.

Currently, in the absence of formal government-run extension system, non-governmental organizations (NGOs), farmers associations and biolaboratories are involved in providing training and outreach services to farmers. The governments in the region are also encouraging agricultural universities to play a proactive role in outreach and extension education and services. Because agricultural ecosystems are constantly changing and the methodologies of IPM continually improving, it is imperative to enhance the IPM capacity-building attributes of the existing institutions involved in training farmers and the next generation of scientists/leaders.

Design And Formulation of a Regional IPM Program In Central Asia

A. Background on IPM CRSP Program

The IPM CRSP was established in 1993 through funding from the USAID. The IPM CRSP is a global program that supports agricultural research programs to improve crop yields through ecologically sound practices (<http://www.oired.vt.edu/ipmcrsp>). The program is funded in 5-year phases. During the first phase, the program activities focused in four countries (Uganda, Guatemala, Jamaica and the Philippines). During the second phase which began in 1998, 6 more countries were added to the IPM CRSP (Honduras, Ecuador, Albania, Mali, India and Bangladesh). In October 2004, the USAID through Virginia Tech University announced a US \$12 million grant for Phase III of the program.

B. Approach and process of the design of a regional IPM program in Central Asia

For Phase III of the IPM CRSP project, Virginia Tech initiated new activities through competitive Proposal Planning Grant (PPG) for regional IPM Programs and IPM Global Themes. Michigan State University was awarded a PPG grant to visit and interact with IPM stakeholders in Central Asia Region. As part of the PPG grant, MSU organized a regional IPM stakeholders forum in Tashkent Uzbekistan in May 2005. The goal of the IPM Forum was to assess the needs and identify key collaborators for initiating a collaborative and participatory regional IPM program. More than 50 participants from Uzbekistan, Tajikistan and Kyrgyzstan attended this regional forum. Participants represented governments, NGOs, universities, international organizations, and inter-governmental organizations (see annex 1). During the forum, breakout sessions were formed to

identify constraints and priorities for IPM research and capacity building in the region. The U.S. team also visited research institutes, universities, and public and private biolaboratories and met with farmers in the Samarqand area. The assessment of the stakeholders was as follows:

1. Cotton is a dominant crop in many countries in the region. Besides wheat, the importance of other food crops such as potatoes, tomatoes and fruit crops in the region is growing. As a result of these changes, there is a need to conduct research that assesses the impacts of agricultural diversification on the dynamics of pests and beneficial organisms.
2. The current emphasis of biological control and IPM programs in Central Asia is on augmentation through mass rearing and release of bio-control agents by a network of insectaries known as 'biolaboratories'. There are no programs that promote conservation of natural enemies and biodiversity in the agricultural landscape. Therefore, there is a need to enhance IPM practices via landscape ecology and biodiversity.
3. Well-trained human resources are available. However, research facilities and infrastructure need to be upgraded and modernized. There is also a need to diversify the production of bioagents for pests in newly introduced food crops. For example, there are more than 800 biolaboratories in Uzbekistan alone that rear and provide bio-control agents to farmers. These biolaboratories would benefit from outside collaboration to introduce new predatory mite species and to develop methodologies that would help improve their efficiency.
4. In the absence of a formal government-run extension system, NGOs and farmer organizations provide farmer training, technology transfer, and outreach services. There is a lack of IPM components in these outreach and farmer train-

ing programs. There is a need to develop IPM packages that can be integrated into farmer field schools and other outreach programs.

5. Although components of IPM programs are in place, there is a need for collaboration among institutions and between countries to benefit from these human resources and experiences. Communication and interaction with IPM specialists outside the region is lacking due to language barriers and limited financial resources. Therefore, there is a need for collaborative projects and networking activities to foster interaction and exchange of knowledge and information.

Using the inputs and feedback from the regional stakeholders, a full proposal was developed and MSU received a four-year grant for implementing a regional IPM program in Central Asia.

C. Program Goals and Objectives

The IPM CRSP project in Central Asia began on October 1, 2005 with a focus on collaborative research, outreach, and capacity building in IPM. The project includes the following objectives:

1. Help improve the efficiency and expand product lines of biolaboratories in the region.
2. Introduce emerging research concepts of landscape ecology to enhance biodiversity and biological pest management.
3. Train and build a team of IPM specialists from the Central Asia region that could provide leadership and support to various stakeholders (e.g., governments, universities, NGOs) for promoting ecologically-based IPM research and outreach programs in the region.
4. Develop and integrate ecologically-based IPM information into educational packages in crop management programs in the region through Training of Trainers (ToT) approach and Farmers Field Schools (FFS).

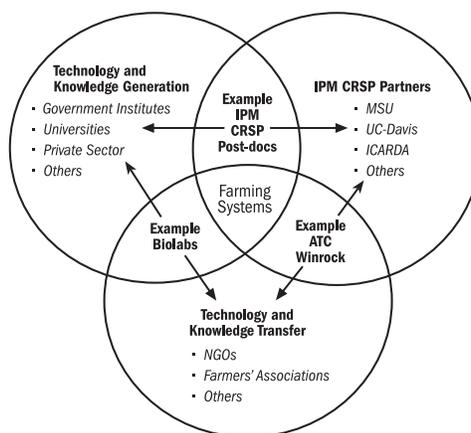
5. Help break the isolation of scientists and institutions in the region through networking among IPM specialists and institutions in the region and with the international IPM community.

6. Integrate socio-economic and gender issues in the program development and implementation.

D. Program Implementation

For the project implementation, MSU is working closely with ICARDA taking advantage of its well-established Project Facilitation Unit (PFU) and a regional network in Central Asia. Through the IPM CRSP project MSU is the first U.S. university to become a member of the CGIAR-PFU Network in the Central Asia region. In cooperation with ICARDA-PFU, a three-member team from the Central Asia region (Tajikistan, Kyrgyzstan, and Uzbekistan) was identified through a competitive process. This team is based at the ICARDA-PFU in Tashkent, Uzbekistan and is implementing the project activities in collaboration with component leaders from MSU, UC-Davis and local/regional partners. The IPM CRSP team works with

Figure 1: Collaboration framework for Central Asia IPM Program



research institutes, universities, NGOs, private sector and farmer associations in the region.

The MSU-UC Davis-led consortium is taking a participatory and integrated approach

to research, training, outreach, and institutional capacity building (*Figure 1*). With limited funding from the IPM CRSP project, our initial approach is to develop and implement a collaborative research, extension, training and institutional capacity-building project in Uzbekistan, Tajikistan, and Kyrgyzstan and then scale up to other countries in the region depending on the availability of financial resources.

MSU, UC-Davis, and ICARDA are working with government institutions, universities, NGOs, and international organizations for the implementation of the project activities. The project partners include: ICARDA-PFU in Uzbekistan, the Advisory Training Center of Rural Advisory Service (ATC-RAS) in Kyrgyzstan, the Institute for Plant Protection (IPP) in Uzbekistan, Private Biolaboratory in Samarqand in Uzbekistan, the Botanical Research Institute of Academy of Sciences in Kyrgyzstan, the Bio-soil research Institute of Academy of Sciences in Kyrgyzstan, the Institute of Zoology and Parasitology Academy of Sciences in Tajikistan and the Institute of Plant Protection and Quarantine in Tajikistan.

E. Project components

Given the limited funding and based on the priorities identified by the regional stakeholders, the Regional IPM CRSP in Central Asia is focusing on the following three components: a) Collaborative research on enhancing efficiency and product lines of biolaboratories, b) Collaborative research on landscape ecology and biological control of pests, and c) Strengthening IPM outreach and educational programs.

a. Collaborative research on enhancing efficiency and product lines of biolaboratories

As stated earlier, there are more than 800 biolaboratories in Central Asia that produce entomophages for field release. Various institutions working on these species would like to expand their current research activities to address additional

pest problems. The focus of this component is to enhance the efficiency of Central Asian biolaboratories by introducing new candidate entomophages to control spider mites, thrips, leafminers and whiteflies of vegetables crops. In addition, this research component is looking at developing efficient methods for rearing the entomophages and identifying appropriate timing and methods for their release. This collaborative research is conducted by a research fellow from Uzbekistan, Dr. Barno Tashpulatova, in collaboration with Dr. Frank Zalom at the UC Davis and other biolaboratories in the region (Tashpulatova and Zalom, 2007).

b. Collaborative research on landscape ecology and biological control of pests

The focus of the landscape ecology collaborative research project is to enhance biological control through the application of the principles of landscape ecology and habitat management for enhancing biological control of pests. This approach is new to the Central Asia region. This research project includes identification, screening and field-testing of native plants from the Central Asia region that could be used in various cropping systems. The research is focusing on field evaluation of the attractiveness of these native plants to natural enemies of crop pests and identification of the plant characteristics most strongly associated with attractiveness. Once the most attractive plants have been identified, they would be tested individually in laboratory or greenhouse settings to determine if the resources they provide actually enhance the longevity or fecundity of natural enemies. This collaborative research is conducted by a research fellow from Tajikistan, Dr. Nurali Saidov, in collaboration with Dr. Douglas Landis at MSU, Dr. Mustapha Bohssini at ICARDA, and other research institutes in the region (Saidov *et al.*, 2007).

c. Strengthening IPM outreach and education programs

The IPM outreach/education component

aims at strengthening current crop management outreach/education programs by introducing ecologically-based IPM information and materials into existing farmers training programs such as the training of trainers (ToT), farmer field schools (FFS), and the development of IPM educational materials (extension bulletins, leaflets, flyers, etc). In addition, ecologically-based IPM educational materials are introduced into local university curriculum in the Central Asia region. An outreach fellow from Kyrgyzstan, Dr. Murat Aitmatov, coordinates this component in collaboration with Dr. George Bird and Dr. Walter Pett at MSU and other NGOs, universities and research institutes in the region (Aitmatov *et al.*, 2007).

Training and Team Building

To help promote and implement an ecologically-based regional IPM program in Central Asia, the three team members of the IPM CRSP Project were trained at MSU and UC-Davis in summer 2006. During this visit to the U.S., the three team members also attended the two-week international short course on agroecology, IPM, and sustainable agriculture at MSU. In addition, the Deputy Director of Winrock International Farmer to Farmer program in Uzbekistan also attended this course. The training of the Deputy Director of Winrock International was aimed at helping to link our project activities with already established farmers training programs and the network of NGOs in the region. The three IPM CRSP Project team members have also attended various training programs organized by ICARDA in the region.

Networking in the Region and Internationally:

To foster networking among IPM specialists in the region and with international IPM communities, the IPM CRSP project has provided memberships in the International Association for the Plant Protection Sciences (IAPPS). In addition, a directory of IPM professionals/

stakeholders in the region was developed and distributed to key institutions and IPM specialists in the region. This directory is also posted on the IPM CRSP project website at: <http://www.oired.vt.edu/ipm/crsp/regional/IPM%20Directory%202006Central%20Asia.pdf>

The IPM CRSP team members regularly attend regional meetings and conferences to present the project activities. In addition, the team members have organized special training programs in the region to explain and share the ecologically-based IPM approach to scientists and outreach specialists in the region. The project progress/achievements were presented during the 5th National IPM Symposium in St. Louis, Missouri in April 2006. Efforts are underway to foster collaboration between the Central Asia regional IPM Program and other regional programs and Global Themes of the IPM CRSP Project. This will provide opportunities for exchange of IPM experiences and information within the global community. The ultimate goal of this regional IPM program is to build a team and network of IPM specialists in Central Asia, which can carry forward ecologically-based IPM research, education and outreach programs in the region.

Annex 1. National and International Institutions and NGOs represented at the Stakeholders IPM Forum in Central Asia, May 4-6, 2005, Tashkent, Uzbekistan.

- ◆ Michigan State University, USA.
- ◆ University of California-Davis, USA.
- ◆ Virginia Tech University, USA.
- ◆ United States Agency for International Development (USAID)
- ◆ The Science and Technology Center of Ukraine (STCU), Uzbekistan
- ◆ Tashkent State Agrarian University, Uzbekistan
- ◆ Samarqand Agricultural University, Uzbekistan
- ◆ Institute for Plant Protection, Uzbekistan

- ◆ Institute of Genetics and Experimental Biology, Uzbekistan
- ◆ Institute of Zoology, Uzbekistan
- ◆ Gulistan State University, Uzbekistan
- ◆ Institute of Microbiology, Uzbekistan
- ◆ Institute of Bioorganic Chemistry, Uzbekistan
- ◆ Winrock International, Uzbekistan
- ◆ Advisory Training Centre of the Rural Advisory Service (ATC-RAS), Kyrgyzstan
- ◆ Training Extension System Center, Kyrgyzstan
- ◆ International Center for Agricultural Research in the Dry Areas (ICARDA)
- ◆ Asian Vegetable Research and Development Center (AVRDC)
- ◆ International Finance Corporation (IFC), The World Bank
- ◆ United Nation Development Program (UNDP)
- ◆ International Potato Center (CIP)
- ◆ Japan International Cooperation Agency (JICA)
- ◆ United Nations Educational, Scientific and Cultural Organization (UNESCO)
- ◆ German Association of Technical Cooperation (GTZ)

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A History of Habitat Management in the Former USSR and the Commonwealth of Independent States and Current Research in Central Asia

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Literature Review

The early recommendations for the use of habitat management to enhance biological control in this region preceded a modern understanding of the science. Skrzhinskaya (1936) pointed to the treatise of Albert Veliki in the thirteenth century, which stated, "To avoid generating bad animals with vegetables... plant also in many places amongst vegetables—particularly among cabbages—mint". A modern understanding of the advantages of plant diversification to enhance biological control was first published by Frederic (1932). He suggested that the presence of artificial plantings near grape vineyards reduced tortricid moth damage by supporting alternate hosts for their parasites and predators. Similarly, Telenga *et al.* (1936 a, b) noted increased parasitism of a grape leaf-roller moth in Crimea (Ukraine) in proximity to forest plantations where they believed the parasitoid found additional food and shelter.

Melinichenko (1938) pointed out the useful role of insectivorous birds in protecting forest plantations from insects. Stark (1940 a, b) noted that tiphiid and scoliid wasps were particularly effective where they were attracted to the plants on which they foraged for pollen and nectar; on this basis he recommended sowing attractive plants in proximity to where pests occur. Flandres (1940) reported that the parasitoid *Anarhopus sydneyensis* Timb., introduced against *Pseudococcus adonidum*, performed best where the *Dracaena* plant occurs in abundance. However, outside the range of this plant, either the parasite did not establish or was otherwise less efficient. It is unclear if this was an observation of the parasitoid

utilizing the plant or a case of them requiring similar abiotic conditions.

The composition and nature of vegetation around agricultural crops can provide natural enemies with additional food sources such as plant nectar. For example, the egg-parasitoids *Microphanurus vassilievi* Mayr. and *M semistriatus* Nees, which attack sun-pest, benefit from the presence of various Apiaceae (Umbelliferae) around the field (Rubtsov, 1944). It has also been shown that the bark of mulberry, apricot, and other trees form ridges where beneficial insects congregate for overwintering (Rubtsov 1948). Finally, the wildflowers *Ferula assa-foetida*, *F. badrakema*, *Senecio subdentatus*, *Lepidium draba* and *Anethum graveolens* attract parasitic Braconidae wasps in natural landscapes of Tajikistan and Turkmenistan (Tobias, 1964; Tobias *et al.*, 1992; Saidov, 1996, 2000).

Several researchers noted greater abundance of parasitoids in proximity to nectar plants than in control fields. Schumakova (1959) found that the absolute number of parasitoids of *Aspidiotus californicus* on apple trees as 10 times higher in the presence of phacelia than on trees in the control area. Feeding on nectariferous plants has also been found to enhance the fecundity and longevity of many natural enemies (Kopvillem, 1960, 1962; Adashkevich, 1970). Adashkevich (1974) studied the predator population dynamic on nectariferous plants in the steppes of Moldova and found that they attracted primarily predators.

Shumakov and Schepetilnikova (1970) suggested that it may be possible to increase the efficiency of parasitoids by creation of multi-tiered habitats consisting

of flowering plants, blooming bushes and high-density forest stands. Work at the Moscow station of the Soviet Union Plant Protection Institute (VIZR) and the Vegetable Industry Institute showed that the Tachinid fly *Ernestia* sp. was attracted to flowering carrot, dill, and onion plants in proximity to cabbage and suppressed the cabbage moth up to 60-90%. Increasing the concentration of *Ageniaspis* sp. (Hymenoptera, Encyrtidae) on dill and buckwheat and *Aphytis* sp. (Hymenoptera, Aphelinidae) on phacelia plantations in a garden increased the efficiency of these parasitoids in biological control of the fruit moth and black pine-leaf scale (*Aspidiotus californicus*). Thus, provision of pollen and nectar may be accomplished by careful association of crop plants as well as non-crop plantings (Shumakov and Schepetilnikova 1970; Adashkevich, 1971). Aliev (1971) also noted the importance of flowering vegetation such as white mustard and clover in the attraction of insect parasitoids in Azerbaijan. Galunko and Dyadechko (1971) found that in Ukraine's woodlands and forest-steppe region, seeding phacelia in pea plantations attracted 86 different species of natural enemies, many of which are important in reducing pea pests.

Eremenko (1971) found that the fecundity and efficiency of parasitoids of the winter moth (*Agrotis segetum* Schiff), such as *Apanteles congestus* Nees, *Microplitis spectabilis* Hal., *Ambliteles panzeri* Wesm, and tachinid flies depended on their feeding in adult stage. The results of his studies showed that feeding these parasitoids on a 20% sugar solution, winter cress, carrot, or onion nectar increased their longevity 2-3 fold and promoted egg maturation. In particular, he noted that under field conditions of the Tashkent region of Uzbekistan, parasitism of caterpillars and pupae during the winter month was greater in experimental plots close to nectariferous plants when compared with the control. Rogochaya (1971) conducted the studies on the food relationships of tachinid flies

with wild flowering vegetation and identified 60 adult tachinid species feeding on 39 plant species from 15 families. The most widespread were plants in the family of Umbelliferae (13 species), Compositae (7 species) and Cruciferae (5 species). Among the tachinid flies collected on flowering cow parsnip, wild carrot, and bishop's goutweed, the most numerous were a species from the genera: *Tachina*, *Limnaemyia*, *Frontina*, *Leskia*, *Cylindromyia*, and others which contain parasites of silkworms, cutworms, glasswings, leaf-roller moths, and other garden pests.

Vorotynseva (1975) studied the influence of nectariferous plants on parasitism of the codling moth (*Laspeyresia pomonella pomonella* L.), and apple-leaf moths (*Lithocolletis corylipholiella* Hb. and *Lithocolletis pyripholiella* Gtsm.) for the purpose allocating flowering vegetation in complex orchard landscapes. The results of her studies have shown that parasitism of the codling moth by parasitoids in the genera *Microdus*, *Ascogaster* and *Pimpla* decreased with the distance of apple tree rows from nectariferous areas. Frunze (1988) recommended sowing early-blooming nectar plants such as; hyssop, celery and spring rape to attract predatory thrips in onion fields. Mikhalsev (1994) studied the influence of nectar plants on cabbage pests and their natural enemies by planting cabbage at varying distances from flowering plants. He determined that nectar plants should be placed every 50-60m to enhance fecundity of the majority of natural enemies. Finally, many years of study by Nagirnyaka and Krasavina (2005) have shown that sowing peppermint - *Mentha piperita*, clary - *Salvia selarea* melissa- *Melissa officinalis*, sweet basil- *Ocimum basilicum*, caraway - *Carum carvi*, anise - *Pimpinella anisum*, onion - *Allium nutans*, and leek - *A. porrum* is effective in attracting natural enemies of various vegetable pests in north-west Russia.

Current Research in Central Asia

Ecologically-based IPM seeks to maximize the suppression of insect, weed and disease pests by enhancing the effectiveness of their natural enemies. Prior research has shown that many natural enemies are enhanced by landscape diversity (Lee *et al.*, 2001; Thies *et al.*, 2003). Recently, there has been a significant interest in managing agricultural landscapes to benefit natural enemy communities, reduce reliance on pesticides, and increase agricultural sustainability (Altieri and Letourneau, 1982; Pickett and Bugg, 1998; Gurr *et al.*, 2000; Landis *et al.*, 2000). The presence of diverse habitats in or near crops can be important in sustaining natural enemies of crop pests. In particular, plant pollen and nectar are frequently utilized by natural enemies for energy and, reproduction, and to survive periods of prey scarcity. Diverse plant communities also provide shelter and alternate prey for many natural enemies (Landis *et al.*, 2000).

Landscape diversity can be increased by preserving, restoring, or creating plant communities that provide needed resources to natural enemies. In the intensively farmed landscapes of Central Asia the latter is required while in parts of the region preservation or restoration may be appropriate. The practice of managing plant communities for natural enemies is termed habitat management (Landis *et al.*, 2000).

The specific objectives of our study were:

1. To adapt existing principles and practices of landscape management to enhance IPM for use in Central Asian agricultural landscapes.
2. To research the use of native plants for conserving natural enemy communities and enhancing biological control of field crop pests in Central Asia.
3. To investigate and implement the most promising landscape management techniques in partnership with governmental agencies, universities, NGOs, and farmers in the region.

Methods

The experiment site was a research field located at the Institute of Zoology and Parasitology of the Academy of Sciences of Tajikistan in the Rudaki district of the Hissar valley. This land was previously used for vegetable production for several years. The Hissar valley is one of the basic areas of agriculture in Tajikistan and consists of typical sierozem and gray-brown soils (Tajikistan, Nature and Natural Resources, 1982). In the Hissar valley, high temperatures in the summer can reach 43-47°C, with the average monthly temperature of the hottest month (July) between 29-31°C. The area receives 600-700 mm of rainfall per year and typically accumulates 5000-5500 degree days. In 2006 we established preliminary research plots to test the attractiveness of 12 known and potential resource plants currently available in Central Asia (table 1). The experiment was conducted in a continuous single block design with one replicate of each plant species in a block. Plants were established in 2 m² plots spaced 0.5 m apart except for two plants, *Ocimum basilicum* L. and *Helianthus annuus* L., which were planted in narrow 0.5 m strips 20 m in length and parallel with both side blocks separately.

Table 1. List of plant species established at the research plot in Tajikistan, 2006.

##	Family	Genus and species	Common Name	Plant Type
1	Apiaceae (Umbelliferae)	<i>Anethum graveolens</i> L.	Dill	annual
2	Apiaceae (Umbelliferae)	<i>Coriandrum sativum</i> L.	Coriander	annual
3	Asteraceae (Compositae)	<i>Calendula officinalis</i> L.	Marigold	annual
4	Amaranthaceae	<i>Celosia cristata</i> L.	Cockscomb	forb
5	Asteraceae (Compositae)	<i>Tagetes erecta</i> L.	African marigold	annual
6	Apiaceae (Umbelliferae)	<i>Foeniculum vulgare</i> Mill.	Sweet fennel	forb
7	Balsaminaceae	<i>Impatiens balsamina</i> L.	Balsam	forb
8	Lamiaceae (Labiatae)	<i>Ziziphora interrupta</i> Juz.	Interrupta	forb
9	Asteraceae (Compositae)	<i>Aster</i> Sp.	Aster	forb
10	Amaranthaceae	<i>Celosia argentea</i> L.	Cockscomb	forb
11	Lamiaceae (Labiatae)	<i>Ocimum basilicum</i> L.	Sweet basil	forb
12	Asteraceae (Compositae)	<i>Helianthus annuus</i> L.	Common sunflower	forb

From June through October 2006, arthropods were sampled weekly from flowering plants between the hours of 8:00 am-12:00 pm EST on windless, sunny days. Insects were collected by standard entomological sweep nets (70 cm long with a diameter of 45 cm, Tryapisin V.A. *et al.*, 1982) with five samples from each plant block. Insects were divided separately into natural enemies, herbivores, or other and were identified by family and counted. Insects from any parasitic or predaceous family, or any genus or species within a family known to be parasitic or predaceous, were included as natural enemies. Insects were counted as herbivores if they were a member of a family known to be broadly herbivorous. Attractiveness here is based on the number of natural enemy arthropods collected per sample; therefore, it includes both arthropod attraction to the plant and subsequent retention on it.

Results

Plant species were divided into two categories according to their bloom period: mid season (15 June through 25 August) and late season (15 July through 31 October) (table 2).

The proportion of total natural enemies collected at all flowering plants by order and family is summarized in tables 3 and 4. The most numerous taxons by order were Hymenoptera (including the families of Braconidae, Aphidiidae, Chalcidoidea, Cynipoidea, Ichneumonidae, Sphecidae and Vespidae), Diptera (Syrphidae and Tachinidae) and Heteroptera (Anthocoridae and Nabidae). Most number of taxons identified include the families of Syrphidae, Anthocoridae, Coccinellidae, Chalcidoidea, Sphecidae, Braconidae and Ichneumonidae.

Table 2. Flowering phenology of nectar plants 2006 in Tajikistan. Plants are listed in order of bloom.

■ = peak bloom date, ◆ = full bloom, — = in bloom

		June			July					August					September					October				
Week		3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Mid Season	<i>Coriandrum sativum</i> L.	—	—	◆	◆	■	■	◆	◆	—	—													
	<i>Anethum graveolens</i> L.		—	◆	◆	■	■	◆	◆	—	—													
	<i>Ziziphora interrupta</i> Juz.		—	◆	■	■	■	◆	—	—														
	<i>Ocimum basilicum</i> L.		—	—	◆	■	■	■	■	◆	◆	—	—											
	<i>Calendula officinalis</i> L.		—	—	◆	■	■	■	■	◆	—	—	—											
	<i>Helianthus annuus</i> L.			—	—	◆	■	■	◆	◆	—													
Late Season	<i>Zinnia elegans</i> Jacq.						—	—	◆	◆	■	■	■	◆	◆	◆	—	—						
	<i>Celosia cristata</i> L.								—	—	◆	■	■	■	◆	◆	—	—						
	<i>Celosia argentea</i> L.								—	◆	■	■	■	■	◆	◆	—	—						
	<i>Impatiens balsamina</i> L.								—	—	◆	◆	■	■	■	◆	—	—						
	<i>Tagetes erecta</i> L.											—	—	◆	◆	■	■	■	■	◆	◆	—	—	
	<i>Foeniculum vulgare</i> Mill.											—	—	—	—	—	◆	■	■	■	■	◆	—	

Table 3. Proportion of total natural enemies collected at all flowering plants by order.

Plant species	Number of samples	Coleoptera	Heteroptera	Diptera	Hymenoptera	Neuroptera	Odonata	Arachnida	Mantoptera	Total
<i>Coriandrum sativum</i> L.	10	35	24	24	89	16	0	14	0	202
<i>Anethum graveolens</i> L.	9	26	28	32	74	21	0	17	1	199
<i>Ziziphora interrupta</i> Juz.	9	25	46	37	107	7	2	11	0	235
<i>Ocimum basilicum</i> L.	12	35	46	45	96	17	2	12	0	253
<i>Calendula officinalis</i> L.	10	29	18	27	69	16	0	15	2	176
<i>Helianthus annuus</i> L.	8	10	8	5	16	14	1	5	4	63
<i>Zinnia elegans</i> Jacq.	13	15	25	46	52	12	4	13	3	170
<i>Celosia cristata</i> L.	12	20	14	21	64	2	3	17	0	141
<i>Celosia argentea</i> L.	11	17	11	30	45	5	1	15	0	124
<i>Impatiens balsamina</i> L.	10	8	13	27	111	6	0	8	0	173
<i>Tagetes erecta</i> L.	12	15	53	89	116	11	1	15	0	300
<i>Foeniculum vulgare</i> Mill.	12	21	26	80	116	15	2	13	0	273
Total per taxa		256	312	463	955	142	16	155	10	2309

Table 4. Proportion of total natural enemies collected at all flowering plants by family.

ORDER	Plant species	Number of samples	Hymenoptera										Neuroptera	Odonata	Arachnida	Mantoptera	Total
			Braconidae	Aphididae	Chalcidoidea	Cynipoidea	Ichneumonidae	Sphecidae	Vespidae	Chrysopidae	Odonata	Spider	Mantidae	Total			
	<i>Coriandrum sativum</i> L.	10	20	17	12	6	16	14	4	16	0	14	0	202			
	<i>Anethum graveolens</i> L.	9	14	15	13	5	15	7	5	21	0	17	1	199			
	<i>Ziziphora interrupta</i> Juz.	9	16	15	21	4	22	23	6	7	2	11	0	235			
	<i>Ocimum basilicum</i> L.	12	18	7	19	7	20	16	9	17	2	12	0	253			
	<i>Calendula officinalis</i> L.	10	17	8	11	2	14	13	4	16	0	15	2	176			
	<i>Helianthus annuus</i> L.	8	0	0	0	0	0	10	6	14	1	5	4	63			
	<i>Zinnia elegans</i> Jacq.	13	8	2	7	6	13	7	9	12	4	13	3	170			
	<i>Celosia cristata</i> L.	12	9	4	24	0	6	15	6	2	3	17	0	141			
	<i>Celosia argentea</i> L.	11	7	0	15	0	5	14	4	5	1	15	0	124			
	<i>Impatiens balsamina</i> L.	10	20	10	40	2	17	16	6	6	0	8	0	173			
	<i>Tagetes erecta</i> L.	12	24	16	14	8	20	22	12	11	1	15	0	300			
	<i>Foeniculum vulgare</i> Mill.	12	18	20	32	6	14	20	6	15	2	13	0	273			
	Total per taxa		171	114	208	46	162	177	77	142	16	155	10	2309			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
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			330	133	53	259	38	218	38	259	53	330	133	218			
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			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
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			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
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			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330	133	53	259	38	218	38	259	53	330	133	218			
			330														

Conclusions

Several of the plants tested in this preliminary trial were very attractive to a variety of natural enemy taxa. Based on this successful preliminary test, we established two larger trials in 2006-2007 to test the attractiveness of a series of plants native to the region using the best of these plants and an unmanaged control strip of weedy vegetation. Initial results suggest that native plants may be similarly attractive to natural enemies and hold promise for habitat manipulation in Central Asia.

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Enhancing the Efficiency and Product Lines of Biolaboratories in Central Asia

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Introduction

Protecting plants from pests, diseases, and weeds is necessary to enhance crop productivity, thereby assuring abundant food products for the inhabitants of the Republics of Central Asia as well as raw resources for their industries. However, plant protection must be approached with respect for the environment, using an Integrated Pest Management (IPM) approach. Ecological concerns with the use of chemical pesticides became widespread throughout the world during the 1960s (Maredia *et al.*, 2003). It was during that time and with shared concerns within the former Soviet Union that biologists, agriculturalists, and ecologists began addressing problems of environmental pollution from pesticides. These scientists researched alternative methods of plant protection, building upon the foundation of a number of 19th and early 20th century Russian scientists, who had studied biological control of key insect pests such as Sunn pest and codling moth. The first of these pioneers of biological control was the famous Russian scientist I. I. Mechnikov who in 1879 studied the use of fungal pathogens against cereal beetles and sugar beet weevil (Rubtsov, 1948). In his papers devoted to entomophages for control of Sunn pest, I. A. Rubtsov, identified several species of natural enemies including *Telenomides* and *Micropharus* spp. (Starets, 1975). In 1903, I. V. Vasiliev obtained 60 % parasitism of Sunn pest eggs following field releases of *Micropharus*.

Experiencing success in their own research on alternative pest management practices, plant protection researchers of the former Soviet Union proposed that the government take measures to reduce pesticide use and instead emphasize the

use of biological control agents, including microorganisms, to control pest insect populations (Rubtsov, 1948; Starets, 1975; Tryapitsin, 1965). However, it was recognized that the complete elimination of chemical controls would not be possible (Filippov, 1990). Therefore, the development and implementation of new strategies to utilize chemical and biological methods compatibly within an IPM program was initiated. Integrated Pest Management has been an important force in shaping crop protection strategies in Central Asia for the past three decades (Soper *et al.*, 1990). Biological control has remained the key to IPM as practiced in Central Asia during this period, with conservation of natural enemies and augmentation using predators and parasitoids as the most important tactics employed. However, to implement this approach successfully, it was necessary to develop facilities and methods for mass-rearing biological control agents, and to determine how to use them compatibly with the chemical pesticides needed for plant protection (Alimukhamedov and Adilov, 1991).

In 1970, the government of the former Soviet Union resolved to create a number of biolaboratories for mass-producing entomophages to release on crops against pest insects (Shepetilnikova and Fedorinchik, 1968; Chenkin, 1997). With this resolution, about 70 biological laboratories and over 300 farm product line biolaboratories were established for mass rearing the parasitoid *Trichogramma*. Subsequently, the area of entomophage releases in Central Asia increased every year. Micropathogen preparation of *Bacillus thuringiensis* bacteria was also initiated on a large scale targeting lepidopteran pests. Concurrently, research was conducted to identify additional

species of biological control agents to target other crop pests.

A number of important Soviet scientists including I. A. Porginskiy, I. V. Vasiliev, I. V. Kurdyumov, I. Ya. Shevirev, V. P. Pospelov and others worked throughout the 1970s and 1980s, contributing greatly to the knowledge of entomophage species and their role in pest control, and eventually leading to effective methods for utilizing entomophages as biological control agents (Chenkin, 1997).

Because of the well known efficiency of *Trichogramma* as a parasitoid in nature, there was considerable emphasis on improving their mass rearing to increase availability for field releases (Adilov, 1986). In depth studies of *Trichogramma* releases began in Central Asia in the early 20th century. In 1911, A. F. Radzedskiy in Samarqand made the first attempt to use the *Trichogramma* species brought from Russia (Povoljje) for codling moth control. At the Kiev Entomological Station in 1912, the famous Russian scientist V. P. Pospelov began to study the potential for mass rearing and release of *Trichogramma*. I. A. Porginskiy used methods identified by Shepetilnikova to contribute to this work (Alimukhamedov, 1986). Further research on *Trichogramma* biology and ecology identified the significance of interspecific differences and the importance of different climatic conditions on their success (Meier, 1941). Additional work during this time emphasized additional aspects of artificial rearing and mass release of *Trichogramma* in the field (Telenga, 1959; Rusnak, 1988).

In 1926, the American scientist S. G. Flanders identified that *Trichogramma* could be mass reared in the laboratory on grain moth eggs, and from that time this approach to mass rearing became favored in the Soviet Union as well (Adilov, 1971). Research on the rearing and use of *Trichogramma* in the Soviet Union was greatly expanded in 1934, with the establishment of the Biocontrol Laboratory of the Soviet Institute of Plant Protection,

and later at the Scientific Research Institute, which was headed by N. F. Meier (Meier, 1940).

The initial attempts to mass rear and release *Trichogramma* in the Soviet Union in the manner done in the United States failed as it was assumed that only one *Trichogramma* species, *T. evanescens*, was available in the Soviet Union. This species was applied broadly against many insect pests and on many types of crops. The *T. evanescens* utilized for these releases was isolated from the cabbage moth in the Krasnodar region, and mass reared in Leningrad for distribution throughout the country (Adilov, 1986).

Later, several scientists at the Soviet and Ukrainian Institutes of Plant Protection identified additional *Trichogramma* species and biotypes differing in their biological characteristics. These additional *Trichogramma* species and biotypes proved successful in various regions of the Soviet Union and for different types of pests and crops. At present, different forms of *T. evanescens* are applied in mass releases that target the winter moth, cabbage moth and, other Lepidoptera (Adilov, 1986).

Scientists in the former Soviet Union have contributed considerably to the development of IPM of cotton pests. They developed economic damage thresholds for different insect pest species and mites and contributed experimental data on biological control, including entomophage species composition, ecology, and levels of biological efficiency for naturally occurring entomophage populations, production, and application technologies for reared entomophages and use of microbial control agents (Shepetilnikova, 1968; Chenkin, 1997).

On the recommendation of V.A. Shepetilnikova of the Central Asia Scientific Research Institute of Plant Protection in 1967, further studies on *Trichogramma* applications were conducted. This research focused on comparisons of species and biotype

efficacy focusing on entomophages targeting cotton bollworms and others phytophagous species of cotton and other crops. Additional studies on their biological features and behaviors, release rates for *Trichogramma* application, and methods for their conservation were also conducted (Adilov, 1971). In 1970, the government of Tajikistan SSR established the Central Biolaboratory in Dushanbe where *Trichogramma* biotypes were mass-produced for application against crop pests. Two biotypes introduced initially did not survive the harsh climatic conditions there and soon died. However, a *Trichogramma* introduced from the United States proved to be acclimatized. Its field application was first made later that year on a Tajikistan collective farm over an area of 166 ha against the cotton bollworm on cotton, and it proved successful (Peregunchenko, 1970).

Scientists of the former Soviet Union Research Institute in Uzbekistan further improved the mass rearing of *Trichogramma* by conducting research that led to a process for mechanical rearing of these parasitoids. The authors (S.V Andreev, *et al.*) of the mechanical line, together with Institute researchers, established a prototype for the large-scale mechanical mass rearing of *Trichogramma* and its host, the grain moth, at the "Mikond" plant. In the Ministry of Agriculture of the former Uzbekistan Soviet Socialist Republic, a special department on assembly, delivery, repair, release, and use was created to implement the mechanical rearing approach. The scientific production department "Agropribor" was created for technical aspects of the program (Chenkin, 1997).

During the 1960s, several scientists in Russia, Ukraine, and Moldova studied the biology of additional species of Lepidopteran larval parasitoids and predators. Most of these parasitoids belonged to the Hymenopteran family Braconidae (Tobias, 1959). Adashkevich and others reported the beneficial features

of the parasitoid *Habrobracon hebetor* for control of cabbage moth and codling moth, and proposed the development of mass rearing methods for this species using wax moths. They also acknowledged the significant role of predatory arthropods such as spiders, lady beetles, lacewings, and predaceous bugs, including *Orius* spp., *Podisus maculiventris* and *Perillus bioculatus* for management of the Colorado potato beetle and *Leptinotarsa decemlineata* on early potatoes and eggplants (Mangutova, 1970; Moiseev, 1973; Adashkevich, 1974; Filippov, 1988.).

Research on braconid parasitoids for releases in Central Asia were initiated in 1961 by the Soviet scientist V.I. Tobias (Tobias, 1951). Especially significant was his work on *H. hebetor*. He found this ectoparasitoid to be a very effective biological control agent for a number of different lepidopteran pests. Since then, scientists in Uzbekistan and Turkmenistan have reported that natural populations of this parasitoid could reduce the first generation of bollworms on cotton by 10-18 %, with parasitism increasing to about 50 % later in the season. They considered that the braconid complex, together with other native entomophages, were the primary mortality factor limiting the bollworm population (Hamraev, 1961). The parasitoid was also found to reduce the number of bollworms on corn by 15-25 % and by about 60 % on tomatoes. These studies resulted in a resolution issued by the government calling for the mass rearing of *H. hebetor* in biolaboratories for release on the cotton crop (Adashkevich, 1988).

In addition to these parasitoids, there was considerable interest in a polyphagous predator, the green lacewing *Chrysopa carnea*. The international literature supported the effectiveness of lacewing releases against pest moths on pears and gardenia plants, and against bollworms on cotton (Ridgway, 1968). Concurrently in the Soviet Union, scientific studies indicated that lacewings could

reduce populations of a number of key insect pest species, and this research led to a proposal for their mass rearing and release (Luppova, 1969). However, this approach could not be pursued initially in the former Soviet Union because of the lack of suitable methods for mass rearing. A lacewing mass rearing technique developed in the United States and based upon feeding the lacewing larvae with eggs and larvae of the potato tuber moth could not be used in the Soviet Union because the prey insect was not present in the country and was considered a potential pest. In 1966, scientists of the Biocontrol Laboratory at the Soviet Research Institute of Phytopathology first developed the technique of mass rearing of lacewings applicable to the Soviet Union. In the 1970s, G. A. Beglyarov and others further modified and improved the method of lacewing rearing and evaluated its efficiency (Beglyarov, 1967, 1972, Hizhniak et al, 1971).

The ability to mass rear and release the two parasitoids and the green lacewing, and the apparent effect of these biological control agents on pest insect populations, resulted in a decision by the Cabinet of Ministers in Uzbekistan issued on September 20, 1973, CP # 421, "on measures of enhancing scientific research and the wide introduction into crop production of biological control of pests, diseases and weeds" which enabled the establishment of biolaboratories on a massive scale. At the Central Asia Scientific Research Institute of Plant Protection in Tashkent in 1980, scientists representing several disciplines established a biolaboratory with the ability to mass produce a product line of local species of *Trichogramma*, *H. hebetor*, and the green lacewing, *C. carnea*, for augmentative release on a large area of cotton fields for control of phytophagous pests and mites (Shepetilnikova, 1968).

The large-scale introduction of biological control agents required extensive training of scientists, technicians, engineers, and

others professionals. Many of the laboratory managers and their assistants were trained in courses at institutions such as Tashkent University, the Leningrad Soviet Institute of Plant Protection, the Soviet Institute of Biocontrol Plant Protection, the Ukrainian Research Institute of Plant Protection and others (Luppova, 1969). By 1988, there were 730 biolaboratories and an additional 288 biofactories with 553 mechanical mass rearing lines for *Trichogramma* in Uzbekistan alone, and more than 3000 biocontrol specialists were employed for their operation.

Since its independence from the Soviet Union in 1991, Uzbekistan has maintained its focus on biological control releases for the cotton crop. Most biolaboratories established during the time of the former Soviet Union remain in operation to the present time, but biofactories where mechanical lines were installed for the production of entomophages have largely been abandoned due to the lack of parts needed to maintain the equipment. There are still more than 900 biolaboratories functioning in Uzbekistan, and entomophages continue to be released on more than 1.5 million ha of cotton.

The USAID IPM CRSP for Central Asia proposal, of which this biolaboratory component is one part was developed following a Stakeholders Forum held in Tashkent, Uzbekistan, in May 2005, at which the stakeholders present identified as priorities improving efficiency of entomophage production, expanding biolaboratory product lines to include additional entomophages targeting different pest species than those currently produced, and expanding the release of entomophages to include pests of additional crops. The sources of new biological control agents could include those which are introduced, established (previously introduced and now endemic), or naturally occurring in the region, as well as more effective or better acclimatized strains of those entomophages already in production.

Methods

IPM CRSP Project is being conducted in partnership with ICARDA. The primary focus of the project is to enhance the potential of the biolaboratories of Central Asia by introducing new entomophages. Our initial focus was on mass rearing and release of predatory mites of the Acari family, Phytoseiidae, which are successfully utilized in the United States, Europe, and the Middle East for control of spider mites, thrips, and whiteflies. The project was initiated by the visit of Dr. Tashpulatova to the laboratory of Dr. Zalom at UC Davis in May and June of 2006, for training on predator mite rearing and research methodology. Subsequently, and after obtaining an importation permit from the government of Uzbekistan, two species of Phytoseiid mites (*Amblyseius cucumeris* and *Amblyseius swirskii*) were brought to Central Asia for further study. These Phytoseiid mites are produced commercially both in the United States and Europe, and are sold and shipped throughout the world. *A. cucumeris* is generally regarded as safe to release by the European and Mediterranean Plant Protection Organization (EPPO) standards (OEPP/EPPO, 2002), which provide guidelines to national authorities in the EPPO region (including Europe, North Africa, Russia, Turkey, Israel and Jordan) on the introduction and release of exotic biological control agents in order to identify and avoid hazards for agricultural and natural ecosystems. These standards are based on extensive previous knowledge and experience of the use and introduction of entomophages sufficient to indicate the absence of significant risks.

Results

Of the Phytoseiids introduced, only *A. cucumeris* has been successfully colonized under conditions present in the biolaboratories in Uzbekistan and Kyrgyzstan. Currently, this species is being reared at both the Uzbekistan Institute for

Plant Protection and the Kyrgyzstan Centre on Biological Facilities Production for Plant Protection. Results to date suggest promise for its application to commercial crops. Our studies have revealed the optimal condition for rearing these predatory mites, and the optimal predator: prey ratios for their mass rearing in culture. For example, we established that the optimal predator: prey ratio on the prey mite, *Acarus siro*, is 1:5 for *A. swirskii* and 1:7 for *A. cucumeris*, and on *Tyrophagus putrescentiae* 1:7 for *A. swirskii* and 1:10 for *A. cucumeris*.

In the fall of 2006, scientists of the Kyrgyz biolaboratory conducted plots trials of *A. cucumeris* on onions and in winter, 2006-07 on flowers in laboratory greenhouses against *Thrips tabaci*. The density of thrips on the onion crop was very high, about 10 per leaf, and the entomophages could not suppress the pest population. However, satisfactory results were obtained on flowers in the greenhouse releases, as the thrips population was low when the predators were introduced. With the establishment of mass rearing of *A. cucumeris* there is potential for their application for management of spider mites, thrips, and whiteflies on cotton, vegetable, fruit, and greenhouse crops.

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Development and Dissemination of IPM knowledge through Outreach and University Education Programs in Central Asia

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Introduction

After the collapse of the Soviet regime in the 1990s, many independent states proceeded with land reform policies. In the former Soviet Union system, agricultural extension was non-existent. Crop management was decided by managers and supporting technical staff of collective farms. After the transition from agricultural collectives to private farms, crop management was thrust upon the new individual farmers. Farmers were not prepared to make their own farm decisions. In addition, before the independence, pest management was characterized by overuse of pesticides. However, after 1991, the lack of income by individual farmers to purchase pesticides presented some real challenges for pest management. Some countries have initiated Integrated Pest Management (IPM) programs since it is a comprehensive approach that utilizes all available tools and methods for pest management as an alternative to heavy use of pesticides. Despite these efforts, the knowledge generated is insufficient and hardly reaches the end-users, i.e., the individual farmers.

In the absence of a formal government-run extension system, NGOs and farmer organizations provide farmer training, technology transfer, and outreach services. There is a lack of IPM components in these outreach and farmer training programs. The absence of a structured extension system and lack of structured outreach services have created some gaps in knowledge sharing and dissemination within these independent states. Participatory training methods, in which farmers are in the center of learning, are most appropriate to empower them with

skills and knowledge for making their own decisions. The IPM-Farmer Field School (FFS) concept, which has evolved over the last 15 years, could be very appropriate to provide information to farmers. This educational approach emphasizes farmer-led learning and adaptation to changing conditions, which are necessary skills for farmers to be successful in the new economic system. There is a need to develop IPM packages that can be integrated into farmer field schools and other outreach programs.

Because agricultural ecosystems are constantly changing and the methodologies of IPM are continually improving, it is imperative for all of those engaged in IPM education to maintain their capacities in a way that best uses their human resources and involves current IPM technology. This requires comprehensive training for both teachers and students in IPM, biological monitoring, environmental monitoring, information management systems, and the process of decision-making. The current level of expertise in these components of IPM throughout Central Asia is variable and there is a distinct need to enhance the IPM capacity-building attributes of the existing institutions.

Currently, some governments in the region are also encouraging agricultural universities to play a proactive role in outreach and extension education and services. There is a lack of trainers and outreach specialists with appropriate training and experience in IPM that goes beyond biocontrol and integrates all available tools and approaches. To develop a comprehensive IPM outreach and extension program requires a strategy to build training capacity. It would require a core group of ToT trainers who can tailor

the outreach and educational programs to the needs of different cropping systems, and it requires a cadre of facilitators who can spread the program to new areas. Trainers trained through Training of Trainers (ToT) could serve in FFS for implementing IPM programs.

To help address some of the challenges, the IPM-CRSP Project in Central Asia has initiated a project on strengthening IPM outreach and university education in the Central Asia region. To achieve this, the project is partnering with local NGOs, national research institutions and universities, and international organizations. The goals of this project are to:

1. Strengthen IPM outreach and education by developing IPM training modules/materials that can be integrated into crop management training programs offered by the NGOs, and government institutions.
2. Further develop the capacity of ATC of RAS in Kyrgyzstan, other NGOs, and state institutions in Central Asia by developing a pool of trainers that can support Farmer Field Schools (FFS) and other outreach activities.

Approach

Strengthening IPM Outreach and Education

In collaboration with ICARDA, NGOs, and local universities in the region, IPM training materials and modules for priority crops such as wheat, potatoes and tomatoes are being developed and distributed to farmers. An inventory of IPM and crop management training materials used by universities in Central Asia and at Michigan State University has been conducted. This inventory is being used in integrating new information, teaching tools, and methodologies into the existing IPM curriculum. Initial contacts have been made with universities in the region to assess IPM curriculum development. Similarities and differences among IPM

training programs are being assessed. Based on this analysis, the content of a pilot IPM course will be developed for the Kyrgyz Agrarian University. In conjunction with the development of this course, a Student Field School (SFS) was created to provide hands-on experience in farm and pest management decision making. An IPM training program for SFS on vegetable and wheat has been developed. In collaboration with the project on landscape ecology, successful local nectar plants that provide habitat to enemies of pests will be introduced into existing vegetable farms systems.

Training of the Trainers and Farmer Field Schools

After basic training materials are developed, in collaboration with NARs, universities, and local NGOs, a Training of Trainers (ToT) program is established. The ToT focuses on ecologically-based IPM, training methodology, and a mixture of experiments and practical exercises relevant to crop and pest problems of Central Asia. The ToT targets university faculty members who are being prepared to help manage Farmers Field Schools and Student Field Schools. IPM technologies developed by the IPM CRSP project in Central Asia are being extended to farmers through a participatory approach using farmer field schools (FFS). Various materials (pamphlets, brochures, leaflets, publications and electronic information) are being developed and distributed to assist farmers in understanding pests and control methods in field and vegetable crops. Pamphlets on insect, disease, and weed identification will be produced and printed in the appropriate languages.

Achievements

- ◆ In collaboration with the Tajik Institute of Plant Protection and Quarantine, the IPM-CRSP has opened a Farmer Field School (FFS) in the Hissar District of Tajikistan where 13 women and 2 men have been trained. Trainers from this

FFS were selected from a group of faculty members and researchers who participated in the ToT workshop. Participants in this workshop were from the Tajik State Agrarian University (TSAU), the Tajik Institute of Zoology and Parasitology, and the Tajik Institute of Plant Protection and Quarantine (IPPQ). This FFS in Hissar district has 0.2 ha where various IPM experiments are conducted. In collaboration with TSAU, the IPM-CRSP has developed a manual on creation and training of ToT and FFS. In addition, both partners will be conducting a training of trainers of scientists from various universities including the Andizhan Agriculture Institute, Namagan and Fergana Universities and the Nunkun State University. Discussions are underway with the TSAU to introduce IPM in their agricultural education curriculum. In addition, a manual on pest management in organic agriculture is being developed and will be widely distributed to agricultural universities and NGOs in the Central Asia region.

- ◆ A Student Field School (SFS) was created at the Kyrgyz Agrarian State University. Unlike the FFS, the SFS is providing theoretical knowledge in addition to practical knowledge on various subjects including entomology, pesticides, agroecology, biological control methods, etc. This is going to be a certificate program.
- ◆ A flyer describing the project in greater detail was developed and published in Russian. This flyer was distributed electronically and in hard copy to more than 40 donors, NGOs, and government organizations in Kyrgyzstan, Uzbekistan, and Tajikistan. The project has developed an electronic database of IPM publications by various institutions in Central Asia. The electronic catalogue “The work of scientists and experts on IPM in the Central Asia” covers Kyrgyzstan, Kazakhstan, and Uzbekistan. A summary
- ◆ of research activities by 12 scientists from Kyrgyzstan, 7 scientists from Kazakhstan and 1 from Uzbekistan during the last five years is presented in this document. Copies of this electronic catalogue will be distributed to the Kyrgyz Agrarian University, the Kazakh Agrarian University and the Tajik Institute of Plant Protection and Quarantine. This database includes also a list of IPM researchers and resource persons in the region.
- ◆ Many publications on IPM have been produced by the project in collaboration with the IPPQ, TSAU or ATC-RAS and used for training farmers in the FFS. Calendars for three major vegetable crops were developed (a calendar of cabbage damage by insects, a calendar of carrot damage by insects, and a calendar of tomato damage by insects). To help farmers identify pests, a terminological dictionary of the main diseases—pest of the cotton and vegetable crops—was published in Latin, Russian, and Tajik. To help the trainers manage the FFS, a brochure was published on “Organization and Management of the Farmer Field School on IPM” and two modules on FFS were developed (Module 1—Introduction of FFS, published in Russian, and Module 2—Biological Control Methods of Main Insect Pests and Tomato Disease).
- ◆ In addition, the project has published the following documents:
 - In collaboration with the AVRDC-CAC, an extension bulletin on “Weeds in vegetable crops in Central Asia” has been published.
 - A brochure on Sunn-pest developed by ICARDA was translated into Kyrgyz for distribution to farmers, IPM specialists, and extension personnel.
 - In collaboration with the project the ATC has published two scoutin guides:
 - ✓ Determination of cucumber pests and diseases (30 pages, in Russian)

✓ Determination of tomato pests and diseases (30 pages, in Russian)

- ◆ A survey was conducted on 35 farmers in Andreev Village of the Hissar district in Tajikistan to assess the knowledge and skills of farmers on IPM. The questionnaire covered many aspects including decision-making for pest management, use of pesticides, knowledge of vegetable pests and their natural enemies, etc. Survey results revealed that there was no assistance in pest management decision-making. Most farmers purchase pesticides from markets and no training on pesticides use and safety was provided. With regard to pests, farmers were familiar only with cotton worm and had little knowledge of vegetable pests. In addition, a survey has been conducted on 55 farmers in Kyrgyzstan to assess their knowledge and needs in IPM tools and techniques. The data is being reviewed and analyzed.

Conclusion

In conclusion, training farmers using the FFS approach is much simpler and the most comprehensive method of transferring IPM knowledge and skills to farmers. Regular interaction with farmers during the FFS meetings strengthens farmers' confidence in making decisions on crop management including pest management decision. The teaching methodologies and content of Farmer Field Schools are regularly improved based upon farmers' needs. The creation of Student Field Schools will help to disseminate IPM knowledge and create IPM interest in the younger generation of agricultural professionals. Due to limited funding, one of the challenges includes the non-expansion of FFS concept in other villages or provinces. In addition, due to lack of access to the Internet by various end-users, the information and material developed are not available to many universities and private and state institutions.

Pest Management Practices and Strategies in Tajikistan

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Introduction

Tajikistan is situated in Central Asia, far from seas and oceans between 36° 40' and 41° 05' North latitude and 67° 31' and 75° 14' East longitude. It lies in the same latitudes as Greece and the southern regions of Italy and Spain. Tajikistan occupies an area of over 143.1 square kilometers, 93 % of which is mountainous. Its territory stretches 700 km from west to east and 350 km from north to south. On the southeast Tajikistan borders Afghanistan and China, on the west and north, Uzbekistan and Kyrgyzstan. According to 2006 data, the population consists of 7 million people, 72 % of whom live in rural areas. Dushanbe, the capital of sovereign Tajikistan, is located in the picturesque and fertile Hissar valley at the height of 750-930 m above the sea level. The climate in Tajikistan is dry, subtropical, and continental with warm winters and hot summers. The average summer temperature is about 30°C and may reach as high as 45-50°C in the southern part of the country in June and July. The average annual precipitation ranges from 150 to 650 mm (Tajikistan, nature and natural resources, 1982).

Agricultural in Tajikistan

Agriculture in Tajikistan is still the backbone of the economy and continues to be largest single sector and driving force for the growth of the national economy. It accounts for over 30-40 % of gross domestic product (GDP) and about 50% of the country's total exports. The total land for agricultural production is 850,300 hectares, with 720,000 hectares under irrigation (Tajik State Statistical Agency, 2005-2006). The main crops are cotton and wheat (table 1). Other crops such as maize, rice, potatoes, water-melons, sweetmelons, cucumbers, chickpeas, beans, tomatoes, onions, garlic, apples, pears, quince, apricots, peaches, cherries, grapes, pistachio nuts and pomegranates are very important.

Table 1. Total area for wheat and cotton production in 2005-2006 growing seasons.

Crops	2005		2006	
	Planted (ha)	Harvested (tons)	Planted (ha)	Harvested (tons)
Wheat	167 644	360 996	199 290	437 927
Cotton	288 655	447 918	262 893	437 898

Crop Pests And Their Economic Importance In Tajikistan

Migratory Pests: The desert (*Schistocerca gregaria* Forsh.), Moroccan (*Doclostaurus maroccanus* Thnb.), and migratory locusts (*Locusta migratoria* L) are sporadic pests that cause substantial crop losses in Tajikistan. During 2006-2007, more than 100,000 ha of agricultural crops were attacked by locusts in the north and south of Tajikistan. The loss of crops in the locust-affected area forced the government of Tajikistan to spend significant funds for chemical control of locusts in more than 80,000 ha in 2007 (Newspaper Asia Plus, 2007).

Invasive Pests: Recently, new and quarantined pests were migrating from neighboring countries to Tajikistan. Noteworthy and most dangerous among these pests are the Colorado beetle (*Leptinotarsa decemlineata* Say) in potatoes (Qakharov, 2004; Saidov *et al.*, 2004; Saidov, 2006), the whitefly (*Bemisia tabaci* Gen) in cotton and vegetable crops (Tashpulatov *et al.* 1998), the mulberry moth (*Margaronia pilosalis* Dem) in mulberry trees (Tadjibaev, 1998, Saidov and Tadjibaev, 1998), and the melon fly (*Miopardalis pardalina* Big) in sweet melons and water melons.

Storage Pests: Over the last decade, in connection with trade liberalization and the change of structure of crop rotation, there was an increase of harmful rodents (Rodentia). The most dangerous rodents in

cotton, grain, leguminous and vegetable crops, and in warehouses are the house mouse (*Mus musculus*) and three species of rats (*Rattus turkestanicus*, *Nesokia indica* and *Meriones libica*) (Saidov A., 2001).

General Situation of Pest Management

In Tajikistan, the different agro-ecological zones and climatic conditions make the country profitable for growing a wide range of agricultural crops, including subtropical crops. In the lowland agro-ecological zone, farmers grow and harvest crops twice a year on the same land. These conditions allow the continuous presence of certain pests and diseases and cause more serious problems. An estimated 30-35% of crops are lost to pests in the field.

Chemical control: In the last decade, pesticides were used as the most powerful tool for pest control in Tajikistan (figure 1). A major part of the pesticides were used for control of cotton pests. However, a significant reduction of pesticide use has been noticed for the past few years (figure 1) due to high prices and lack of income for farmers.

Biological control: There are 10 biolaboratories in Tajikistan which produce three beneficial insects for pest control in cotton fields (table 2). In 2006, beneficial insects were applied on more than 130,000 ha.

Figure 1. Trend in use of Pesticides in Tajikistan from 1983 to 2006

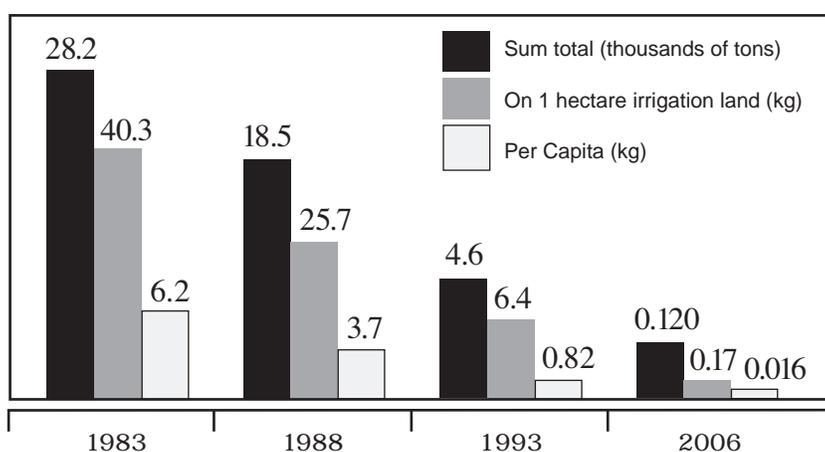


Table 2. Beneficial insect and controlled pests.

Beneficial insects	Controlled Pests
<i>Chrysopa carnea</i> Steph.	<i>Aphis gossypii</i> Glover <i>Aphis craccivora</i> Korch
<i>Trichogramma</i> sp.	<i>Heliothis armigera</i> Hb. <i>Agrotis segetum</i> Schiff <i>Laspeyresia pomonella</i> L.
<i>Bracon hebetor</i> Say	<i>Heliothis armigera</i> Hb. <i>Agrotis segetum</i> Schiff <i>Laspeyresia pomonella</i> L. <i>Polychrosis botrana</i> Schiff

Integrated Pest Management (IPM)

Long-term application of pesticides in various agricultural systems has led to large-scale environmental contamination. Therefore, researchers at the Institute of Zoology and Parasitology in Tajikistan (IZ&P), have been developing and implementing new methods for pest control which are based on minimal use of pesticides. The methods are based on biocenosis approach and designed for maximal use of natural mechanisms to regulate the number of harmful organisms. The IZ&P started to implement environmentally-friendly methods of pest control in Tajikistan in 1967. The institute is the initiator of the development and introduction of IPM in cotton and horticultural crops in Tajikistan.

Studies at the IZ&P on the fauna of invertebrate animals in cotton landscape found 320 species of arthropods (Narzikulov et al., 1977). Among these species, the most dangerous to cotton crops are: spider mites (*Tetranychus telarius* L), black alfalfa aphids (*Aphis craccivora* Koch), melon aphids (*Aphis gossypii* Geov), big cotton aphid (*Acyrtosiphon gossypii* Mordv), cotton cutworms (*Heliothis armigera* Hb), winter cutworms (*Agrotis segetum* Schiff) (Mukhitdinov, 2007), green cutworms (*Spodoptera exigua* Hbn), alfalfa bugs (*Adelphocoris lineolatus* G), field bugs (*Lygus pratensis* L), and tobacco thrips (*Thrips tabaci* Lind).

The most effective natural enemies against cotton pests in Tajikistan are lacewing (*Chrysopa carnea* Steph), spider eating thrips (*Scolothrips acariphagus* Yakh), Coccinellidae (*Coccinella septempunctata* L. and *Stethorus punctillum* Weise) and several species from the family of Syrphidae, Ichneumonidae, and Braconidae (Narzikulov et al., 1977; Saidov, 1996). In 1976, recommendations by scientists of the IZ&P and the Ministry of Agriculture, for the use of IPM in cotton, decreased cotton pests in Tajikistan. In the 1990s, IPM was used on more than 50,000 ha of cotton. Similarly, in the 1990s, IPM methods were also used on apple and grape crops on more than 10,000 ha. However, the adoption of IPM has strongly decreased with the collapse of USSR in 1991 and the economic crisis in Tajikistan from 1992-1997.

Botanical Pesticides

Soil and climatic conditions of Tajikistan are favorable for various types of plants. More than 4,450 species of plants were identified, among which there are a number of insecticide-containing plants (Ismoilov, 2002). In order to produce botanical pesticides, the IZ&P setup a laboratory in 2002 with the capacity of preparing botanical insecticides in the form of decoction and infusion.

The following plants are used:

- tobacco plant (*Nicotiana tabacum* L), waste from Dushanbe Tobacco factory;
- white mustard (*Sinapis alba* L), mustard powder;
- common wormwood (*Artemisia absinthium* L), above-ground part of the plant;
- ordinary milfoil (*Achillea millefolium* L), whole plant. Many botanical pesticides are effective in controlling vegetable insect pests (Saidov and Nazirov, 2002 a, b; Saidov, 2003; Mukhitdinov *et al.*, 2007).

Landscape Ecology and Biological pest management

Landscape diversity can be increased by preserving, restoring, or creating plant communities that provide needed resources to natural enemies. In collaboration with the International Center for Agricultural Research in the Dry Areas (ICARDA) and Michigan State University (MSU), and under the Central Asia Regional IPM CRSP Project, the IZ&P is hosting a study on the evaluation of the role of native plants for conserving natural enemy communities in agro landscapes. In 2006, (table 3) experiment plots were established to test the attractiveness of various native plants to beneficial insects. Several of the plants tested in this preliminary trial were very attractive to a variety of natural enemy taxa (Saidov, 2006). Initial results suggest that native plants may be similarly attractive to natural enemies and hold promise for habitat manipulation in Central Asia.

Main Crop Protection Problems and Approaches to Solve Them

Some of the major concerns are misuse and overuse of pesticides by farmers; and adverse effects on the environment, health of farmers, and consumers.

1. Inappropriate use of pesticide. Farmers tend to have a strong preference for pesticides that wipe out pests rapidly, thus using the most hazardous chemicals.

In addition, farmers often mix pesticides with different active ingredients to save on labor and to increase the concentration of pesticides, which is perceived to provide greater protection.

2. Pesticide Resistance. Pesticide resistance is one of the serious problems. In intensively sprayed crops, insecticide resistant pest populations develop rapidly, particularly if the same pesticide is used frequently. As more frequent treatments and higher concentrations of insecticides have to be applied when insects have developed resistance, this has led to the overuse of pesticides.

3. Adoption of IPM. The promotion of cotton IPM tools by the IZ&P and Ministry of Agriculture was successful, but did not result in a wider adoption of IPM when compared to blanket use of synthetic pesticides.

Approach to Solve Crop Protection Problems

The Ministry of Agriculture has promoted IPM methods. The effort concentrates on strengthening IPM in farmer associations with a high frequency of pesticide application. The assumption is that farmers are willing to adopt IPM, provided that alternative control methods are almost as effective as synthetic pesticides and that consumer awareness of hygienic and organic products increase. This approach encourages correct use of pesticides by improving handling, storage, and application. The government, NGOs, and other private sector companies will do the development and dissemination of IPM information. The government expects to see an increase in the production and use of botanical pesticides to replace synthetic pesticides. More importantly, the Department of Agricultural Extension should concentrate its research efforts exclusively on the development and dissemination of information about IPM and stop advocating pesticides.

Table 3. Highlights of some major pests in Tajikistan and control methods (Saidov N., 2001).

Pest	Crop attacked	Control measures
Insects and Others		
<i>Aphis gossypii</i> Glover (Aphididae)	Cotton	Cultural, chemical
<i>Acyrtosiphon gossypii</i> Mordv. (Aphididae)	Cotton	Cultural, chemical
<i>Aphis craccivora</i> Korch (Aphididae)	Wide range	Cultural, chemical
<i>Brevicornia brassicae</i> L. (Aphididae)	Cabbage	Cultural, chemical
<i>Aphis pomi</i> Deg. (Aphididae)	Apple	Cultural, chemical
<i>Thrips tabaci</i> L. (Aeolothripidae)	Wide range	Cultural, chemical
<i>Haplothrips tritici</i> Kurd. (Aeolothripidae)	Cereals	Cultural, chemical
<i>Bemisia tabaci</i> Gennadius (Aleyrodidae)	Wide range	Cultural, chemical
<i>Pseudococcus comstocki</i> Kuw. (Pseudococcidae)	Wide range	Cultural, chemical
<i>Pseudococcus citri</i> Russo (Pseudococcidae)	Grape	Cultural, chemical
<i>Quadraspidiotus perniciosus</i> Comst. (Diaspididae)	Wide range	Cultural, chemical
<i>Parlatoria oleae</i> Colvee (Diaspididae)	Wide range	Cultural, chemical
<i>Agrotis segetum</i> Schiff (Noctuidae)	Wide range	Cultural, chem., biological
<i>Heliothis armigera</i> Hbn. (Noctuidae)	Wide range	Cultural, chem., biological
<i>Plutella maculipennis</i> Curt. (Plutellidae)	Cabbage	Cultural, chemical
<i>Pieris brassicae</i> L. (Pieridae)	Cabbage	Cultural, chemical
<i>Pieris rapae</i> L. (Pieridae)	Cabbage	Cultural, chemical
<i>Coleophora tadjikilla</i> Danilev (Coleophoridae)	Wide range	Cultural, chemical
<i>Oncocera (Salbria) semirubella</i> Sc. (Phycitidae)	Wide range	Cultural, chemical
<i>Euzophera punicaella</i> Moore (Phycitidae)	Pomegranate	Cultural, chemical
<i>Alophia combustella</i> H.S. (Phycitidae)	Pistachio	Cultural, chemical
<i>Hyponomeuta padellus</i> L. (Hyponomeutidae)	Wide range	Cultural, chemical
<i>Laspeyresia pomonella</i> L. (Tortricidae)	Apple and pear	Cultural, chemical
<i>Polychrosis botrana</i> Schiff. (Tortricidae)	Grape	Cultural, chemical
<i>Pandemis chondrillana</i> H.S. (Tortricidae)	Wide range	Cultural, chemical
<i>Margaronia piloalis</i> Dem.	Mulberry	Cultural, chemical
<i>Leptinotarsa decemlineata</i> Say	Potato	Cultural, Chemical
<i>Lema melanopus</i> L.	Wheat	Cultural, Chemical
<i>Eurygaster intergriceps</i> Put. (Hemiptera)	Wheat	Cultural, Chemical
<i>Tetranychus telarius</i> L. (Tetranychidae)	Wide range	Chemical
Diseases		
<i>Rhizoctonia solani</i> Kuehn	Wide range	Cultural, Chemical
<i>Verticillium dahliae</i> Klev.	Cotton	Cultural, Chemical
<i>Fusarium oxysporum</i> Schl.	Cotton	
<i>Tilletia tritici</i> Wint.,	Cereals	Cultural, Chemical
<i>Tilletia triticoides</i> Savul).	Cereals	Cultural, Chemical
<i>Ustilago tritici</i> Jens.	Cereals	Cultural, Chemical
<i>Phytophthora infestans</i> dBy	Potato& tomato	Cultural, Chemical
<i>Peronospora desfructor</i> Casp	Onion	Cultural, Chemical

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Current State and Prospects for Integrated Pest Management in Tajikistan

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Institute of Plant Protection and quarantine of Tajik Academy of Agricultural Sciences (TAAS)

Agriculture is one of the vital sectors of the national economy of Tajikistan. After independence, the Republic of Tajikistan took a market-oriented economy and started a reorganization of Soviet collective and state farms. Since January 2006 more than 462,773 hectares of land were distributed to 27,000 dekhkan farms (farmer economy) that now employ 792,877 rural laborers. As the disbandment of the state agricultural enterprises into individual farms proceeds, crop protection from pests is a very important challenge. Before 1990, agriculture in Tajikistan widely used Integrated Pest Management resulting in significant reduction of chemical pesticide applications, and selective applications allowed the creation of favorable conditions for the build up of natural enemy populations of the agricultural crop pests.

At that time, the lowest level of pesticide application was achieved (2-2.5 times against cotton cutworm, 0.8-1.2 times against spider mite), whereas earlier pesticides were applied 15 times to save crops from pests. The greater importance in control of agricultural crop pests was obtained from protection by plants by biological means. In 1976 the biological method was applied on a general area of 30,000 hectares, and in 1986 the area was increased to more than 300,000 hectares. Now in Tajikistan, there are 10 biolaboratories that mainly produce *Chrysopa carnea* Steph., *Trichogramma Sp.*, and *Bracon hebetor* Say for mass rearing to control of cotton pest. In 2006, beneficial insects were released in more than 130,000 hectares. The results of long-term industrial biolaboratories have shown that application of beneficial insects allows protection of agricultural crops from pests by minimal application of chemicals. Along with seasonal entomophages colonization, an arsenal of protection plants and

pheromone traps were used. The practical value of pheromones was significant for forecasting of pests such as *Heliothis armigera* Hb., *Agrotis segetum* Schiff, *Laspeyresia pomonella* L., and *Polychrosis botrana* Schiff.

The pheromone traps helped to determine exact time of emergence of each generation of the pests, to determine the pest outbreaks, and the optimum periods of chemical applications. As a result, a high level of efficiency of plant protection was achieved at less expense which did not pollute the environment. In Tajikistan in 1986, pheromone traps were used in horticulture crops on 20,000 hectares and on 15,000 hectares on cotton crops. In the same period microbial preparations were also applied. However, the wide application of preparations such as DNB and BTB were restrained because of the short term of their storage life. Researchers at the Institute of Zoology and Parasitology at the Academy of Sciences of the Republic Tajikistan (IZ&P) studied in detail the fauna of invertebrate animals in cotton fields and discovered 320 species of arthropods. Based on these findings, Integrated Pest Management methods have been developed (Narziqulov *et al.*, 1977).

Unfortunately, from 1993 to 2006 the crop protection service budget was reduced. The situation is aggravated by the fact that farmers have limited knowledge on pest control and there is no functioning agro-extension service at the country level. It is necessary to note that in 2006 in Tajikistan alone, there were 123.5 tons of pesticides belonging to the following chemical groups: 15.5 tons of fumigant; 79.7 tons of insecticides and 38.3 tons of fungicides. The available assortment of pesticides does not cover the current requirements of pesticide applications against agricultural pests.

Consequently, the phyto-sanitation condition of agricultural crops in recent years has worsened and the number and zones of prevalence of plant diseases have increased. Therefore, the government of Tajikistan repeatedly requested technical support from international organizations for renewal and introduction of Integrated Pest Management.

Today, the Institute of Plant Protection and Quarantine, and the Institute of Zoology and Parasitology of the Academy of Sciences of Republic Tajikistan, in collaboration with International Center for Agricultural Research in the Dry Areas and Michigan State University, carry out research on improvement of the IPM in Tajikistan under the Central Asia Regional IPM CRSP project. Under this program, we established research plots on screening of agro-characteristic native plants for conserving natural enemy communities in agro-landscapes. Along with this research plot, we also established nectar plant strips between wheat and cotton crops to determine the impact on targeted crop pest populations (Fig.1). In collaboration with farmers, we launched an experiment to determine the impact of existing predators on cotton pest populations with cage effects (Fig. 2, 3).

Additionally, researchers from the Institute of Plant Protection study the interaction of various crop hybrids with pests for selection of resistant lines. This research is conducted on wheat, potato, and cotton crops in cooperation with the scientists of the Plant Production (Farming) and Horticulture Institutes of TAAS. Biological pest control methods are emphasized as it remains the main component of the IPM and other activities including the restoration of biological laboratories.



Fig 1. Nectar plant strip.



Fig. 2. Setting of cage.



Fig. 3. Cages in cotton field.

Within the framework of the Central Asia Regional IPM CRSP, and with financial support from USAID, the Institute of Plant Protection provided a special IPM course in 2007, with elements of Farmer Field School (FFS) (photo 4, 5). There were 16 local vegetable farmers involved in the FFS that operated March- August 2007 in the village of Andreev in the Hissar district which was chosen for the results of the analysis of the knowledge and skills of the farmers on growing vegetable crops and pest management. Through farmers' initiative, studies were conducted on 0.04 hectares for screening three pest resistant tomato varieties; "Novichok", "Shedrost" and "Kaskader". To promote the landscape ecology concept, nectar plants such as *Ocimum basilicum* L., *Ziziphora interrupta* Juz., *Salvia sclarea* L., *Melissa officinalis* L. and *Mentha asiatica* Boriss were planted. During flowering, insects were collected every seven days by standard entomological net and preserved for future taxonomy identification.

With the purpose of enhancing the farmers' understanding of IPM approaches on FFS sites, a number of experiments were established:

- ◆ Integrated Pest Management;
- ◆ Farmer practices;
- ◆ Innovation variant for the given region. Then farmers following agronomical research methods subjected themselves to agro ecological analysis:
 - ◆ First farmers developed a seasonal calendar for cultivation of tomatoes.
 - ◆ The FFS farmers began with selection and preparation of a seed material; then using a different seed material and series methods of processing (chemical, biological, botanical), determined the seed germination value;
 - ◆ The large section is devoted to agro-ecological analysis of IPM and farmer-practice variants. Farmers collected the data spending the weekly analysis on crop vegetations and distribution of insect pests, crop diseases and weeds and their severity.



Fig 4. One day of IPM FFS.



Fig. 5. IPM CRSP Forum Participants visit to FFS.

- ◆ One of the main directions of the IPM FFS is the conservation of a biodiversity in agro-landscapes, which is necessary to show the farmers in practice all advantages in using botanical pesticides prepared from local plant resources.
- ◆ The other approach of training of the participants of the IPM in FFS is about the life cycle of insect and their natural enemies through direct supervision and manipulation of an insect zoo. Farmers were thus able to correctly distinguish basic pests and beneficial insects in the field.
- ◆ The most significant concern for farmers was the understanding of methods of conservation and increase of number of beneficial insects in agro landscapes. With this goal in mind, farmers in Field School of the IPM carried out an agro-ecological analysis (7-14 days) on insects on 5 nectar plant species.

The IPM with elements of FFS covers topics such as management of FFS, agro-ecological analysis, experiments, etc. In the last subcomponent, the farmers did not pass the large theoretical training on IPM. The main focus of the training was directed on management of FFS and leadership skills. The master trainers on the experimental field fulfilled the main parts of FFS: and approach. The given component was held from March until August, i.e., during the entire tomato growing season.

Thus, training farmers on the use of FFS techniques is the most simple and accessible method of transfer of knowledge and skills of IPM. The regular contact of the farmers among themselves at FFS strengthens reliance and acceptance of the decisions on selection of pest control methods. Consequently, the wide introduction of the IPM in Tajikistan will allow improvement of phyto-sanitation conditions on agricultural fields and will enable the farmers to obtain increase in yields of agricultural crops.

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Integrated Pest Management in Uzbekistan

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Introduction

The development of a theoretical and methodological basis on Integrated Pest Management for crop protection is the main strategy for the government of Uzbekistan. The primary pests and diseases (species composition, their distribution, economic importance and biological features) of cotton, alfalfa, cereals, vegetables and melons and other crops have been comprehensively studied for the last 20 years in Uzbekistan. The level of scientific development on improvement of economic, cultural, chemical, and biological methods of pest control in the republic is sufficient. For control of sucking pests (aphids, thrips, spider mites, whiteflies, bugs, and others) on cotton, fruit, vegetables and other crops, a wide assortment of low-toxic chemicals and microbiological preparations available are recommended for wide application. Seed treatments with several chemical fungicides such as bronotak, panoktin as well as local preparations developed in the Uzbek Research Institute P-4 are applied annually against root rot and bacterial blight diseases. Avoidance of wilt diseases on cotton and other crops are achieved using cropping systems such as crop rotation, planting of resistant varieties (C-9070, C-6524 and others), and fungicide application. There are about 20 preparations that have been tested and applied against crop diseases. The most effective domestically produced ones were darmon, GMK, and P-4, which can increase plant emergence and development by inhibiting microbial infestation (Rashidov, 2001).

Cotton crop protection strategy in Uzbekistan

Cotton crop is one of major export crops in Uzbekistan. All 13 regions in Uzbekistan are responsible for cotton production. In

each region there is a center of plant protection with the major tasks of seed multiplication, distribution of quality seed to conduct research work, and technology transfer to the farmers. The area for cotton production is estimated to be 1.5 million ha. Scientists from research institutes have identified about 20 species of pest insects, 80 types of weeds, and 20 types of diseases. Generally, about 30-40% of cotton yield can be lost due to pests. Therefore IPM development is very much in need for cotton production in all regions in Uzbekistan (Alimukhamedov, 1991).

Biological control: Biological control is the leading method to control leaf-chewing pests in Uzbekistan. Its annual application on cotton crops, including repeated applications is 5.5-6.0 million per ha. In many cases, beneficial insects released together with other components regulate the numbers of seasonal pests and provide an ecological balance sooner than would occur under natural conditions. *Trichogramma pintoii*, *Bracon hebetor* and *Chrysopa carnea* are used on cotton in conjunction with parameters developed at the Uzbek Institute of Plant Protection. These entomophages are produced by an estimated 1000 biolaboratories in the Republic and are released at the optimum rate of 60,000 moth eggs per hectare of grain infested by trichogramma and at the pest threshold of 20-25 *Heliothis armigera* eggs/100 plants assuming 50% hatch. To provide control of pest eggs of three generations of *Heliothis armigera*, "flood" method of 3-4 times release every 15-20 days is the normal (Adashkevich *et al.*, 1991).

The effectiveness of *Bracon* and Lacewing depends on several factors including which crop borders cotton. Thus, if *Bracon* and lacewing are released in a tomato field surrounded by a cotton crop and if they remain on tomatoes, biocontrol effect on cotton is high. If a vineyard, a

blossoming corn field or orchards surround tomatoes fields the efficacy is decreased (Alimukhamedov, 2000). In Uzbekistan, alfalfa is the main ecologically important entomophage conserving crop, which is cultivated in crop rotation with cotton or bordering of different crops. Alfalfa creates a suitable climate for development of many entomophages, especially aphidophages (Chrysopidae, Coccinelidae, Syrphidae, Chamaemyodae and Aphididae) (Daminova, 2001). These differences must be taken into account in making *Bracon* and *Chrysopa* releases. Parasitization of 15-20% of *Heliothis* sp larvae by *Bracon* requires a release of 800 parasitoids/ha. The rate is higher (1000 parasitoids) when the parasitoids larvae occurs in 8-12%.

etc). This technique is used in arranging for and planning of plant protection.

There are wilt tolerant cotton varieties that have been selected at the research institutes. The method of plant-resistant conservation by enhancing their immunity using physiological active substances helped to increase yield up to 2-2.4 c/ha. A method of cotton wilt resistance determination by molecular-genetic analysis of chloroplast DNA has been developed (Rashidov, 2000).

Fusarium wilt (*Fusarium oxysporum* f.spp *vasinfectum*), Verticillium wilt (*Verticillium dahliae*), and virus diseases are also starting to challenge not only cotton but also vegetable and melon production. The technology of trichoderma

Table 1. List of seasonal cotton pests and the control measures adopted in Uzbekistan

	April-May	June-July	August-September
Pests	Aphids, <i>Agrotis segetum</i>	<i>Agrotis segetum</i> , <i>Heliothis Armigera</i> Spider mites	<i>Heliothis Armigera</i> Spider mites
Pesticides	Fury 10%EC Mospilan 20%WP Avaunt 15% SC Decis 2.5% EC Karate 5% EC	Omaid, 57% EC Nissorán, 5% EC Ortus, 5% SC	
Beneficial Insects	Lacewing, trichogramma	Lacewing, trichogramma bracon	Trichogramma lacewing bracon

EC-Emulsion Concentrate; SC- Suspension Concentrate; WP – Wet Powder

Chemical control: Chemical control is practiced on 400-600 thousand ha annually mainly against sucking pests. In past years researchers in the Institute of Plant Protection have developed automatic methods for short- and long-term predictions of the duration and development cycle of the main cotton pests (boll worm, cut worm, winter moth

production for tomatoes, melons, and mangel seed pretreatment has been developed. As many as 30 strains of trichiderma have been isolated and are active against soil pathogens (Rashidov, 2001).

Scientists at research institutes have tested more than 62 preparations that meet requirements of pesticide ecology,

approximately half of which are included on the list of Uzbekistan Republic Govchem commission (Rashidov 2001). The following chemicals are used for seed treatment including Gaucho-M; insecticides: konfidor, kalipso, adonis, fury, mospilan, and avaunt; acaricides: nissoran, ortus, demitan and vermitec; and herbicides: flurtomon, dahlor, and aramo (Table 2).

with thrips in the stage of tube formation causes 41% loss; in the earing phase loss is about 28%; and in milky stage the yield loss is 3%. Tests conducted showed that insecticides such as Regent, Buldok, Sumi-Alfa, and Arrivo were the most effective in controlling these pests. Red rust, loose, covered smuts, powdery mildew, and other diseases have appeared on dry and irrigated wheat crop

Table 2. Pesticides applied on cotton crop in Uzbekistan

Insecticides	Acaricides	Herbicides
Adonis 4% EC Fury 10%EC Mospilan 20%WP Avaunt 15% SC Decis 2.5% EC Karate 2.5EC Nurell-D 55% EC	Omait 57% EC Nissoran 5% EC Ortus 5% SC Serum 80% WP Dargit 57%E	Alienza 60% CS Dahlor 50% EC Aramo 5% EC Shogun 10% EC

Wheat protection measures in Uzbekistan

The increase of grain crop area has caused significant changes in the agro-ecosystem. This change requires the study of species composition, bio-ecology of pests and their entomophages, selection of effective chemicals and microbiological preparations with low toxicity, and the rearing and application of beneficial insects as biological control of pests on grain crops. There are about 16 species of wheat pests, of which the four most important ones are: Sunn pest, wheat thrips, aphids, and cereal leaf beetle. Sunn pest and cereal leaf beetle are found in the Fergana Valley, Tashkent, Jjizah, Sirdarya, and Kashkadarya regions and wheat thrips and aphids are found on wheat in all regions in Uzbekistan.

The harmful effect of wheat pests is dependent upon the phases of wheat development. For example, wheat infested

fields in Uzbekistan.

In 2000, observations showed that in the stages of wheat tube and ripening, the yellow rust is the most widespread disease on the crop field (Rashidov, 2001). Severe damage by this disease was noted in the Surhandarya, Tashkent and Syrdarya regions. The severity was dependent on crop varieties, crop protection strategies, and chemicals used. To control these diseases the following fungicides are recommended: rex, folikur, flamenko, tilt, and baileton. For weed control in grain crops the following herbicides are recommended: granstar, starane, pardner, banvel. In 2005, more than 300 thousand ha of wheat received applications of herbicides (Sagdullaev, 2006).

In desert and dry areas pests such as locusts occur every year and are widespread, threatening agricultural crops by yield loss. Italian, Morocco and desert locusts are the major species of pests encountered. Annually, 150 to 500

thousand ha are treated to control locusts. Researchers in Uzbekistan have studied the occurrence and outbreak period of these pests to develop short-term and long-term predictions of their appearance for application of ecologically-based pest control methods. Thus there are dominant and subdominant species, the density of locust, their emergence patterns and development have been studied in Surhandarya, Kashkadarya regions and in Karakalpakstan. Last year, Morocco locusts were noticed in Surhandarya and Kashkadarya regions where pupa density was 2.0-9.3 m⁻². In Karakalpakstan, the density of Italian and Asian locusts was 1.6-7.3 m⁻². With expedition forces, the total area treated for locust control was 243,700 ha. However, locusts that fly from Kazakhstan to the Tashkent region, from Turkmenistan to the Kashkadarya region and from Tajikistan, Afghanistan to the Surhandarya region present a significant danger. To control these locusts, Fury, Regent, and Dimilin were tested to determine the time of application and effectiveness of these insecticides.

Fruit crop protection

On fruit crops, about 200 species of pest organisms were identified. The most dangerous are codling moth, scale insects, spider mites, leaf roller, and aphids. Spider mites on pumpkins during the summer time can produce 12-18 generations. The damage from spider mites can be noticed especially during the second half of the summer. Without timely control, yield loss can reach 25-30%. Farmers have been trying to decrease the loss to 15-20% by conserving beneficial insects, using nectariferous plants for biological control. In recent years 5 species of *Trichogramma* and 3 species of predator mites have been identified. Researchers, farmers, and agronomists have developed a scheme for *Trichogramma* rearing and their release. Entomologists identified 6 species of scale and false scale insects, among which the most dangerous include San Jose scale,

Violet scale and Plum false scale. There are several insecticides recommended to control these pests, including Nurell-D, Fury, Match, Hostation, Cirax, and Omait. To control diseases fungicides such as vectra, topaz, and saprol have been applied; against weeds herbicides basta, fusilad, super, and others have been applied.

In 1994 in the Surhandarya region Mulberry pyralid (*Diaphania pyloalis* Walker, Lepidoptera: Pyralidae), a pest fly from Tajikistan, was identified for the first time. This pest has very big gluttony features and can not only defoliate leaves but also buds, causing severe depletion of feeding material for silkworm production. The highest prevalence of this pest has been noticed in the Fergana valley. Scientists in Uzbekistan have studied its biological and ecological features and distribution for control recommendations.

Vegetable crop protection

In potatoes, the main pest is the Colorado beetle. In some years, yield loss can reach up to 40-50%. To control Colorado beetle, chemical and cultural measures have been developed. Short and long-term population prediction methods have been developed. Insecticides such as Regent, Admiral, Buldok, Fury, and Dorsan-C have been applied to control Colorado beetles. For weed control in potatoes Fusilad, Nabu, Goltix, Aroma and Titus have been recommended and applied (Zahidov, 2001).

Thrips tabaci on onion is a pest of greenhouse and field crops. Besides onions, it also damages many other crops including garlic. It overwinters in adult stage and stays on the ground under plant residues and weeds. In summer it can complete up to seven generations. It can develop the entire winter during storage and seriously damage onions (Sidorov *et al.*, 1965).

Western flower thrips (WFT) *Frankliniella occidentalis* (Pergande) is presently recognized as the most dangerous pest on vegetables and decorative flowers in

greenhouses. Chemical treatment is very complicated as the pest is a very small insect (2 mm) and hides in flower buds under the scaly flowers in plants; its mass development can be noticed on leaves (Zahidov, 2001).

Farmers in the Tashkent region are the main suppliers of vegetables for cities. The main pests in greenhouse crops are: aphids, whiteflies and spider mites. Since the 1970s, biological control of aphids and spider mites was achieved using the entomophages: lacewing and coccinelids. In Uzbekistan there are several species of whiteflies on different crops; the two most widespread species are the greenhouse *Trialeurodes vaporariorum* Westw and cotton whitefly *Bemissia tabaci*. *T. vaporariorum* was recognized in the Tashkent region for the first time in the 1970s. But *B. tabaci* was widespread and caused severe damages to many crops, especially on cotton in the north part of Uzbekistan since 1989. Natural enemies such as lacewings, *Encarsia*, and others cannot suppress the increasing development of the whitefly to its high potency. In greenhouses and field conditions the whitefly develops without undergoing diapause. Therefore, if a plant is infested with this pest it is recommended to use chemicals (Zahidov, 2001).

In the past few years, the rusty mite *Aculops lycopersici* (Eriophyidae) caused serious damage to tomatoes and potatoes. The pest was first found in Karakalpakstan greenhouses in 1986 (Mamatov, 1993). Then, it has spread very fast and now it is present in all regions of Uzbekistan, becoming as serious as the Colorado potato beetle. Chemical preparations such as mitak, Malathion, talstar, karate, fosalon and others were very effective against rusty mites on tomatoes (Mamatov, 1993).

Currently, the main objectives in Uzbekistan agricultural institutions are:

- ◆ Improve techniques for forecasting pest development on agricultural crops using computers and multi media methods;
- ◆ Conduct investigations on chemical methods of pest control using cheaper and less toxic preparations and reducing pesticide imports;
- ◆ Enhance the efficiency of biological methods of crop protection and its development as a progressive, ecologically safe technology for plant protection.

Table 3 Insecticides and acaricides used in Uzbekistan

Pests	Insecticides and acaricides
1. Whitefly	Sumi-alfa5% CE
2. Aphids, thrips, spider mites, whitefly	Carbophos (malathion) Rus. 50% CE.
3. Aphids, thrips, spider mites, whitefly	Fufafon (malath). Den.57% CE
4. Aphids, thrips, spider mites, whitefly	Danadim 40% CE Denmark
5. Aphids, spider mites, whitefly	Talstar 10% CE
6. Spider mites	Flumait 20% CS
7. Whitefly, heliothis sp, bugs, aphids	Cipermetrin 25% CE
8. Aphids, thrips, spider mites, whitefly	Ciperphos 55% CE
9. Whitefly, heliothis sp, bugs, aphids	Cirax 25% CE
10. Spider mites	Uzmait 57% CE

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State of the Integrated System for Plant Protection in Kazakhstan

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The Republic of Kazakhstan is an agrarian-industrial country where grain crops, primarily wheat, are the most important sources of national wealth in the republic. In 2005, the republic was sixth in grain production among the grain producing countries of the world, and has annually exported up to 5 mln tons of wheat to foreign countries. When Kazakhstan enters the Worldwide Trade Organization (WTO) the production of grain will increase due to the demand for Kazakhstan wheat in C.I.S. and ES countries, particularly those in Central Asia. The other agricultural specialty of the republic is the production of cotton which takes place in the most northern zone of cotton growing countries in the world.

As N.A. Nazarbaev, president of the republic noted in 2006, the creation of cotton-textile production will promote the development of this industry and improve the quality of cotton products from its raw state up to the final product in order to be competitive in world market. According to scientists' data, the system of Integrated Pest Management (IPM) is not the first decennial event being introduced; in the USA, for instance, by 2000 75% of cropping areas were using IPM. Comprehensive programs of IPM are realized with FAO facilities in nine Asian countries. The World Bank in collaboration with FAO has founded special international organizations, which are working on IPM (Kempbell, 2003).

Natural-climatic conditions in the Republic of Kazakhstan are suitable for growing many crops. However, some years the crops are severely infected with different phytopathogens and damaged by pests and weeds. In Kazakhstan there are 50 types of polyphags and over 100 specialized pest species, as many as 70 types of diseases, and 120 species of weeds which occur on agricultural crops

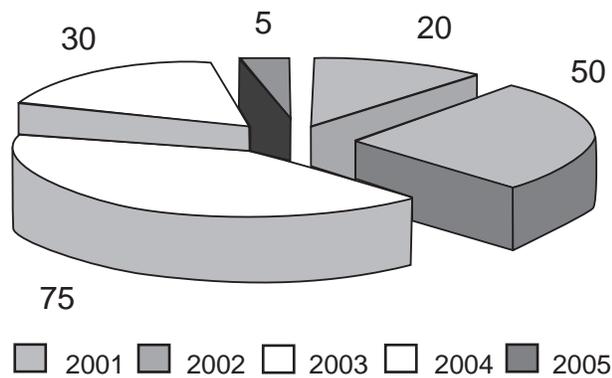
and pastures and cause significant harmful effects. According to the UNO, the world loss on crop production is 35% of potential yield, including 13.8% from pest, 9.2% from diseases, and 12.0% from weeds. During years of epiphytotic developments from fungal diseases alone, the agricultural crops yield decreased to 20-35% or higher. Similar losses of crop yield occurred from pests and weeds.

Cereals are infected with many diseases, among which the most harmful are rust, septoria spot, blight, root rot, powdery mildew, and others. For example, at the beginning of the 20th century, crop yield losses in Canada and the United States from stem rust were 82 mln centner of grain (Golyshin, 1989).

Intensive studies on breeding resistant wheat lines to the Hessian fly have been conducted in the USA, where prior to introduction, annual losses from pests averaged \$5- \$25 million, reaching \$100 million some years (Hatchett, Stark, and Webster, 1987). In C.I.S. countries including Kazakhstan, after the collapse of the Soviet era (1992-1999), agricultural intensification decline and the areas for agricultural production for grain was reduced. Minimum technology and reduction in amount of soil treatment was necessary because of financial difficulties, including lack of facilities and mechanics, deterioration in park agricultural machines, inflated growth of prices of agricultural technology, and others factors.

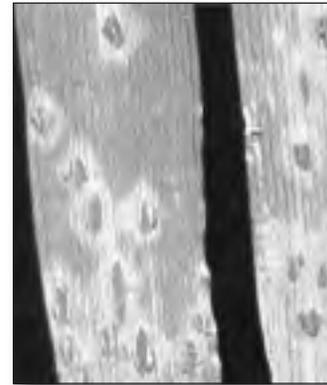
Integrated Pest Management as a principle approach and a long-standing practical direction in plant protection has a positive effect on agriculture. However, formation of this method required facts, serious motivation, and deep all-round phytosanitary analysis. The main trend of scientific development of plant protection in the world is the study and improvement of the integrated system of crop protection

Figure 1— Dynamics of yellow rust damaging on winter wheat in Almaty region



from pest organisms by the rational combination of the different control methods (agro-technical, chemical, biological, sanitary-preventive, use of tolerant varieties, and others) based on scientifically-motivated phytosanitary monitoring of their numbers and harmful effects.

The scientists of our institute annually conduct phytosanitary monitoring on sowing of agricultural crops, grains in particular. Based on the monitoring of crops between 2001-2005, it was determined that in the Almaty region yellow rust on winter wheat in 2001 and 2004 developed in moderate degree (20-30%), in 2002-2003 in high degree (50-75%), but in low degree in 2005 (1-5%) (figure 1). Similar data were obtained in southern Kazakhstan.

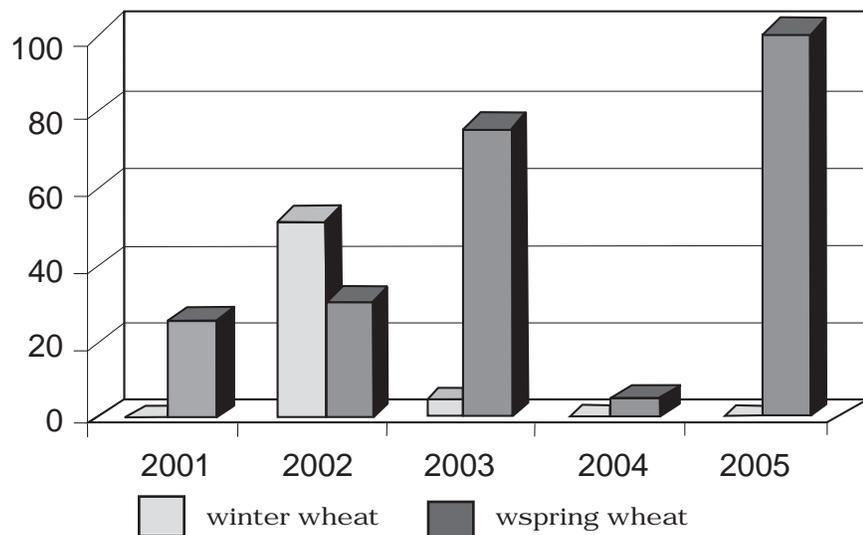


Yellow rust



Brown rust

Figure 1— level of brown rust development on winter and spring wheat 2001-2005 in north region

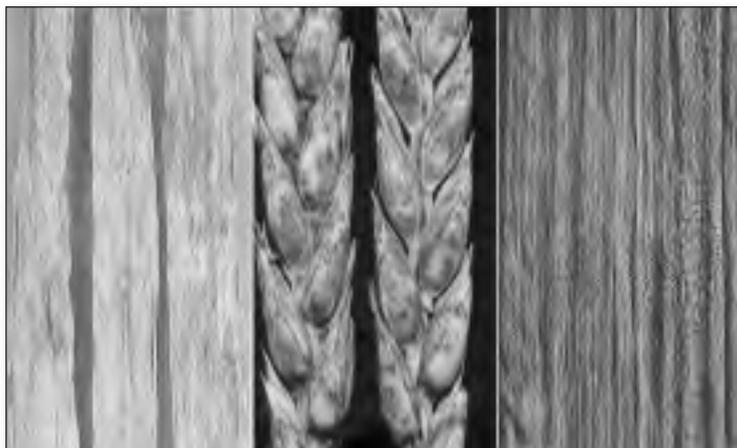


In the northern part of the republic yellow rust was revealed on spring wheat in 2002, but only in the region of Karaganda (10-25%) and Akmolinsk (25-50%).

In the Kostanay region brown rust developed on spring wheat sowings in 2003 and 2005 had reached the epiphytotic level of 75-100% and a moderate level of 20-30% in 2001-2002, with depression of disease development occurring in 2004. Winter wheat damages caused by disease reached 50% in 2002, but in 2003 it did not exceed 5%. In 2001, 2004, and 2005 there was no disease revealed on wheat (fig. 2). In 2003-2005 in the Almaty region brown rust on winter and spring wheat developed from moderate (20-30%) to a high (50-75%) degree. In the northern part of the republic, stem rust on spring wheat was revealed in 2001-2002 and 2005 and ranged from 5 to 15%, but on winter wheat in 2002 it only appeared on 0-5%.

spring wheat diseases such as brown rust, septoria spot, and powdery mildew were prevalent. In 1994-1996, 2001-2002, and 2004-2005 they developed from moderate to high degree. Brown rust in 1997-1998 and in 2003 developed in moderate and low levels, but in 1999 no rust was noted; at the same time powdery mildew developed in low degree and septoria spot in 1998 appeared in low degree but in moderate degree in 1999 and 2001.

In northern Kazakhstan pests hiding in stems (Swedish and Hessian flies and stem fleas) had the most harmful effect on wheat in 2001-2003 during a time characterized by increased rainfall in the spring and summer. The mass reproduction of gray grain moth and its high level of harmful effects were noted in 2003. The very dry conditions in 2004 caused a decrease of pests, so their number and harmful effects were very low.



Septoria spot



Stem rust

In 2001-2005 in Kostanay, Akmolinsk, and the north region of Kazakhstan, septoria spot on leaves developed noticeably from 10-25% to 50-75%. In the Almatinsk and Zhambyl regions, septoria spot developed moderately in 2001-2004, but in 2005 was at a low level (5-10%). During 12 years of studies in eastern Kazakhstan it was noted that on winter and

In 2005, the growth of high numbers of stem-hiding pests and gray grain moth was registered. Pest such as wheat thrips developed in mass during 2001-2003.

Hierological monitoring has shown that composition of weed species in sowing of the winter wheat and spring barley on the crop in the southeast has presented accordingly 60 and 50 types of weeds,

representing 16 botanical families. Annual weeds are 66.1-71.8%, biennial are 10.0-11.3% and perennial are 18.2-22.6%, of which stem sucker was 6.5-6.8% and root sucker 11.4-16.1%. In northern region the weed component of the agro-ecosystem on spring wheat is presented with as much as 82.3% of annual spring weeds and its biomass was 71% for biennial winter, over wintering weeds 3.8-4.8%, and perennial 13.9-24.2%. Phytopathologists and entomologists of the institute conducted the immunological estimate of local perspective wheat varieties and hybrids on their resistance to pests.

slight damage on plant samples noted. The big group of tolerant varieties was revealed from collection of ITV on samples taken from China, USA and Canada.

The diseases

According to the program of KASIB 1-6 screening of tolerant plant to brown and yellow rust, covered smut and septoria spot, the 514 perspective varieties and hybrid lines of the spring wheat breeding taken from Kazakhstan and Russian Federation (the regions West Siberia and South Ural) has been conducted. The complex of the above mentioned diseases has been estimated



Hessian fly



Wheat thrips

Pests

In 2002-2005 the estimation of spring wheat samples with Kazakhstan and Siberian selective institutions on ecological varieties test program of CIMMYT was organized. This is Kazakhstan-Siberian nurseries KASIP -2, 4, 6, as well as wheat lines of International test varieties (ITV), were given by CIMMYT. The evaluation of the main material of KASIP and ITV, 207 samples in detail, has shown their main amount to be weak resistant to Hessian fly. Tolerant and middle tolerant samples, basically, derived from selective institutions of the south region in Kazakhstan.

As a rule, the samples taken from North Kazakhstan and Siberia were not tolerant to pests, although among them there was

on more than 2500 samples of the spring soft wheat, received through CIMMYT-Mexico, countries of the Latin America, and Western Europe. Among them, more than 100 samples were tolerant to 2-3 types of the rust, septoria, and covered and loose smut diseases and have high productivity and adaptability to the arid conditions of Kazakhstan. In Kazakhstan-Mexico breeding program for tolerance to brown rust, 595 hybrid lines and population of the spring soft wheat have been identified. In north and east regions in the republic the analysis of the structure of *Puccinia recondita* populations with the use of isogenetic wheat lines on the base of the Thatcher variety has been organized.

As far back as 1970, agricultural practices in foreign countries have shown that one of the optimum ways to reduce energy consumption is the use of methods such as reduced or non-treatment of soil. Minimum soil treatment leads to reduction of expenses (fuel, mechanization and others - about 50% of total embedding) and parallels the use of pesticides to achieve desired results (Fadeev, Novozhilov, 1982). In 2004-2005 employees of the institute developed and monitored the condition of crop production and the integrated system of disease, pest, and weed management on agricultural crops depending on the different technologies of plant growing.

The treatment of crops with mixture of pesticides against complexes of pest

organisms vastly reduced the expenses and increased the profits. The greatest yield gain was obtained when a complex of chemicals for plant protection – herbicide +insecticide +fungicide- were used. Under minimum treatments the wheat productivity was higher than under traditional technology – 17.1 and 13.5 c/ha- but the yield gain was 4.3 and 3.3 c/ha accordingly.

Wheat growing with new technology and using chemicals for plant protection, the increase in yield was 7.3 c/ha due to the the following factors: treatment of seeds with fungicides 2.7 c/ha, minimum soil and pre sowing seed treatments 2.6 c/ha, use herbicides 1.2 c/ha and insecticides 0.8 c/ha (table 1).

Table 1 – The effect of complex facilities for plant protection on the yield of spring wheat growing on different technologies of soil treatment (2005)

Variant (Seed treatment with preparation Raxil rate 0.4 l/t)			Traditional Technology			Minimum Technology		
Herbicide	Insecticide	Fungicide	Yield c/ha	Yield c/ha	% to Control	Yield c/ha	Yield c/ha	% to Control
Control (without treatment)			10.2	-	100	12.8	-	100
Secator, (0.1 kg/ha) + Puma super-100, (0.7 l/ha)	—	—	11.3	1.1	110.8	14.0	1.2	109.4
—	Fastak, 10% c.e. (0.1 l/ha)	—	10.7	0.5	104.9	13.6	0.8	106.2
—	—	Falkon, (0.5 l/ha)	11.9	1.7	116.6	15.5	2.7	122.6
Secator, (0.1 kg/ha) + Puma super-100, (0.7 l/ha)	Fastak, 10% k.3. (0.1 l/ha)	—	11.5	1.3	112.7	14.9	2.1	121.1
Secator, (0.1 kg/ha) + Puma super-100, (0.7 l/ha)	—	Falkon, (0.5 l/ha)	12.7	2.5	124.5	17.0	4.2	132.8
Secator, (0.1 kg/ha) + Puma super-100, (0.7 l/ha)	Fastak, 10% k.3. (0.1 l/ha)	Falkon, 0.5 l/ha	13.5	3.3	132.3	17.1	4.3	133.6

The studies on biological methods remain a priority. Condition of the biological method of protection of the cotton plant is necessary to note. Presently biological efficiency to trichogramma and bracon colonization, which mother material is delivered from adjacent country and are reared in private biolaboratories is in low state, as much as 25-30%. This is explained not following to technology their mass production and maintains in specified laboratory, as well as weak viability of the uterine material.

In southern-Kazakhstan, where cotton is grown on more than 200 thousand ha, our employees have been regularly observing the development of the main pests on cotton. Complex monitoring of plant protection has been conducted in 2004-2005 using biological agents and insectoacaricides against the main pests on the cotton plant (table 2).

It was determined that expenses for chemical protection against sucking and leaf-chewing pests on cotton was different depending on the sowing periods and quantity of the pesticides.

In the field in 2004, where a double treatment was conducted (first against thrips and aphids, then against spider mites, cotton bollworms and cutworms), cost of the saved yield has exceeded the expenses for the usual plant protection by 6.7 times, but in the field with a one-time treatment (against spider mites, cotton bollworms and cutworms) by 3.2 times. Under a three-phase treatment in 2005 expenses for protection with chemicals and biological control was 14190 tenge/ha, and the value of the harvest was 54800 tenge/ha, which exceeded the expenses for usual protection by 3.9 times (40610 tenge/ha). It is established that depending on the aspectual composition of the pests, their complexity and phases of treatment, clear income at protection of the cotton plant varied from 9547 to 40969 tenge/ha.

The Institute also developed and improved an integrated system of protection of orchards from pest organisms, reducing the number of chemical treatments by 2-4 times to account for the use of biopreparation and biological agents in order to get pesticide residue free products and to meet the modern market requirements. To develop pest and disease control methods in fruit orchards, biocenosis was adopted. It allowed to solve complex problems in fruit gardens, by suppressing pests, diseases and weeds development. This protection method of crops from pest organisms is being used in Russia, Italy and others countries. This approach is known as adaptive-integrated system of plant protection, which consists of the following interconnected elements: organizing-economic actions with consideration for economic practicability of the recommended measures, agrotechnical methods, chemical, biological pest control of crops and others.

Our studies have shown that integrated system of protection of the garden from complex of pest organisms, including agrotechnical ways (rarefying of tree crowns, point entering of NPK, underground irrigation, weeds elimination in areas near of stalk, collection of falling leaves, clear of trunks from destroyed cortex), biological (the preparations hormonal actions or bio preparations, attraction of the birds, ant, planting of nectar ferrous plants), organizing-economic (night treatment, small volume spraying, account of EPV) and chemical (application of preparations not causing negative influence upon useful fauna) methods, has provided high efficiency against the main dominant species of pests and diseases, promoted the activations of beneficial entomofauna, has vastly improved the growth processes and productivity to apple trees (table 3).

Table 2. Economical efficiency of biological agent application and insectoacaricides application against complexes of pests (southern-Kazak region, Maktaaralsk district)

Year	Variant	Yield, c/ha	Income of yield, c/ha	Purchasing price row cotton, tenge/c	Cost of yield income, tenge	Expenditure for treatment and biomaterials, tenge	Total income of yield, tenge once	Return on expenditures,
2004	Control (without treatment)	17.9	—	4500	—	—	—	—
	One phase treatment (Fastak, 10% . - 0.15 l/ha)	21.0	3.1		13950	4376	9574	3.2
	Two phase treatment (Nissoran, 10 % p. - 0.1 kg/ha + Dimilin, 48% s. - 0.1 l/ha)	28.6	10.7		48150	2805+4376 = 7181	40969	6.7
2005	Control (check)	17.5	—	4000	—	—	—	—
	Biomethod (60 x 80 x 60 + 1000 x 2000 x 1000 numbers/ha) + Three phase treatment (Flumait, 20% s.- 0.25 l/ha + Dimilin, 48% s.c - 0.1 l/ha; Nurell, -1.5 l/ha; Dimilin, 48% s.c. - 0.1 l/ha)	31.2	13.7		54800	14190	40610	3.9

Table 3. Economical efficiency of plant protection complex measures for control of pests in orchards (farm «Darmen»)

Indications	Variants of test		
	Control	Integrated system	Chemical system
Fruit damage In harvested yield, %	28.3	2.5	2.0
Total yield, c/ha	80.4	103.7	93.2
Expenditure for purchasing facilities For protection and spraying, thous. tenge	—	5.5	5.5
Expenditure for planting nectariferous plants, delivering bird, treatments, thousand tenge	—	4.5	—
Expenditure for harvest, transit and storage of additional yield, thousand tenge	—	1.5	1.5
Total expenditure, thousand tenge	—	11.5	108.0
Yield income, c/ha	—	23.3	12.8
Total cost of yield, thousand tenge	402.0	518.5	466.0
Pure income, thousand tenge	—	116.5	64.0
Profit per1 tenge/expense, tenge	—	10.1	8.0

Damage on fruits caused by apple codling moth on IPM variant was 2.5%, on chemical variant – 2.0%, comparing to 28.3% in checking variant. The number of garden spider mite varied during the whole vegetative period: on IPM variant there were 0, 5-2, 8 pest numbers on leave, on chemical - 0, 8-6, 7 numbers on leave.

The growth processes was improved on IPM variant and the productivity was increased. The income of the harvest in comparison with checking variant was following: on IPM variant is as 23.3%, on chemical – 12.8%. Profit by 1 tenge of expenses from applied of complex under system of integrated action of the garden protection was 10, 1 tenge, under chemical that was 8, 0 tenge.

Regarding the above data of laboratory and field studies, it was shown that even the use of solely efficient methods of plant protection there cannot be permanent suppression or complete elimination of number of pest organisms. This particularly can be reached only with all available actions in systematic complex of measures that is the integrated pest management.

Integrated Pest Management in Kyrgyzstan: Experience of the Advisory Training Center

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Background

In Kyrgyzstan, 3 million people—more than 60% of its population—live in rural areas and are engaged in the agricultural sector. After the disintegration of the Soviet Union, farmers faced many difficulties. The change from collective farming to private farms created some new challenges and it took significant time and effort for farmers to adapt. The lack of agricultural knowledge and necessary information affected farm productivity and, consequently, farmers' income. Farmers were spending a lot of time and resources for crop cultivation, but yields were low. Thus, individual practices and experience in rural areas prompted farmers to acquire applied knowledge, information, and skills for agricultural production, animal husbandry, and management, planning, and marketing skills.

Finally, there was a need to provide customized training on Integrated Pest Management (IPM) programs in Kyrgyzstan, as IPM aims at increasing crop production while preserving the environment and improving people's health. Thus, the Advisory Training Center (ATC), with the support of the World Bank and the Food and Agriculture Organization (FAO), launched the IPM Program in 2003.

Advisory Training Centre of the Rural Advisory Services is an NGO that strives to increase the efficiency of agricultural production and processing in Central Asia through assistance to organizations working in the fields of livestock development and crop production by providing educational, consulting and information services.

ATC has 4 basic activities:

- ◆ Educational activities including seminars, workshops and trainings
- ◆ Consultancy
- ◆ Publications of brochures and manuals

◆ Integrated Pest Management Program

How it all started—In 2002, during an International Conference on "Biological and indigenous methods of disease and pest management" in Jalalabat, the FAO and the Agricultural Supportive Services Project (ASSP) created the idea of Farmers Field Schools (FFS) for ecologically clean and economically viable cotton production. In 2003 the first Farmer Field School for cotton was opened in Jalalabat.

The objective of the IPM Program is the improvement of farmer practices, so that by acquiring knowledge farmers could increase their income. What does IPM mean? IPM is directed towards searching for improved farmer practices, which would provide greater profit along with preserving the environment and improving the community's health.

The implementation of integrated vegetable production is based on four fundamental principles:

—*Cultivation of healthy crops:* This principle foresees knowledge of all aspects, which influence crop productivity and skills to choose the best options (for example, optimum soil structure, crop rotation, healthy seed, proper irrigation or watering, disease and pest prevention, storage, etc).

—*Understanding agro-ecosystem:* The second principle implies that farmers should understand the role of beneficial insects in controlling a number of pest populations, therefore, whenever some pests are seen, it is not always necessary to apply chemicals. Chemicals also kill useful insects, and with repeated applications, pests develop resistance. These actions are harmful to the environment and people's health. Therefore, knowledge about agro-ecosystems is very important for crop production.

—*Regular field observations*: The farmers conduct agro-ecosystem analysis. This principle foresees that farmers constantly monitoring their own fields can assess the occurrence of pest population, soil humidity, etc. Based on monitoring these findings, a farmer can make decisions regarding the issue (e.g., the field requires watering, the need for applying bio agents, the need for chemical spray, etc).

—*Farmer becomes a field expert*: The fourth principle means that farmers constantly observe their own field, implement improved approaches, and learn how to distinguish between harmful and useful insects; hence, they become the experts.

IPM training developed in order to realize IPM in fields

An IPM educational plan consists of the following parts:

◆ *Agro-ecosystem analysis*: A compulsory component of IPM training is agro-ecosystem analysis. For this purpose, weekly sessions are held by farmers to make observations on experimental sites. Here they observe whether insects or disease can be found on crops. Discussions are held on preventative measures or treatment

methods, soil condition, etc. The brainstorming by farmers help them to make proper decisions on how to protect crops.

◆ *Field experiments*:

Each FFS has its site where farmers conduct experiments. One of the basic field experiments in FFS sites is farmers' practice. For example, see chart below:

◆ *Small experiments*:

The training plan also includes small experiments on insects and exercises on soil composition. For example, if farmers have found some unknown pests and are unsure whether or not it is a useful insect, they can make specific insects zoos-i.e., replant a crop item into a bucket, place the insect in the bucket and observe its behavior.

◆ *Specific topics*:

In the educational plan there are specific topics such as viruses, insect life cycle, diseases, etc., which farmers may not know. If the subject is very important, experts are invited for introduction of special topics.

◆ *Group dynamics*:

To ensure that training events are less theoretical and boring, an interactive method is applied. Farmers are divided into groups and practical tasks are imple-

Integrated Pest Management	Farmer's practices
• Crop rotation	
• Applying organic fertilizers and additions (compost, liquid manure, manure)	• Farmers grow crops applying methods of usual farmer practices (i.e. traditional practices)
• Planting scheme	
• Choosing healthy seed	• The circuit of landing (planting)
• Applying biological methods for disease and pest control (e.g. trichodermin, etc).	
• Applying biological methods for pests control (e.g. trichogramma, pheromone traps, habrobrakon, BT and other) and other	

mented in a group. Additionally, there are special interactive exercises, which help farmers to better understand some topics.

◆ *Field days:*

Twice a year, farmers conduct demonstration field days, when other neighboring farmers are invited to participate in Field School demo exercises. Participating farmers explain to visitors what they could learn in FFS and demonstrate ways experiments are implemented, etc.

How do we introduce IPM Program?

The IPM training approach means the following: ATC sets up Training of Trainers Center (ToT) to prepare and train the trainers among active farmers. Trainers are trained during the whole season practically and theoretically. Then, the trainees create Farmers' Field Schools (FFS) in the villages where they train farmers how to grow and produce healthy crops.

The IPM approach has raised the interest of farmers and partner organizations; since 2003 the IPM Program has extended both in terms of crops quantity and activity scope and geography. Currently, in 5 regions of the Kyrgyz Republic, IPM is implemented in 4 crops: cotton, potatoes, tomatoes, and cucumbers. In the beginning of 2007, Farmers Field Schools on animal husbandry were opened. International experts from Bangladesh, Nepal, and Pakistan provided the technical support to the ToT Center in the training and introduction of IPM approaches. Thus, from 2003 to 2006, 174 FFS were opened and approximately 2,600 farmers and students have been trained. The approach of IPM ToT / FFS has been successful, as it is a bottom-up approach, where farmers conduct experiments and are able to recognize pests/diseases and beneficial insects in their own fields.

Farmers participated in 18 training seminars during seasonal training sets. Within 18 training courses farmers carry out different experiments:

1. In the fields they test different crop varieties for diseases and pests resistance, and the effectiveness of different preparations (chemicals, bio-agents, indigenous methods, etc) against pests).

2. Mini-experiments when farmers make trials on determination of soil composition, observe the life cycles of insects, etc.

Thus, farmers learn by doing based on their observations.

Impact of IPM training:

According to the results of IPM seasonal training it was important to find out the level of effectiveness of IPM training for farmers regarding increasing the yield. In this context, a survey of farmers who were trained in FFS on IPM was conducted in October 2006. The results showed that the gross margin of farmers in 2006 increased by 33% compared to 2005. To ensure that differences between the two years were due to IPM practices, a secondary study was carried out to compare IPM participants and farmers to non IPM participants. Results showed that the gross margin of IPM participant is 21% higher than of non-IPM participants. The additional important effect of IPM is strengthening partnerships between farmers, such as creation of self-help groups and cooperatives participation in various trainings, and working together during the whole season.

Sustainability:

There is a small fee of 80 Kyrgyz som (approximately US \$2) for each farmer to participate in seasonal training in FFS. According to a survey, farmers are willing to pay more for training to guarantee the salary of trained trainers. In addition, there is a case when trained IPM trainers decided to unite into "IPM Trainers" networks. Trainers held the general meeting independently and decided to promote IPM locally, seeking donor

organizations for training of farmers in FFS. Processing companies are interested in IPM trainings as well. There are cases where processing companies will pay the salary for a trainer who conducts FFS training for farmers.

Role of IPM in value chain:

If we talk about IPM program, we talk about farmer income increase. Then it means not only to train farmers how to grow high-yield products, but also to help them with marketing, because farmers can increase their income if they learn how to sell their products favorably. Therefore, during IPM training we emphasize creating trust and good relationships between farmers and processing companies. Various stakeholders are invited to planning meeting of farmers, including representatives of processing companies, seed and fertilizer suppliers, and credit organizations. They develop general plans of actions during the meeting. In addition, monthly meetings of the above-mentioned stakeholders are organized during the growing season. During these meetings representatives of these groups and organizations can discuss various issues as well as propose some actions. All discussions and contracts are made through farmer group leaders. An agreement with a processing company is concluded on behalf of the leader. The leader is also responsible for delivery of products, provision of seeds and fertilizers, etc.

IPM constraints:

- ◆ We carry out good experiments using bio preparations, which are provided by international experts. Preparations have a good effect and farmers are ready to buy them, but preparations are not available in local markets.
- ◆ There are problems with farmers' attendance at meetings during seasonal activities such as irrigation and harvesting periods.
- ◆ Sometimes the motivation of farmers is not training itself but in getting credits, coffee breaks, grants, etc.
- ◆ There is no clear mechanism of FFS training impact analysis.

In this context there are suggested solutions:

- ◆ Closer cooperation with bio-laboratories
- ◆ Promotion of local businesses for bio-preparation import
- ◆ Introduction of student field schools into universities with a view of training future trainers
- ◆ Introduction of a simple system of impact analysis

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Major Virus Diseases of Crops in Uzbekistan

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Uzbekistan is one of the agrarian republics of Central Asia. The basic agricultural crops include cotton, wheat, potatoes, vegetables, melons, and others. Warm winters, moist springs and steady retention of viruses in nature are the principal reasons for widespread viruses in the ecological conditions of Central Asia. Worldwide, more than 700 plant viruses are known and cause significant crop loss. In Uzbekistan, more than 50 viruses are known and were identified in the period of 1956-2006. Some of the important viruses in Uzbekistan are described in table 1.

In Uzbekistan, the study of virus diseases in plants started in 1956 and 1962. The first laboratory was created in the Central Asian Institute of Phytopathology. In 1972, the second laboratory was established in the Institute of Microbiology of the Academy of Sciences of Republic of Uzbekistan. Two additional laboratories were created in the Institute of Vegetable Crops and the Institute of Fruit Crops. Thus, by 1991, there were four laboratories that were investigating virus diseases of plants.

Table 1. Identified viruses in Uzbekistan

Crop	Virus	Year
Tomato	Tobacco mosaic virus (S, Tsh, K isolates) Cucumber mosaic virus 1 Potato Virus–X	1972, 1976, 1984, 2005, 2006
Cotton	Cotton Leaf Curl Virus	1990, 2002
Radish and Cabbage	Turnip mosaic virus Radish mosaic virus Cauliflower mosaic virus Cucumber mosaic virus	1980
Potato	Potato Virus – M Potato Leaf Roll Virus Potato Virus–Y Potato Virus – S Potato Virus–X Potato Virus–A	2005
Wheat	Barley Yellow Dwarf Virus (PAV, MAV, RPV, SGH isolates) Wheat Streak Mosaic Virus Barley Yellow Streak Mosaic Virus Wheat Dwarf Virus	2002 2005
Maize	Maize Dwarf Mosaic Virus	1980

Recently, researchers in Uzbekistan have started to study virus diseases of wheat. The study of virus diseases of wheat is important in two aspects: 1) to help determine dissemination methods and identification of viruses; and 2) to reveal virus resistant wheat varieties.

To achieve these objectives, a field survey was conducted in Uzbekistan, in the regions of Tashkent, Jizzah, Samarkand, and Kashkadarya. More extensive studies have been conducted on experimental plots in the Institute of Plant Industry, the Institute of Genetics and Experimental Plant Biology, Tashkent Agricultural University (Tashkent region) and the Institute of "Zerno" (Jizzah region). Results revealed symptoms of virus diseases on wheat including streak mosaic, yellowing of leaves, and yellow spots on leaves. Scientists found that dwarf plants infected by viruses grew half as large as the control and were not able to produce grain.

We conducted virus diagnostics using the method of indicator plants, double diffusion on agar, tissue-blot immunoassay (TBIA) on nitrocellulose membranes, and ELISA. Serums of wheat viruses were provided by ICARDA in Syria and Moscow State University. Serological tests showed that several viruses infect wheat plants in Uzbekistan including Barley Yellow Dwarf Virus (BYDV) (luteovirus), Wheat Streak Mosaic Virus (potyvirus), Barley Yellow Streak Mosaic Virus (rhabdovirus), and Wheat Dwarf Virus (geminivirus) (Kadirova et al, 2002). BYDV is the dominant virus; we identified PAV, MAV, SGH, RPV isolates of BYDV, but BYDV-PAV and its carrier (aphid *Sitobean avenae* L), spread everywhere (Makkouk et al, 2002).

Field observation and serological tests showed that weed (*Polypogon Desf.*, *Cynodon Rich*, *Sorghum halepense* L. Pers, *Poa L.*, *Echinochloa crus-galli* L., and *Phragmites communis* Trin) and maize are infected by BYDV and play an important role in disseminating BYDV in ecological conditions in Uzbekistan. To test for

resistance of wheat varieties, we artificially infected local wheat varieties such as Sanzar, Unumli bugdoy, Demetra, Intensiv, Marjon, Dostlik, Boz Su, Knyagna, Yonbosh, Kupava and 54 of ICARDA's wheat and triticale lines with BYDV-PAV. Results showed that, all local varieties were sensitive and ICARDA's wheat lines were resistant. Immune/tolerant lines were not clearly recognized. We purified BYDV-PAV by using the Rochow process (Rochow, 1971). In conclusion, in the environment of Uzbekistan, several viruses attack wheat. BYDV-PAV and its carrier *Sitobean avenae* L. –aphid are widely spread and important.

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Integrated Pest Management of Sunn Pest in West and Central Asia: Status and Future Plans

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Introduction

Sunn pest (*Eurygaster integriceps* Puton) is a destructive insect pest of wheat in West and Central Asia and Eastern Europe. Apart from the direct reduction in yield, the insect also injects chemicals into the grain that greatly reduces the baking quality of the dough. If as little as 2-3% of the grain is affected, the whole grain lot might be rendered unacceptable for baking. About US \$150 million is spent each year on pesticides in the Sunn pest-prone areas.

In collaboration with its partners in the national agricultural research systems (NARS) in West Asia and Central Asia, the University of Vermont (USA), CABI Bioscience and the Natural Resources Institute, University of Greenwich, UK, the International Center for Agricultural Research in the Dry Areas (ICARDA) has been developing Integrated Pest Management (IPM) alternatives to pesticide-based control for the management of Sunn Pest by making use of natural enemies, entomopathogenic fungi, host plant resistance, and cultural practices.

Major Achievements Of This Collaborative Program

1. Economic thresholds (ET) for Sunn pest populations assessed and improved.

Experiments were conducted to refine the economic thresholds in Turkey, Iran and Syria. These studies, which were carried out in the field, were based on quality

damage caused by Sunn pest feeding. In Turkey, Sunn pest densities under 10 nymphs/m² did not cause significant damage to wheat quality and thus control should be initiated only at densities of about 9 nymphs/m². On the other hand, under Iranian conditions, a density of 7.2 nymphs/m² resulted in gluten degradation. Thus spraying insecticides should be initiated only at about 6-nymphs/ m² (El-Haramein et al., 2007; Canhilal et al., 2007). Future studies for refining the ET should take into consideration the different cropping systems, species (durum or bread wheat), and varieties.

2. The role of egg parasitoids in suppressing Sunn pest populations determined.

To determine the role of egg parasitoids in suppressing Sunn pest populations, studies were conducted in 1-ha fields in Turkey, Syria, and Iran. Sunn pest eggs were collected from each field after the first egg was seen and collection continued once a week until harvest. Each egg mass was placed in a separate tube (plastic capsule) and recorded for each field. The eggs were kept in the lab and the percentage of parasitism was recorded.

Another study was conducted to determine the effect of pest and parasitoid densities on the percentage of egg parasitism and wheat grain quality. This study was conducted in cages. At harvest, the grain from each plot was analyzed for total protein content and gluten quality.

The level of egg parasitism varied across locations. In Iran, the percentage of

parasitism ranged from 8-21%; in Syria from 18-59%; and in Turkey 0-67%. The wide variation could be due to the use of pesticides, and the cropping system in each location, irrigated vs. dry land, and monoculture vs. polyculture in each system.

The percentage of parasitism ranged from 65% to 83% 4 wks-post exposure when 1, 2, or 3 egg parasitoids were present at Sunn pest densities of 2 and 4 insects/m². At 6 Sunn Pests/m², significant differences in the percentage of parasitism were only detectable for the 1 egg parasitoid/m² rate, indicating that the level of egg parasitism is robust to Sunn Pest densities up to 6 adults/m² when challenged with a minimum of 2 *Trissolcus grandis* per m².

In general, gluten quality was significantly better and comparable to non-Sunn pest infested wheat when 1, 2, or 3 egg parasitoids were present at Sunn pest densities of 2 and 4 insects/m². At 6 Sunn pests/m², the same effect was found for levels of 2 and 3 egg parasitoids/m², while the SDS sedimentation value was significantly lower than the control wheat plot at the 6 Sunn pest/m² density challenged with only 1 mature egg parasitoid (El Bouhssini *et al.*, 2004; Trissi *et al.*; 2006, 2007).

The beneficial role of egg parasitoids in reducing Sunn pest populations has been recognized in Syria, Iran, and Turkey. As a result these countries have started mass rearing these natural enemies and releasing them in wheat fields. This has increased awareness among farmers who have started conservation/enhancement programs for these natural enemies through plantation of trees/shrubs around wheat fields.

3. Effectiveness of entomopathogenic fungi determined and promising fungal isolates formulated and evaluated for control of Sunn pest.

◆ Collections of over 250 insect-killing fungal isolates were made from overwintering Sunn pest adults in 9 countries in West and Central Asia and

eastern Europe (Syria, Turkey, Iran, Afghanistan, Uzbekistan, Kazakhstan, Kyrgyz Republic, Moldova and Russia) (Parker *et al.*, 2003).

◆ Seven isolates of *Beauveria bassiana* were also obtained from Sunn pest cadavers collected from wheat fields in summer (Edgington *et al.*, 2007).

◆ Isolates were purified, identified, and placed in permanent storage (–80°C) at ICARDA, the University of Vermont, and CABI Bioscience.

◆ Molecular analyses were conducted to better understand the genetic relationships among the Sunn pest isolates collected throughout the region (Aquino *et al.*, 2005).

◆ Bioassay methods were developed for laboratory, greenhouse, and field testing of isolates, providing standard procedures for regional testing.

◆ Fungi were assayed against Sunn pest in the laboratory (on leaf litter) and in greenhouses (on plants), from which the most virulent were identified. Mortality of over 90% was commonly obtained in litter, and up to 75% on plants within 10 days.

◆ Sunn pest isolates were characterized for spore production, growth and germination rate – key traits for field performance and mass production. Many displayed high sporulation rates, a prerequisite for large-scale use or commercialization.

◆ Simple fungal mass production techniques, using appropriate substrates for the region, were developed.

◆ A model insect pathology facility was established at ICARDA to develop insect-killing fungi for IPM. This serves as a place to produce fungi for large-scale field tests and a training site for regional capacity-building in this promising field of research.

◆ Fungal trials were conducted at Sunn pest overwintering sites in and around wheat fields in Turkey, Syria, and Iran to determine efficacy and persistence.

Mortality rates of over 85% were achieved with some of the test isolates (Skinner *et al.*, 2007a).

- ◆ Innovative formulations (oil and granular based on millet) were developed to improve efficacy and persistence in the field.
- ◆ Temperature, humidity, and rainfall were monitored at overwintering sites in Syria and Iran to determine appropriate times of the year to apply entomopathogenic fungi (Skinner *et al.*, 2007b).
- ◆ Field trials at overwintering sites were conducted in the fall and spring to determine efficacy of fungi relative to environmental conditions and the length of time adults were exposed to the pathogens.
- ◆ Millet-based granular formulations have demonstrated the longest persistence in Sunn pest overwintering sites, remaining effective over a year after application.

The scope of expanding this work is possible now that ICARDA has developed a new model facility with up-to-date equipment, designed to fully adhere to safety of the workers and production of high quality pure conidia.

For the granular formulation, plans have been developed to move from small single bush/tree treatment to larger plots (20 x 20 m) using different formulations, including one based on whey, containing 5% protein, and designed to prolong persistence and improve efficacy.

The research on oil formulation has led to a phase where two possible use strategies need testing. The options are to target the early season adults as they migrate from the overwintering sites and as they enter the fields or to obtain an isolate that is more effective at high temperatures. In the former, a cordon sanitaire around the edges of wheat fields would be treated with a persistent isolate so that insects would pick up the inoculum as they pass through. The second option would treat the entire fields after the adults have laid all their eggs and would be the less preferred option if efficient monitoring enabled

the first option to be effective. However, if situations arose where areas were heavily infested with Sunn pest, a mycoinsecticide that was quick-acting and effective at high summer temperatures would be a useful management tool to have. This is likely to require a different isolate to the one being presently tested; other summer isolates remain to be studied, with more to be discovered.

4. The role of semiochemicals in host and mate finding by Sunn pest established and their use in management of the pest evaluated

Effective systems for bioassaying the responses of Sunn pest to olfactory stimuli were developed based on a wind tunnel and a Y-tube linear track olfactometer. However, extensive studies of responses of male or female bugs to volatiles from wheat or from male or female bugs failed to show consistent, strong behavioral responses for any combination. Some attraction of females to males on wheat was observed in the wind tunnel and the most marked effect with the Y-tube linear track olfactometer was attraction of female bugs to high doses of volatiles collected from male bugs. Females were significantly repelled by components of the metathoracic gland (MTG) secretion.

Male and female bugs were shown to produce characteristic vibratory signals. Attraction of male bugs to signals from both males and females was observed in a Y-track system, but results with recorded sound were inconsistent. No responses to vibratory signals were observed in the presence of odor from male or female bugs.

Male bugs produce large amounts of homo-y-bisabolene with bisabolene and vanillin as minor components. No ethyl acrylate was detected although this has been reported previously. Female bugs do not produce significant amounts of any volatile compounds. The homo-y-bisabolene is only produced by sexually mature males and only during daylight hours when the bugs are most active and

mating takes place. These compounds would thus seem to be involved in mating, but they were not detected by receptors on the antennae of females in EAG studies.

Thus although it has been demonstrated that both olfactory and vibratory signals are produced by adult Sunn pest, the roles of these signals in location of mates and host plants are still unclear. Observations that the bugs are positively phototropic and negatively geotropic and easily run up narrow tubes or cylinders, as found in the stems of host plants, might suggest that this behavior is important in locating mates and that olfactory and vibratory signal are used more for recognition than attraction. Such behavior would mean that synthetic semiochemicals or even vibratory signals would have limited potential in management of the pest. However, the strong repellency of the chemicals in the MTG secretion could be exploited. The synthetic compounds are cheap and readily available (Athanasios *et al.*, 2007; Hall *et al.*, 2007; Green *et al.*, 2007).

Future work should involve detailed observation of how Sunn pest locates mates and host-plants in the field. The positive results in the laboratory bioassay should be followed up with much larger doses of odor from bugs and host plants. The repellency of compounds in the MTG secretion should be further investigated.

5. Sources of resistance to Sunn pest in wheat and its wild relatives identified and germplasm developed

The screening test was conducted at the ICARDA experimental station Tel Hadya under artificial infestation. This method consists of using mesh screen cages of 6 x 9 x 3 m. The test was carried out in two stages, initial and advanced evaluation. In the initial screening test entries are planted in hill plots at the usual planting time in the fall. Plants are infested at the time of insects' migration to wheat fields, around mid-March, using six adults/m².

Two scales from 1-6 are used, one for

visual infestation and one for damage, to assess vegetative stage damage (the % shoot and leaf damage and plant stunting). Entries with a score of 2 or less are classified as resistant to Sunn pest feeding at the vegetative stage. The total number of accessions/lines screened for Sunn pest resistance was 282 *Aegilops* spp., 93 *Triticum* spp., 288-bread wheat and 434-durum wheat.

In the advanced screening, the selected wheat lines from the initial test were planted in rows 2-m long. A separate cage was kept uninfested as control. The method of infestation consisted of adding two adults/m² at the time of insect migration to wheat fields and later the number of nymphs was adjusted to 8-10/m². The evaluation is based on grain quality analysis: total protein content and SDS (Sodium Dodecyl Sulphate) sedimentation test.

Sources of resistance to Sunn pest feeding at the vegetative stage have been identified in wild relatives (*Aegilops* and *Triticum*) and bread wheat and durum wheat. It appears from the screening results that only a very limited number of wheat lines and wild relative accessions showed resistance to Sunn pest feeding at the vegetative stage. Only 2% of the *Aegilops* and 5% of the *Triticum* accessions tested were resistant. Out of the total number of wheat lines tested, the percentage of resistant lines identified for Sunn pest was 2% and 3% for bread wheat and durum wheat, respectively. Four out of eight sources of resistance in bread wheat are synthetic wheat.

Most of the identified sources of resistance of wheat, *Aegilops* and *Triticum*, originated from Sunn pest-prone areas in West and Central Asia. These are the first sources of resistance identified against Sunn pest feeding at the vegetative stage (El Bouhssini *et al.*, 2007).

However, none of these sources of resistance provides resistance at the grain level (quality). These sources of resistance are being used in breeding programs to develop resistant varieties to feeding by the overwintered Sunn pest adults, which

cause damage to wheat at the vegetative stage.

6. Appropriate IPM package tested on-farm and disseminated through a farmer participatory approach

Two IPM pilot sites including Farmer Field Schools (FFS) were established in Iran, Turkey and Syria. The 25-30 farmers per school were meeting on key events during the growing season to learn about the different aspects of Sunn pest IPM. NARS researchers and extension personnel ran these FFS.

The establishment of IPM pilot sites and FFS in each country has been very successful in teaching farmers the different aspects of management of Sunn pest (the pest biology, damage, economic threshold, egg parasitoids, the advantage of early planting and early harvesting). There has been a noticeable increase in awareness among farmers on hazards associated with the excessive use of insecticides on natural enemies, health, and the environment.

As a result, farmers are now fully participating in the implementation of IPM of Sunn pest. Because of the great success with FFS, the governments of Iran and Turkey have decided to use their own means to have FFS established throughout the Sunn pest-prone areas. Syria is gradually increasing the number of FFS.

7. NARS capacities in formulation of IPM options strengthened.

NARS scientists, plant protectionists and extension agents received IPM training at ICARDA, UVM, and through in-country workshops held in West and Central Asia. Around 500 persons have been trained on IPM of Sunn pest. The training covered a wide range of categories of people (scientists, extension agents, plant protectionists). In July 2004, ICARDA held the second international Sunn pest conference, which was attended by 150 people from 23 countries.

8. Impact of the IPM program

The most significant outcome of this program has been the revision of govern-

ment insecticide-use policies.

When the program began, Sunn pest management was the sole responsibility of local governments and was achieved through aerial spraying. This covered large areas indiscriminately, killing some of the pests and most of the beneficials.

As a direct result of this project, reliance on insecticides was shown to be ineffective and even counter-productive. NARS scientists have used project results to convince national policymakers that ground applications by farmers (based on revised ETs) is cheaper, more ecologically sound, and most importantly, more effective. This policy change has been fully implemented in Turkey and Iran on over three million hectares, producing significant savings and decreased Sunn Pest damage.

These shifts in government policy have resulted in targeted pesticide applications, which will help restore the natural enemy complex. In turn, this increases the effectiveness of other IPM components (fungi, predators, host-plant resistance, etc.) in reducing Sunn Pest populations. Without the changes in government policy, the goal of this research—implementation of sustainable IPM practices—would have been impeded. The success of this project should persuade governments throughout the region of the potential of comprehensive, sustainable IPM systems for other crops.

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Preliminary Implementations of Information Technology in IPM

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Abstract

Many IPM issues, such as pest occurrence, management technologies and strategies, and knowledge of interactions among pests, their hosts, and their natural enemies, are regionally and globally significant. Disseminating and sharing research results generated locally to broader audiences is important to IPM acceptance, research, education, and training. Information technology (IT) and IPM-related databases must play a critical role in today's world. Additionally, decision support tools, data analysis software, GIS and mapping, and other IT tools can play a much broader role in IPM than simple information delivery and communication.

This project is thus structured around three aspects: (i) a Global IPM Technology Database (IPM Technology Database hereafter), (ii) the application of IT in Regional Programs and other Global Themes (IT Applications hereafter), and (iii) capacity building in IT for IPM.

The IPM Technology Database is tailored to the needs of developing countries, especially those where IPM CRSP programs are present. The IPM Technology Database will serve as (i) a repository for IPM technology developed from IPM CRSP programs and other research, extension, education, and training programs around the world; (ii) a primary source for researchers, extensionists, educators, and other IPM stakeholders for information about IPM technology and outreach materials; and (iii) an aid for training, pest identification, quarantine, and globalization/regionalization of IPM technologies. The IT Applications will serve to develop decision support tools, GIS applications, Web and database systems, data analysis, and other applications in collaboration with IPM CRSP Regional Programs and Global

Themes. Capacity building will (i) train participants to develop and use IT systems and software tools; (ii) help International Agricultural Research Centers (IARCs) and Host Country (HC) institutions to build their information infrastructure; and (iii) develop expertise in IT for IPM in developing countries. We include training workshops and novel pilot programs for implementation of IT in IPM programs.

This project adopts a participatory approach in the development and execution of our Plan Of Work (POW). The tasks outlined above are the result of an appraisal and consultation process with all partners and stakeholders involved. This participatory approach will continue during project execution. The expertise of the PI, Co-PIs, and other project participants covers information technology and database design and use, and disciplines involved in the practice of IPM (e.g., ecology, plant pathology, entomology, weed science, and economics).

Introduction

Many important agricultural pests, such as soybean rust and codling moth, cause enormous economical and environmental damages across large geographical areas (http://www.aphis.usda.gov/ppq/ep/soybean_rust). It is important to share information about the pests as well as management technologies and tactics across countries and regions. Although often site-specific, IPM technologies, strategies, and systems are generally regionally or even globally adaptable. This globalization, resulting from local research, is a key component for international IPM research programs such as the IPM CRSP.

Many IPM practices, such as pest population identification, monitoring, quarantine, and control measure selection are time/space critical. World Trade Organization

(WTO) agreement requirements place further demands on information management such as for phytosanitary and food safety issues. It is essential to effectively collect, report, and analyze data on the locations, dynamics, and phenology of pest populations, and then quickly pass the information to stakeholders for decision-making. Inadequate capacity in these areas places many developing countries at particular socio-economic risk (Stinner 1999). A high capacity in data collection, reporting, analysis, and information delivery both temporally and spatially is critical to IPM practice.

Information Technology (IT) can play a significant role in IPM implementation. IT has been used for information delivery and dissemination, IPM communication, data acquisition and analysis, and development of new technologies in the US and many other countries (Stinner 1999, Xia et al. 2005, Knight 1999, Scott and Gilmore 1992). These technologies show great potential in broader applications for IPM such as pest diagnostics (<http://www.npdn.org>), field application control (Bongiovanni and Lowenberg, 2004), pest alerts and reports (http://www.aphis.usda.gov/ppq/ep/soybean_rust/), information management and storage, invasive species monitoring and reporting (<http://www.discoverlife.org/nh/tx/INVASIVES>), and pest management decision support (MacLean, 2000). As an example, the Internet and database management systems have changed the way we store, manage, and deliver IPM information and knowledge in developed countries. Consequently, this has brought about major social, economic, and institutional behavioral changes.

Today, many databases have a spatial component. Accordingly, one IT component will focus on dynamic spatial data acquisition and visualization (Ellsbury et al., 2000), mapping pest presence or density/activity (Fleischer, 1999), advances in regional IPM (Weisz et al., 1996), quarantine programs, export

agriculture, and local eradication programs (Midgarden, 1999). It also helps in protecting the U.S. from invasive pests, and the infrastructure built for these purposes has relevance to bio-containment and invasive species. We envision this IT effort strengthening (i) the institutional capability of traceability programs that will increasingly be needed for agricultural export/import, and (ii) programs to deal with invasive species.

Approaches And Objectives

This program adopts a participatory approach in program design and implementation. All tasks and procedures, such as objectives, timelines, and impact assessment, are identified in a participatory consultation process with involvement of all partners who had similar consultation processes with their stakeholders such as farmers and host country's institutions. The project involves IT specialists, social scientists, and scientists in various disciplines of IPM such as ecologists, plant pathologists, entomologists, and weed scientists from U.S. land grant universities, IARCs, NGO, international organizations, governmental institutions of host countries, universities, and the private sector. The 1890 institutions will have strong representation in the program through participation of Regional Programs and other Global Themes.

Main US collaboration institutes include Penn State University and the University of Georgia. This program also works with all IPM CRSP regional programs and global themes on data sharing and analysis, GIS, globalization, and regionalization through a global IPM technology database and links. Specifically, this program is working with following three regional programs on specific pest information sharing components:

- West Africa Regional IPM CRSP, lead by Virginia Tech

- Southeast Asia Regional IPM CRSP, lead by Clemson University
- Central Asia Regional IPM CRSP, lead by Michigan State University

In addition, this program collaborates with the Caribbean Agriculture Development Authority (CADA) and a number of institutions in the Caribbean to use GIS to monitor the movement and population dynamics of the fruit fly.

Through the regional programs, we collaborate with institutions in the following countries or regions: Jamaica, West Africa, Southeast Asia and Central Asia.

There are five objectives in the program:

OBJECTIVE 1: Develop Decision Support Tools (to organize, analyze, communicate and store IPM information)

Decision support tools can play a significant role in pest management. The typical tools in the category include decision support systems (DSS), expert systems, and databases. This GT will develop and link the decision support tools such as database and expert systems. Specifically, this program will focus on two components under this objective: a) Global IPM Technology Database, and b) West Africa Regional IPM Network.

a) Global IPM Technology Database (GITD)

. Goals or functions of GITD include, but are not limited to:

- Central place to store and search IPM Information relating to IPM CRSP programs
- Letting IPM CRSP programs, HC, and NCSU staff submit data/information
- Search pest and crop information, and IPM technology and experts online
- A main site for coordinating globalization of the technology developed from IPM CRSP
- Consisting of Data Entry System and public access site

- This GT will be responsible for programming, links, a part of the data entry
- RP and other GT will be responsible for entering some of the links and shared materials. No financial obligation to/from each other

b) West Africa Regional IPM Network (Whitefly Information System for W. Africa). Goals/functions of this network include:

- Regional information sharing system
- A major pesticide safety education site
- W. Africa RP, HC, and this GT will be responsible for programming and data entry
- Linking and incorporating whitefly information from U.S. and international sites

OBJECTIVE 2: Analyze data, model interactions, and provide visualization and communication of results

- Establishing a regional web-based database for plant health surveillance and pest response systems.
- Developing interactive cartography for use in monitoring and tracking pests and support the transfer of these technologies. Build from web-mapping tools currently in place that use Delphi code, Active Server Pages, and MacroMedia Flash.

OBJECTIVE 3: A human and information technology infrastructure will be established for agricultural pest information storage and pest monitoring

- The main goal of this activity is to help HC and regional IPM organizations to build or improve their capacity in IPM information sharing and pest monitoring.
- Asian Regional Pest Information Sharing System.

OBJECTIVE 4: IT support and capacity building

- This activity is to provide technical support and layout a foundation for communication among the IPM CRSP programs and HC. All RP and GT will be

involved in some way, but with emphasis on LAC, W. Africa, and SE Asia.

OBJECTIVE 5: Link to USDA Regional IPM Centers' information and IPM CRSP reporting system

- General international and national IPM information systems such as IPM CRSP reports and the USDA Regional IPM Centers National Information System.
- Regional information system sites such as CIPMNET in the Caribbean and other regional IPM information systems this program will help to develop.
- Major IPM-related technology sites such as GIS tutorials.
- Where possible, actual data sharing through web services will be established to allow searching of multiple information sources. At the least, this system will connect in this way with the National System for the USDA Regional IPM Centers, the CSREES IPM Performance, Planning and Reporting System (currently being rewritten) and the IPM CRSP Reporting System.

Year One Results

Progresses are summarized based on the objectives stated earlier:

OBJECTIVE 1. To develop Decision Support Tools (to organize, analyze, communicate and store IPM information)

- Global IPM Technology Database <http://www.ipmnetwork.net/>
- Developed the capacity for searching global pest information by crops and pest names. User can search online pest management information by using crop or pest names, or in combination of crop and pest name (<http://www.ipmnetwork.net/>).
- Developed the capacity for online search biocontrol materials. We have what may be the most comprehensive collections of online biological control materials in the world, containing over 2,500 biological references after screening over 20,000 pest management online materials. We

are working on similar collections for other IPM technologies (e.g. chemical control, and cultural control).

OBJECTIVE 2. To develop Decision Support Tools (to organize, analyze, communicate and store IPM information)

- Southeast Asia IPM Network and Pest Information Sharing
 1. Training using IT for pest information sharing in Kuala Lumpur, Malaysia. Over 20 representatives from south-east Asia countries.
 2. Significant number of IPM materials were collected and made searchable
- West Africa IPM Network
 3. Developing IT infrastructure for pest and pesticide information sharing
 4. Component of West Africa Pesticide Education has been developed

OBJECTIVE 3. Analyze data, model interactions, and provide visualization and communication of results

- A workshop was held with over 40 attendees from institutions in the region
- Survey instrument refined
- All extension staff trained in survey and protocol
- All sampling locations identified
- All trapping supplies procured (except Mcphail traps, lure, strainers)
- Information and feedback supplied to Jon Voortman to facilitate web database development

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An Integrated Pest Management Approach for Mitigating the Impact of Thrips-borne Tospoviruses in Vegetable Cropping Systems

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Introduction. Diseases caused by a group of plant viruses called tospoviruses have received more attention because they cause serious damage to several agronomic crops, ornamentals, vegetables, and fruits (Sherwood *et al.*, 2000). In recent years, the incidence and spread of diseases caused by tospoviruses has increased significantly in different countries, reflecting their negative impact on agriculture worldwide. Consequently, tospoviruses are considered as the most aggressive emerging plant viruses with estimated global yield losses of up to US \$1 billion in a wide range of crops (Goldbach and Peters, 1994). Although diseases now attributed to *Tomato spotted wilt virus* (TSWV), the type species for the genus *Tospovirus*, were first reported in tomatoes in Australia around 1915, it was not until 1990s that scientists came to realize that there are distinct tospoviruses infecting a broad range of plants (Whitfield *et al.*, 2005).

The term tospovirus is derived from Tomato spotted wilt virus (TSWV). Thus, all viruses with morphological and genome properties similar to TSWV are called tospoviruses and grouped under the genus *Tospovirus* in the family *Bunyaviridae*. During the past two decades, several tospoviruses infecting different plant species around the world have been characterized (Table 1). Many other tospovirus-like viruses have been reported in different countries; they are yet to be characterized completely in order to determine whether these viruses are strains or variants of currently known tospoviruses or represent new virus species. Current knowledge indicates that some of the presently known tospoviruses have a wide geographic range occurring

have a restricted distribution limited to a few countries (Mumford *et al.*, 1996; Daughtrey *et al.*, 1997; Peters, 2004; Jones, 2005; Persley *et al.*, 2006; Gent *et al.*, 2006). For example, TSWV has become an economically important virus in a broad range of field crops, vegetables, and ornamentals in several countries of North America, South America, Europe, Asia, and Australia. *Peanut Bud Necrosis Virus* (PBNV, also called *Groundnut Bud Necrosis Virus*) has been documented as an economically important tospovirus on a broad range of field crops and vegetables in India. Similarly, *Impatiens Necrotic Spot Virus* (INSV) has been documented on ornamentals in several countries of North America and Europe. In recent years, *Iris Yellow Spot Virus* (IYSV) has been documented in onions in North and South America, Europe and Middle East, and in India. *Capsicum Chlorosis Virus* (CaCV) is emerging as an important constraint to tomatoes, peppers, and peanuts in many Asian countries and in Australia. Thus, data from several reports published in recent years clearly indicate that tospoviruses are expanding to favorable new geographic environments from their original natural habitats by various means. Once introduced, tospoviruses can establish themselves quickly in a new ecosystem since many of them have a broad host range infecting valuable crop plants as well as weed hosts. However, it should be remembered that the host range varies greatly with individual tospovirus. For example, TSWV can infect several plant species and weed hosts (Parella *et al.*, 2003), whereas others have a relatively narrow host range.

Genome organization of tospoviruses. With advances in molecular biology, an understanding of the complexity

of tospoviruses began to emerge during the 1990s. Tospoviruses have pleomorphic particles of 80-110 nm in diameter. Each particle contains three genomic RNA segments designated as Large (L), Medium (M) and Small (S) RNA (Goldbach and Peters, 1994; Adkins, 2000; Moyer, 2000; Whitfield *et al.*, 2005). The three genomic RNAs are individually packaged or encapsidated by many copies of the nucleocapsid protein and 'bound' together by a host-derived lipid envelope membrane to form a virus particle. The envelope membrane serves as a "shell" protecting the viral genetic material. In addition to the three genomic segments, each virus particle contains a few copies of "replicase" protein inside the envelope. The "replicase" is essential for the virus to initiate replication in a new host. Each virus particle also contains two glycoproteins (GPs) that are integrated on the surface of the envelope membrane and seen as spike-like projections covering the surface of the virus particle. The two GPs contain different types of sugars (hence called glycoproteins) and differ in their size. The GPs play a critical role in different stages of the virus life cycle; for example, virus assembly in the host and virus acquisition and transmission by insect vectors. Indeed, the tospovirus particles are hybrid structures, with proteins and genomic RNAs that are the product of virus genetic information while sugars in viral glycoproteins and the lipid envelope membrane are produced by host cell synthetic machinery (Naidu *et al.*, 2004). Thus, the virus particles of tospoviruses are more complex than any other virus currently known to infect plants.

Spread of tospoviruses. The life cycle of tospoviruses involves spread from an infected plant to a healthy plant by several species of polyphagous thrips (Thysanoptera: Thripidae, Mound, 2005). Tospoviruses, however, are not transmitted through seed. Thrips (derived from Greek meaning "woodworm") are very small (less than 1 mm in length) and their cryptic behavior makes them difficult to detect either in the field or in fresh vegetables,

fruits, and ornamental flowers. Thrips are ubiquitous and opportunistic insects and have the ability to survive under a broad range of diverse ecological conditions. As a result, many species of thrips have now spread from their original natural habitats and hosts to favorable new environments of valuable crops. The geographic expansion of thrips has increased the potential to introduce and spread several non-indigenous tospoviruses in regions where tospoviruses have not been a concern before. Currently, there are at least twelve species of thrips (Table 1) that have been confirmed as vectors of one or more tospoviruses worldwide (Ullman *et al.*, 2002; Mound, 2005). There could be other potential vector thrips species yet to be documented. From the table, it is clear that a single thrips species has the ability to spread different tospoviruses. Conversely, a single tospovirus can be spread by different species of thrips. It is also important to note that many of these phytophagous thrips species can cause direct damage as pests to agricultural crops (Welter *et al.*, 1990); however, their economic impact is far greater as vectors of tospoviruses (Mound, 2005). Currently, thrips are known to transmit several viruses belonging to at least four plant virus groups, viz. ilarviruses, sobemoviruses, carmoviruses, and tospoviruses (Jones, 2005). Members of the first three groups are pollen-borne and thrips facilitate transmission by carrying pollen from infected plant to healthy plant during feeding. In contrast, thrips are "true" vectors of tospoviruses because there is a more intimate biological relationship between tospoviruses and thrips. It should be remembered that not all thrips have the ability to transmit tospoviruses. Indeed, only about 12 out of 5500 known species of thrips (i.e. about 0.16%) have been implicated in the transmission of different tospoviruses.

Tospoviruses are one of the few groups of plant viruses that multiply in both plants and thrips vectors. Thrips-mediated transmission of tospoviruses is unique

among plant viruses because successful transmission of adult thrips occurs only when the virus is acquired during the first instar (and early second instar) larval stages (van de Wetering *et al.*, 1996; Kritzman *et al.*, 2002; de Assis Filho *et al.*, 2002). Adult thrips have the ability to acquire the virus; however, such an acquisition during adult stage does not result in transmission (de Assis Filho *et al.*, 2004). Therefore, tospovirus acquisition and subsequent transmission is closely linked to the developmental stage of vector thrips on plants. Indeed, this type of interdependency between vector life-stage and virus transmission is quite unique among plant viruses. The factors that contribute to the acquisition and transmission of tospoviruses by thrips populations are complex and involve interactions between virus, plant, and vector (Kritzman *et al.*, 2002). Adult thrips that acquire a tospovirus during the larval stage remain viruliferous for life (which may be 20–40 days depending on the environmental conditions), and contribute to short- and long-distance spread of the virus. Since tospoviruses replicate in vector thrips, the insects not only have the ability to spread the virus throughout their life but also serve as a virus host. However, viruliferous adults do not transmit the virus to their progeny through eggs. Viruliferous males are reported to exhibit a higher transmission rate than females (van der Wetering *et al.*, 1998; Sakurai *et al.*, 1998; Naidu *et al.*, 2007), which suggests that their feeding behavior may differ from that of females. Indeed, tospoviruses are only a few groups of plant viruses that have evolved a variety of elegant mechanisms to multiply in both plants and insects by devising “Trojan horse” strategies to overcome vastly different cellular and biochemical barriers of the two phylogenetically and biochemically disparate hosts in order to maintain a successful life cycle.

Several thrips species and tospoviruses have expanded their geographic range due to a variety of factors including globalization and increased trans-border

trade and commerce of agricultural crops and horticultural products. For example, *Frankliniella occidentalis*, a vector thrips species native to the southwestern United States, has been implicated in the spread of TSWV to many regions within and outside the USA through the movement of ornamental greenhouse plants beginning in the mid-1980s (Mound, 1997). Similarly, melon thrips (*T. palmi*), a native to Java and Sumatra islands of Indonesia, is now present in several countries of Asia, and has expanded to many Pacific Ocean islands, North Africa, Australia, Central and South America, and the Caribbean (Walker, 1994). *T. palmi* is reported as a vector of several tospoviruses infecting agricultural crops in Asian countries and Australia (Jones, 2005). *T. tabaci* is a cosmopolitan pest of onions grown between sea level and 2000 m and is known to transmit several tospoviruses, including IYSV in onion (Ullman *et al.*, 2002; Gent *et al.*, 2006).

Symptoms produced by tospoviruses. Symptoms caused by tospoviruses vary considerably, depending on the virus, host plant species and their cultivars, age of the plant at which infection occurred as well as environmental factors. In general, plants infected with tospoviruses show a wide range of symptoms consisting of necrotic and/or chlorotic spots, rings and line patterns on leaves, bronzing and various types of mottling and speckling of leaves, necrotic streaks and lesions on stems, and general chlorosis, stunting, wilting, or necrosis of plants. In many plant species, tospovirus infection leads to necrosis of growing tips resulting in ‘bud necrosis’ symptoms. In addition, different strains of a tospovirus can induce different types of symptoms in the same host. In some cases, virus infection may not show obvious symptoms causing symptomless or latent infections. In general, virus infection during early stages of crop season can cause severe stunting of plants with no yield resulting in total crop loss. Infection during later stages of crop season, however, may affect crop performance leading to a reduction in crop

yield. In the case of vegetables like tomatoes, infection after fruit set not only affect the size of fruits but also the nutritional quality and shelf life of fruits. In addition, tospoviruses like TSWV, PBNV and CaCV cause fruit deformities in tomatoes and the fruits from infected plants exhibit various types of symptoms including chlorotic and necrotic rings leading to poor marketability.

Detection of tospoviruses. Due to variable symptom phenotype, symptom-based diagnosis is inadequate to confirm a tospovirus infection. This is further confounded by the fact that some of the symptoms produced by tospoviruses mimic those of fungal and other viral pathogens. Inability to accurately diagnose diseases caused by tospoviruses could undermine the economic significance of a particular virus, result in misapplication of agrochemicals, and impede progress in breeding for virus resistance. Thus, accurate diagnosis of a tospovirus is the cornerstone for developing disease management strategies. Three different methods are commonly used for diagnosing a tospovirus infection. Mechanical sap inoculations of extracts from a suspected plant tissue onto an indicator host (bioassay) provide an indication of tospovirus infection. Although this assay is easy to perform under minimum facilities, the symptoms may not be helpful in accurate identification of a specific tospovirus due to similar symptoms on indicator hosts produced by distinct tospoviruses. Serological (antibody-based) and molecular (Reverse transcription-polymerase chain reaction or RT-PCR) assays can circumvent this limitation by providing accurate diagnosis of infection by a specific tospovirus. A combination of serological and molecular techniques can provide additional information on the prevalence of different strains of a particular virus and whether a plant is co-infected by more than one tospovirus.

Management of tospoviruses. Diseases caused by tospoviruses, like any other viral disease, cannot be controlled

directly by treating infected plants with chemical agents analogous to treating fungal diseases with fungicides. They must, instead, be controlled by other management practices. These practices include prevention or avoidance of infection by controlling thrips vectors, cultural practices like altering planting dates, increasing crop density and rouging of infected plants to minimize spread of the disease and deploying resistant cultivars to reduce yield losses. It must be remembered that any one of these tactics alone may not be effective in achieving the desired results and in many cases a combination of these control measures are required to reduce the yield losses (Culbreath *et al.*, 2003). An understanding of the epidemiology of tospoviruses and vector thrips species in a given cropping system can provide valuable information on alternate hosts (both crop plants and weeds) that serve as a reservoir for off-season survival of tospoviruses and their vectors, the influence of various environmental factors on disease dynamics, and diversity of tospoviruses and thrips vector species. This knowledge helps to develop integrated control measures appropriate to specific crops or cropping systems. Since the management of virus diseases usually hinge on the control of the vector, subsistence farmers in developing countries use pesticides as the predominant tactic to control thrips. Because of their small size and ability to develop resistance against pesticides, pesticide-based control tactics are less effective to prevent the spread of thrips-borne tospoviruses. Due to growing awareness of harmful effects of pesticides on human health, environment, and biological diversity, Integrated Pest Management (IPM) has been accepted generally as a better alternative for the control of thrips-borne tospoviruses.

IPM utilizes a suite of tactics involving host plant resistance (developed by conventional breeding and/or biotechnological approaches), cultural (crop sanitation, crop rotation, plant density, varietal mixtures, crop-free

periods, reflective mulches, barrier crops, phytophylaxis, etc.), and bio-pesticidal (eg. plant-based products) and biological control measures (predators and parasites) that have different modes of action to achieve synergistic benefits for maximizing the likelihood that losses will remain below the 'economic threshold'. IPM practices will enable the switch from a pesticide-based mode of reducing losses to an ecologically sustainable, economically feasible, and socially acceptable approach in order to protect farming systems in developing countries.

The way forward. The Integrated Pest Management-Collaborative Research and Support Program (IPM CRSP) of USAID has recently initiated a multi-disciplinary and multi-institutional global project to provide science-based knowledge for developing sustainable and eco-friendly IPM strategies to minimize crop losses due to thrips-borne tospoviruses. The project is currently focusing on tospoviruses in the South & Southeast Asia (S&SEA) region because diseases caused by this group of viruses have increasingly become a significant limiting factor in the sustainable production of vegetables in smallholder farming systems of the region (Naidu et al., 2005). At least ten of the sixteen tospoviruses currently characterized worldwide have been found distributed in the region. Of the twelve thrips species implicated globally as vectors of tospoviruses, six species have been documented in the region. Thus, S&SEA region appears to be a 'hot spot' for thrips-borne tospovirus diseases. The specific objectives of the project are to (i) conduct strategic research on tospoviruses and thrips vectors and develop host plant resistance, (ii) carry out applied and adaptive research to deploy eco-friendly integrated disease management strategies to control tospovirus diseases, and (iii) develop strategies for strengthening institutional capacities within host countries to conduct problem-oriented research on virus diseases. The project places special emphasis on the participatory model of

agricultural research to generate new knowledge and technologies for the benefit of host countries in the region. It also promotes global partnerships with research institutions in developed countries and international agricultural research centers for greater synergies in the region and to deploy long-lasting solutions for the management of diseases caused by tospoviruses in vegetables.

The status of tospoviruses and thrips vectors and their economic significance in the Central Asia (CA) region (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan) is poorly documented. It should be remembered that absence of evidence for the presence of tospoviruses is not evidence of their absence in the region. Indeed, a recent visit by the author has noticed symptoms on onions indicative of the presence of IYSV in the region. Since the CA region grows a wide range of vegetables including potatoes, tomatoes, onions, sweet peppers, and many leafy vegetables under diverse agro-ecological conditions, occurrence of tospoviruses have implications for food security and environmental sustainability of the region. Several types of vegetables constitute an integral part of dietary requirements of the people in the region. It is estimated that vegetables like tomatoes, watermelons, cabbages, onions, cucumbers and carrots occupy more than four-fifths of the total vegetable area in these countries. Based on the current information available worldwide, all these crops are vulnerable to infection by many debilitating tospoviruses. Limiting production and reduced nutritional quality of vegetable due to tospoviruses affect the rural livelihoods, economic well-being of women and children and export potential of quality vegetables, ultimately impacting food security in the region. Thus, there is a critical need in Central Asian countries for developing specialized scientific expertise in addressing disease problems due to thrips-borne tospoviruses. The IPM CRSP Regional Project in Central Asia, in partnership with IPM CRSP global theme projects on insect-transmitted viruses and

international centers like the International Center for Agricultural Research in the Dry Areas (ICARDA) and the Asian Vegetable Research and Development Center (AVRDC), should expedite joint R&D efforts to build capacity for addressing tospovirus diseases and programs for effective transfer of technologies to farming communities and other stakeholders. This would involve organizing group-based short-term training courses in one of the countries in the region, training of young scientists in advanced laboratories, and improvement of facilities in the national programs to conduct virus research. IPM CRSP has a comparative advantage in taking a leading role for developing scientific cooperation and networking to address tospovirus disease constraints impacting vegetable crops across the region. Such a collaborative effort will bring opportunities to establish synergistic interactions among cooperating institutions in terms of sharing human and technical expertise to maximize research outputs from limited resources. The IPM CRSP is well positioned to bring various institutions into a cohesive and singularly effective group to develop collaborative R&D efforts that will have mutual benefits for all countries in the region.

Table 1: List of currently recognized tospoviruses, their geographic distribution and thrips vectors¹

Virus	Geographic distribution	Thrips vectors
Capsicum chlorosis virus	Thailand, Australia, India	Ceratothripoides claratris, T. palmi, F. schultzei
Calla lily chlorotic spot virus	Taiwan	T. palmi
Chrysanthemum stem necrosis virus	Brazil	F. occidentalis, F. schultzei
Groundnut (peanut) bud necrosis virus	South and Southeast Asia	F. schultzei, T. palmi, Scirtothrips dorsalis
Groundnut ringspot virus	South Africa	F. occidentalis, F. schultzei, F. intonsa, F. gemina
Impatiens necrotic spot virus	Americas, Europe	F. occidentalis, F. fusca, F. intosa
Iris yellow spot virus	World wide	T. tabaci
Melon yellow spot virus	Japan, Thailand	T. palmi
Peanut chlorotic fanspot virus	Taiwan	S. dorsalis
Peanut yellow spot virus	India	S. dorsalis
Tomato chlorotic spot virus	Brazil	F. intonsa, F. occidentalis, F. schultzei
Tomato spotted wilt virus	Worldwide	F. bispinosa, F. fusca, F. intonsa, F. occidentalis, F. schultzei, T. setosus, T. tabaci, T. setosus, F. gemina, T. palmi
Tomato yellow ring virus	Iran	T. tabaci (?)
Watermelon bud necrosis virus	India	T. palmi
Watermelon silver mottle virus	Japan, Taiwan, Thailand	T. palmi
Zucchini lethal chlorotic virus	Brazil	F. zucchini

¹Modified from Whitfield et al. (2005) and http://www.oznet.ksu.edu/tospovirus/tospo_list.htm

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Oxfam GB in Tajikistan: Current and Future Programs

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This document intends to present to the IPM forum stakeholders the current programs we have in Tajikistan and what we want to do in the future and how it is related to IPM. Oxfam GB is an international NGO working in relief and development campaigns. Oxfam was created from famine relief committees set up in Oxford at the end of the Second World War. It is a member of Oxfam International, a confederation of 13 organizations working together with over 3,000 partners in more than 100 countries to find lasting solutions to poverty, suffering, and injustice. Oxfam started working in Tajikistan in 2001 following two years of drought. Oxfam's work involves improving access to food, livelihoods, water, and healthcare for those in need.

Oxfam GB has 2 offices in Tajikistan; a support office in Dushanbe and a field office in Kulyab. We run three different programs:

- ◆ Livelihood: mainly agriculture-related activities and other income-generating activities
- ◆ Public health and water sanitation: drinking water supply, latrines, etc.
- ◆ Disaster management: to prepare communities to respond to natural disaster (landslides, floods, earthquakes)

This presentation focuses on our Livelihood Program, as it is the one related to agriculture and therefore to IPM. There are 2 projects implemented currently and funded by EC and Oxfam Novib. Their objective is to improve food security and household livelihood. The main problems addressed in the project area are a lack of access to good quality input, especially seeds and tools, and land access problems. On livelihood program, Oxfam GB is currently working on actions in response to the urgent need to provide production means (inputs, tools, irrigated

drained land) and extension services on access and use of land for subsistence agriculture. The current project's impact will be the improvement of food security in the project area. The local communities will be able to manage their food security and livelihood development with the help of created structures (community-based organizations, community-managed agriculture shops, seed farmers associations, etc.). This will be done by:

- ◆ Promoting crop rotation (identify, test, train farmers)
- ◆ Training on agriculture practices and appropriate use of inputs
- ◆ Selection of local high performance varieties for seed multiplication by farmers
- ◆ Support to rainfed agriculture, crop diversification, and farmers with seeds, tools, inputs, and technical support.

Capacity-building activities are being implemented to ensure the sustainability of these activities, to give to the communities the structure to manage its own food security and agricultural development:

- ◆ Community-based organizations (CBO) have been trained to manage projects, community funds, and to address the needs of their communities
- ◆ Support to income-generating activities, women's self-help groups, and activities such as fruit preservation, sewing, vegetable production, cooking, etc.
- ◆ Three information centers will be established to provide training, technical assistance and services in agriculture, land right issues, gender, etc.
- ◆ Community-managed agriculture shops will be able to provide good quality seeds and tools at affordable prices
- ◆ A seed farmers association will be created and will supply agriculture shops

With this project we expect that food security will be achieved in the project area and the community will be able to manage it. But a very important threat could endanger this food security:

- ◆ Unsustainable agriculture practices (fertility management, irrigation methods, degraded drainage infrastructure) lead to erosion and soil salinity
- ◆ Farmer debt and low access to inputs
- ◆ Land rights: lack of basic liberties in production and marketing in cotton growing areas

In answer to these threats, our project is to introduce organic agriculture concepts along the production chain, from farm production to marketing, including label creation and certification. We believe that organic agriculture will:

- ◆ Help to ensure environmental sustainability
- ◆ Reduce dependency toward expensive imported inputs

- ◆ Improve market conditions for local agriculture products, especially when it is introduced with fair trade concepts.

Oxfam GB and Avalon (a Dutch NGO) have conducted a study on the potential interest for organic farming projects in Tajikistan. Avalon has experience in implementing organic agriculture projects in Eastern Europe and Central Asia. Several stakeholders from the agriculture sector have been met during this mission from ministries of agriculture to farmers, including international and local NGOs, academies of science, standardization services, researchers, teachers, students, agro processing companies, etc. All stakeholders gave a very positive feedback, and were really interested in Organic Agriculture.

The planned activities are detailed in the table below.

Activity	Target groups	Capacity building / instruments
Market chain		
Farming: Cotton, Vegetables, Animals, Fruits, Vineyards, Herbs, etc.	Dehkans private farmers household/presid.land women's groups	Demonstration farms, On farm training Farm business plans, Identify leaders for exchange visits, Local seminars, Organic seeds, Bio pest control, Special machinery
Processing: Cotton, Wine, Vegetables, Fruits, Herbs, etc.	Dehkans existing processing plants	Training on standards and procedures On the spot technical advice Exchange visits Local seminars
Marketing: green market cities	Dehkans (private farmers)	Training in market assessment, marketing mix, communication Exchange visits
Common label:	Dehkans	Development/contest, Registration
domestic exports	Private farmers, processors, traders, consumers, MoANP	Use, Promotion, Local seminars
Certification:	Dehkans, farmers, processors MoANP, Institute of Standardization	Training of inspectors Working group on standard development, Institutionalize inspection and certification

In addition to the changes in the market chain, knowledge/ information on organic farming will be strengthened with following activities:

Knowledge support	Target groups	Capacity building / instruments
Research:	Acad. of Science University	Experimental fields Exchange between researchers Visit international conferences (e.g. IFOAM)
Education:	Universities, secondary schools, vocational training, students teachers	Demonstration farms Develop and implement curricula on OA
Farm advisory work:	Government Extension Service, private ext. services, leading farmers	Demonstration farms Training of Trainers Exchange visits
Other support:		
Promotion/publicity: Consumer awareness, Media	Consumers, policy makers, farmers CBO's, NGO's	Training on communication aspects of OA
Policy: National Action Plan, legislation, land rights	Ministry of ANP, oblast, khokumat, Dehkans, CBO's	Creation of multi-stakeholder working group, Training on National Action Plan, Regional seminars
(Micro-) financing:	Dehkans, private farmers processors	Development of credit instrument

Other topics related to organic agriculture can or must be addressed in this program:

Related issues	Target groups	Capacity building / instruments
Integrated rural development: agri-environment, biodiversity, rural tourism, climate change	Farmers, MoANP, policy makers, consumers, CBO's, NGO's	Information seminars
Afforestation/erosion control	Institute of Soil Science	Information, seminars
Gender issues	CBO's, Dehkans, farmers	Information, Seminars
Housing/energy use including: isolation heating, solar systems	rural population	Information, Seminars
Food quality	Inst. of Standardification	Information, Seminars
Genetic Resources	Inst. for Genetic Res	Information, seminars
Health care: - care for handicapped	Institutions like Internat Kulyab Internat children Gizar	Information Seminars Link with food for kitchen Vocational training

Erosion control and energy use in the household are essential because they belong to a vicious circle that needs to be broken.

Following the collapse of the Soviet Union there was a drop in the energy supply (gas, electricity, etc.) and people had to look for alternative fuel for cooking and to warm houses during winter. The cutting of trees for wood and the burning of cow dung increased, therefore decreasing the availability of manure to fertilize fields at the same time access to chemical fertilizer was reduced. These practices led to deforestation, an increase in erosion, and a drop in soil fertility. As a consequence the production of cotton sticks, which is a major combustible in households, is reduced, increasing the need for new energy sources. We find it very important to break this circle by implementing activities related to energy saving, alternative energy sources, and afforestation.

In developing and implementing future livelihood programs, Oxfam GB will need to keep in touch with the IPM program because:

- ◆ Our projects cannot be successful without efficient pest management
- ◆ Knowledge and research in IPM are valuable for organic farming because organic agriculture proscribes the use of chemical pesticides

As a conclusion we could discuss and compare advantages of both methods-IPM and organic-for farmers in Tajikistan. The following points could be discussed:

Organic Agriculture	IPM techniques
<ul style="list-style-type: none"> • Label / standard / Markets are more developed • Better impact on environment and Health • Less input costs 	<ul style="list-style-type: none"> • Less risks for successful pest management • Better economical yield • No production drop during transition

Landscape Ecology and Management of Natural Enemies in IPM Systems

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Introduction

There are three primary means by which managers influence biological control of insects. Importation of natural enemies against pests of exotic origin is sometimes referred to as classical biological control, while augmentation is the rearing and release of natural enemies already present to increase their effectiveness. Conservation of natural enemies involves improving conditions for existing natural enemies by reducing factors which interfere with natural enemies or increasing access to resources that they require to be successful (Ehler, 1998). Habitat management is considered a subset of conservation practices that focus on manipulating habitats within agricultural landscape to provide resources to enhance natural enemies (Landis *et al.*, 2000).

Managing agricultural landscapes to improve biological control relies on a detailed understanding of factors that influence both pest and natural enemy abundance. We begin by examining landscape processes that influence pests and beneficial insects at larger spatial scales. Next we focus on processes that influence these organisms and their interactions at local scales. Finally, we detail steps that pest managers may take to alter agricultural habitats and landscapes to favor natural enemies in IPM systems. Throughout, we attempt to show how both temporal and spatial factors influence the outcome of pest-enemy interactions.

Landscape Processes And IPM

Agricultural landscapes consist of a mosaic of crop and non-crop habitats. The diversity and abundance of both pests and

natural enemies depend on the large-scale structure of these landscapes. Several patterns have emerged that illustrate the impact of landscape structure on pests and beneficial insects. First, the diversity and abundance of predators and parasitoids often increase as landscape complexity and the proportion of non-crop habitat increase. Second, several studies suggest that there may be thresholds in landscape structure below which the search efficiency and the ability of natural enemies to aggregate and control pests is diminished. Finally, landscape characteristics may not influence all species equally, or at the same scale.

Landscape Complexity

The diversity of habitats within a landscape can greatly affect communities of herbivores and their natural enemies within an agricultural crop (Marino and Landis, 1996; Ostman, 2002; Schmidt, Tschardtke, 2005; Tschardtke *et al.*, 2005). A majority of studies finds a decrease in herbivore density and damage as the proportion of non-crop habitat in a landscape increases. The presence of non-crop habitats may increase natural enemy abundance by providing resources such as alternative prey or overwintering habitat. While pest abundance and herbivory generally decline with structural complexity, the abundance and diversity of predators and parasitoids often increase as non-crop habitat increases.

There is also temporal variation in the response of natural enemies to landscape structure. Menalled *et al.* (2003) examined parasitism of the armyworm, *Pseudaletia unipunctata* (Noctuidae), by two braconid parasitoids, *Glyptapanteles militaris* and *Meteorus communis* (Braconidae) across five years in simple and complex landscapes.

The simple landscape had 29% non-crop habitat, and the complex landscape had 41% non-crop habitat and smaller crop fields. Although percentage parasitism in the complex landscape was equal to or higher than the simple landscape in 4 of the 5 years of the study, distribution of the parasitoids varied. *Glyptapanteles militaris* was most abundant in the simple landscape during the last two years of the study while *M. communis* was the dominant species in the complex landscape during the first three years of the study.

Habitat Thresholds

Several studies suggest thresholds in landscape structure below which the search efficiency and ability of natural enemies to aggregate and control pests is diminished. Simulation experiments have shown that search success of natural enemies declined when suitable habitat fell below 20% (With and King, 1999). This observation has also been documented in the field; Thies and Tscharntke (1999) found that parasitism rates declined in agricultural landscapes when the non-crop area fell below 20%. Thies et al. (2003) found that in simple landscapes, parasitism of rape pollen beetle declined below threshold levels needed for successful biological control.

Edge Effects

Natural enemy populations may build up in field borders and move into a crop when pest populations begin to build. A substantial amount of research has been conducted to understand the role of field edges on the biological control of pests by natural enemies. Overall, these data show that measuring the activity and richness of predatory populations in field boundaries can, but does not always accurately predict their potential impact on herbivores in neighboring crops (Hunter, 2002). In some cases, field edges and neighboring habitats contribute to within-field natural enemy assemblages. In other cases, the presence of non-crop habitats surrounding

agricultural fields either had no effect on natural enemy density in the crop or had a positive effect on herbivore abundance.

Local Processes And IPM

Although potential pests and biological control agents occur in a regional pool, local processes impact their interactions and the outcome of biological control at the field level. Some of these local processes include negative impacts of pesticide application and cultural practices such as soil cultivation on natural enemy populations (Croft, 1990; DeBach and Rosen, 1991; Barbosa, 1998; Stark and Banks, 2003). Here, we focus on several phenomena that mediate the effect of natural enemies at the local scale and have received relatively less attention, including timing between natural enemy and pest arrival and interactions within multiple enemy assemblages.

Early-season pest suppression

The difference in timing between the arrival of prey and their natural enemies into a crop often determines the outcome of their interaction. Generalist natural enemies have the potential to be present in crops early in the season, before pests arrive and experience population growth. However, such early season predation usually goes unnoticed due to the relatively low numbers of natural enemies required to suppress initial pest populations. Landis and Van der Werf (1997) showed that the assemblage of generalist predators present in sugar beet fields early in the season significantly reduced aphid abundance and the impact of the aphid-vectored viruses. Using predator exclusion cages, several studies have demonstrated strong suppressive effects of generalist predators on soybean aphid, *Aphis glycines*, early in the season, both during outbreak and non-outbreak aphid years (Fox et al., 2004; Costamagna and Landis, 2006; Desneux et al., 2006; Costamagna et al., 2007).

Interactions within multiple enemy assemblages

Natural enemy assemblages in agroecosystems are typically composed of multiple species, including both generalists and specialists (Symondson *et al.*, 2002). Within these diverse assemblages, positive interactions such as predator facilitation and negative interactions such as predator interference, cannibalism, predator avoidance behavior, and intraguild predation commonly occur and can modify the level of herbivore pest suppression (Roland and Embree, 1995; Sih *et al.*, 1998; Snyder and Wise, 1999; Prasad and Snyder, 2006; Gardiner and Landis, 2007).

Managing Agricultural Landscapes To Increase Pest Suppression

Given an understanding of landscape and local processes affecting pest suppression, pest managers may wish to modify production practices to enhance natural enemy populations. Selective pesticide use is an accepted technique that may decrease natural enemy mortality (Croft, 1990; Ruberson *et al.*, 1998; Johnson, Tabashnik, 1999). Altered cultural practices, such as no-till production (Witmer *et al.*, 2003) and strip cropping (Hossain *et al.*, 2002; Weiser *et al.*, 2003), may also decrease natural enemy mortality. In addition to refuge from disturbance, natural enemies frequently live longer and are more fecund when provided access to shelter, overwintering sites, alternate hosts, prey, and nectar and pollen (Ehler, 1998; Landis *et al.*, 2000). Below we discuss the resources that are frequently absent from agricultural landscapes and their effects on the presence of natural enemies, as well as methods to increase habitat suitability for natural enemies from field to landscape scales.

Overwintering Sites

Many natural enemy taxa require undisturbed sites near crop fields to increase overwintering success. Pickett *et al.* (2004)

found that two aphelinid parasitoids, *Eretmocerus eremicus* and *Encarsia* spp., moved from overwintering refuges into cantaloupe and cotton crops adjacent to the refuge, where they parasitized sweetpotato whitefly, *Bemisia tabaci*. They also found that refuges harbored greater numbers of sweetpotato whitefly than aphelinid parasitoids early in the growing season. This result illustrates the potential of any overwintering site or refuge strip to harbor crop pests in addition to natural enemies.

Alternate host and prey

Parasitoids and predators may also require alternate hosts or prey to complete their lifecycle, or when primary hosts or prey are not available. When alternate hosts live on specific plant species, plants that commonly harbor these species may be planted near crops to increase pest control nearby (e.g. Corbett and Rosenheim, 1996). A greater diversity of alternate hosts and prey may be available in landscapes with more non-crop habitat. Menalled *et al.* (1999) examined parasitoid diversity and parasitism rates in simple landscapes primarily composed of cropland versus complex landscapes that contained cropland and successional noncrop habitats. They found no difference between two of three paired simple and complex landscapes, but did find an increase in both parasitoid diversity and rate of parasitism in a third landscape comparison. Similarly, Elliott *et al.* (2002) found that aphid predator diversity was affected by landscape complexity. These studies indicate that the availability of multiple alternate hosts or prey may be greater in more complex landscapes, increasing natural enemy abundance.

Nectar and pollen

Access to nectar and pollen has been shown to significantly increase parasitoid longevity in laboratory studies (Dyer and Landis, 1996; Baggen *et al.*, 1999). In addition to feeding on prey, predators feed on pollen (Harmon *et al.*, 2000), which can

increase fecundity (Hickman and Wratten, 1996) and may be required for egg maturation (Ehler, 1998). Some species also use plant resources such as phloem fluids to supplement their diet (Eubanks and Denno, 1999). Multiple studies have found increased natural enemy abundance in the presence of flowering plants (Colley and Luna, 2000; Frank, Shrewsbury, 2004; Lee, Heimpel, 2005; Rebek *et al.*, 2005; Forehand *et al.*, 2006; Pontin *et al.*, 2006). Fiedler and Landis (2007a) compared native Michigan plant species with several exotic species that were commonly used for habitat management in the past. They found that natural enemy abundance at flowering native plants was equal to or greater than abundance at flowering exotic species. The most attractive plant of the 51 plant species tested was the native boneset, *Eupatorium maculatum*, with an average of 199 natural enemies / m² during full bloom. In addition, they found that floral area per m² explained 20% of the variability in natural enemy abundance at native plants (Fiedler and Landis, 2007b).

Shelter

Disturbances including cultivation and pesticide use are frequent within fields in agricultural systems. Refuge from these disturbances can be promoted outside of the crop field, and may decrease natural enemy mortality rate (Gurr *et al.*, 1998). Lee *et al.* (2001) examined the effects of non-crop refuge strips on carabid populations in corn with and without pesticide application. In pesticide treated areas, they found greater ground beetle abundance in refuge strips than in corn-planted control strips. As the growing season progressed, ground beetles were also more abundant in pesticide treated crops near refuge strips. These results indicate that refuge strips containing perennial flowering plants, legumes, and grasses benefit ground beetle populations exposed to in-field disturbances.

Summary

Agricultural landscapes are a mosaic of crop and non-crop habitats that support unique pools of insect pests and their natural enemies. The relative abundance and diversity of these species depends on the diversity of habitats within the landscape as well as habitat patch size, arrangement, and connectivity. Understanding the relative ability of a landscape to provide biocontrol agents is a critical first step in implementing an integrated pest management strategy. At local scales, the relative timing of pest and natural enemy arrival into the crop, enemy interactions such as intraguild predation, and the occurrence of key natural enemies all influence the outcome of pest enemy interactions. By understanding the resources natural enemies need in order to be effective, managers can manipulate local cropping systems and the agricultural landscapes in which they are embedded to enhance biological control.

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Connecting IPM Research with Extension

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Agricultural Research and Funding

The U.S. agricultural system is organized at Federal, State, University, Private, and Commodity Group levels. The U.S. Department of Agriculture (USDA) is a federal agency that funds research projects of national or regional relevance. The USDA also plays a regulatory role at the national level. All 50 states have agencies similar to the federal USDA. These agencies fund research projects that have relevance to individual state's needs. They also are responsible for and enforce state regulations. In Michigan, this agency is titled the Michigan Department of Agriculture (MDA). Each state has at least one Land-Grant University that is dedicated to agricultural development. In Michigan, Michigan State University is the university charged with the mission to meet the agricultural needs of the state. The private sector funds agricultural research projects related to their own interests. Examples would include insecticide, herbicide, and fungicide trials, as well as other projects. Commodity groups fund research projects that meet their specific needs. Monies for these projects are usually obtained by adding a tariff, collected by the commodity group, to the amount of the commodity produced.

Background on the U.S. Land-Grant University System and Extension

The U.S. Congress passed the “Morrill Act” in 1862. This act established the Land Grant University System whereby lands were set aside for the development of institutes of higher education to promote agricultural education. The “Hatch Act” (1887) created the Agricultural Experiment Station and this act established a method of using federal monies to fund agricultural research at the university level. In 1914,

the “Smith Lever Act” was enacted establishing the Cooperative Extension Service. These three acts set the framework for the Land Grant University Systems leading to our present day mission of Research, Teaching, and Extension.

Michigan State University

Michigan State University is recognized as the premier land grant public university. It was founded in East Lansing, Michigan in 1885 (Fig 1). The College of Agriculture and Natural Resources (CANR) was the first college of the university meeting the role of the land grant mission. Today there are 17 degree-granting colleges offering studies from fine arts to human medicine.

The College of Agriculture and Natural Resources is the lead college for 14 departments including Animal Science, Crop and Soil Science, Entomology, Forestry, Horticulture, Plant Pathology, and eight additional departments. Faculty members of these departments have split appointments where their time is divided between research, teaching, and extension. This arrangement allows for a means of disseminating information obtained from research to the agriculture community through the extension system.

MSU Extension

The mission of MSU Extension is: “Helping people improve their lives through an educational process that applies knowledge to critical needs, issues, and opportunities”. MSU extension has a statewide presence. There are 83 counties in Michigan and each county has an Extension Educator. These educators are funded by the county and MSU. To understand the agricultural needs of the state, Area of Expertise Teams meet periodically to discuss such issues. These teams include faculty members from the university, county extension educators, people from the private sector, and commodity group personnel.

There are 29 Area of Expertise Teams (Table 1) examining issues related to topics ranging from the beef industry to water quality.

Figure 1. Map of the U.S. and the State of Michigan.



Table 1. Area of Expertise Teams

Beef	Food safety	Youth development
Christmas tree	Forage/pastures/grazing	Land use
Community development	Forestry	Leadership
Dairy	Fruit	Manure
Economic development	Fisheries and wildlife	Ornamentals
Equine	Human development	Pork
Family resource mang.	Tourism	Poultry
Farm management	Vegetables	Sheep
Field crops	Volunteerism	State and local gov.
Food nutrition and health	Water quality	

Information Dissemination

Information from research is disseminated by various methods. The world-wide-web is a useful tool for providing information in real time. Weekly newsletters pertaining to current issues are published on-line as well as mailed to subscribers. Faculty members, as well as extension educators, write articles for trade journals and visit farm sites where problems exist. Researchers and educators from Area of Expertise Teams have demonstration plots on growers' fields, or at one or more of the university

farms, and conduct field days where they interact with the agriculture community. Winter conferences are also a means of providing information to growers. At these conferences researchers from in state as well as from neighboring states present findings from their research efforts.

The Land Grant University system links research and extension by combining the Agricultural Experiment Station, the Cooperative Extension System, and campus and field staff to disseminate information to the agricultural community.



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Integrated Pest Management Stakeholders Forum for Central Asia Region

Dushanbe, Tajikistan
May 27-29, 2007

Organized by:

Institute of International Agriculture, Michigan State University
and:

USAID Integrated Pest Management
Collaborative Research Support Program (IPM CRSP)

in collaboration with:

- Plant Protection and Quarantine Research Institute of Tajik Academy of Agricultural Science
- Institute of zoology and parasitology Academy of Science of Tajikistan
- ICARDA/PFU-CGIAR
- Oxfam
- University of California-Davis, U.S.A.



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 **Oxfam**

**Program for Central Asia Region
IPM Stakeholders Forum
May 27 - 29, 2007, Dushanbe, Tajikistan**

Forum Venue: Kokhi Vakhdat, Rudaki Ave. 105, floor 3,
and conference hall 123, Dushanbe, Tajikistan

Sunday, May 27

Chairperson: Dr. Nurali Saidov

- 8:30 a.m.: Registration
- 9:00 a.m.: Welcoming Remarks
Dr. Tolib Nabiev - President of Tajik Academy
of Agricultural Science.
- 9:10 a.m.: Opening Remarks
Dr. Robert Hedlund, USAID/EGAT/NRM
- 9:20 am: Introduction of Participants

Session I: Central Asia Region IPM Crsp Program

Chairperson: Dr. George Bird

- 9:30 a.m. Overview of the IPM CRSP Program
Dr. Karim Maredia and *Dr. Dieudonne Baributsa*
- 9:45 a.m. Landscape Ecology and Biological Control
Dr. Nurali Saidov and *Dr. Doug Landis*
- 10:15 a.m. Coffee/Tea Break
- 10:45 a.m. Enhancing the Efficiency and Product Lines of
Biolaboratories in Central Asia
Dr. Barno Tashpulatova and *Dr. Frank Zalom*
- 11:15 a.m. Strengthening IPM Outreach/ Education in the
Central Asia Region
Dr. Murat Aitmatov, *Dr. George Bird* and *Dr. Walter Pett*
- 11:45 a.m. Open Discussion
- 12:00 noon Lunch

Session li : Linking Central Asia Region With International IPM Programs

Chairperson: Dr. Sagitov Urazovich

- 1:00 p.m. IPM of Sunn Pest: Current Status and Future Plans
Dr. Mustapha El Bohssini, ICARDA Syria
- 1:20 p.m. Applications of Information Technology and Databases in IPM
Dr. Yulu Xia and Dr. Ron Stinner, IPM-CRSP, North Carolina State University
- 1:40 p.m. Integrated Management of Thrips-borne Tospovirus Diseases in Vegetables Crops
Dr. Naidu A. Rayapati, IPM-CRSP, Washington St. University
- 2:00 p.m. OXFAM Tajikistan
Mr. Christophe Viltard and Mr. Peter Pichler
- 2:30 p.m. Coffee/Tea Break
-

Session lii: Country Presentations Of IPM Programs

Chairperson: Dr. Murat Aitmatov

- 3:00 p.m. IPM Programs in Tajikistan
Dr. Abdusattor Saidov, Institute of Zoology and Parasitology
- 3:20 p.m. Current State and the prospect for IPM in Tajikistan
Dr. Anvar Jalilov, Vice Director of IPPQ
- 3:40 p.m. IPM Programs in Kazakhstan
Dr. Sagitov Abai Urazovich, Director of Institute of Plant Protection
- 4:00 p.m. IPM Programs in Kyrgyzstan
*Dr. Tumanov Janubai Tumanovich—
Director of Central Biolaboratory*
- 4:20 p.m. IPM Programs in Kyrgyzstan—ATC Perspective
Ms. Gulnaz Kaseeva- Advisory Training Center
- 4:40 p.m. Virus Diseases of Plants in Uzbekistan
Dr. Kadirova Zarifa—Institute of Genetics and Plant Experimental Biology
- 5:00 p.m. General Discussion
- 5:30 p.m. Adjourn
- 7:00 p.m. Networking Dinner at Hotel Avesto or at Tea house “Rohat”

Monday, May 28

Special Workshops

Chairperson: Dr. Barno Tashpulatova

8:30 a.m.	Landscape Ecology and Sustainable Agriculture <i>Dr. Doug Landis</i>
10:00 a.m.	Coffee/Tea Break
10:30 a.m.	Soil Quality Renovation and Maintenance Strategies <i>Dr. George Bird</i>
12:00 noon	Lunch

Chairperson: Ms. Gulnaz Kaseeva

1:30 pm.	Enhancing Beneficial Insects with Flowering Plants <i>Dr. Doug Landis, MSU and Dr. Nurali Saidov</i>
2:30 p.m.	Coffee/Tea Break
3:00 p.m.	Plant Parasitic Nematode Management Practices <i>Dr. George Bird</i>
4:00 p.m.	Connecting IPM Research with Extension <i>Dr. Walter Pett</i>

Tuesday, May 29

Field Trips

- ◆ Visit to a Research site with Native plants at the Institute of Zoology and Parasitology of Tajik Academy of Sciences.
- ◆ Visit to Farmer Field School (FFS) site in the Plant Protection and Quarantine Research Institute of Tajik Academy of Agricultural Sciences (TAAS).
- ◆ Visit to a local vegetables farm in Tursunzoda district.

List of Participants

Central Asia Region IPM Stakeholders Forum

May 27-29, 2007

Dushanbe, Tajikistan

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