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PLANT PROTECTION ACTIVITIES AT AVRDC - THE WORLD VEGETABLE CENTER

The World Vegetable Center (AVRDC) based at Tainan, Taiwan, is the principal international center for vegetable research and development in the world. Its mission is to reduce poverty and malnutrition in developing countries through improved production and consumption of vegetables. Plant protection pursuits are integral components in AVRDC's efforts to improve vegetable production in developing countries. The Center's research efforts in plant pathology, entomology, plant breeding and weed science are directed towards developing and disseminating sustainable IPM systems that reduce production costs and provide safe vegetables to consumers at affordable prices.

AVRDC's R&D activities focus on vegetables with regional or global importance. These include tomato, pepper (hot and sweet), eggplant, allium crops (shallot, onion, garlic), vegetable legumes (soybean, mungbean, yardlong bean), vegetable brassicas, and indigenous vegetables. Research on cucurbits has also been initiated.

Surveys, pest diagnosis and characterization
Identification of pests of economic importance is jointly done with advanced laboratories, NARES (national agricultural research and extension systems) and the private sector. AVRDC's research is focused on the following important pests: bacterial wilt, fusarium wilt, late blight, whitefly-transmitted geminiviruses (WTG), and tomato fruit worm of tomato; bacterial wilt, phytophthora blight, anthracnose, chili veinal mottle virus (ChiVMV), cucumber mosaic virus (CMV), and WTG of pepper; bacterial wilt and eggplant fruit and shoot borer (EFSB) of eggplant; stemphylium blight and various viruses of allium crops; soybean rust, mungbean powdery mildew and cercospora leaf spot, WTG, and pod borer of legumes; and diamondback moth (DBM) of vegetable brassicas.

Diagnostic tools including morphology, selective media, ELISA, and others have been adopted or developed for surveys. Recent development of molecular tools has improved diagnostic efficiency. For example, species-specific primers of *Collectotrichum spp*. associated with pepper anthracnose have been developed to complement morphological traits. A multiplex PCR protocol has been adopted to identify *Ralstonia solanacearum* as well as its phylotype. General and specific primers for WTG have been developed and used to identify distinct viruses from different locations and crops. For plant pathogens with large variation like *Phytophthora infestans* and *R. solanacearum*, molecular methods as well as bioassays have been used to characterize local or global populations.

Host plant resistance
Reliable and efficient screening protocols have been developed at AVRDC for breeding and selection of host plant resistance. Accessions in the AVRDC germplasm collection provide an excellent resource for identifying sources of resistance to major pests. Research networks conduct field evaluations in different geographic locations and screen lines with different strains of the pest to enable development of genotypes with durable resistance. In China, Indonesia, India and Thailand AVRDC is working with NARES to improve local chili varieties with multiple disease resistance and to improve local integrated crop management systems. AVRDC in collaboration with Indian and British institutions has developed and released 3 open-pollinated (OP) WTG resistant tomato varieties in India. At the AVRDC Regional Center for Africa in Tanzania, tomato and chili pepper lines are being screened for disease and insect pest resistance and regional adaptation. Host plant resistance will be a major component of the AVRDC-developed IPM strategies for a vegetable-forestry cropping system in Indonesia, where vegetables are being introduced into the agro-forestry for crop diversification.

Understanding the genetic control of resistance traits assists breeders in designing effective selection strategies. Our recent efforts focus on developing molecular markers to improve breeding efficiency. Use of molecular markers linked to different resistance genes against tomato WTG facilitates gene pyramiding and development of lines with resistance to a broader array of WTG. Other activities include developing markers to screen a fruit trait, anthracnose resistance, in pepper seedlings, and identifying and fine mapping quantitative trait loci (QTLs) for tomato bacterial wilt resistance.

When conventional breeding is inefficient or it has not been possible to develop improved lines with resistance to

certain pests, gene transformation technology is explored. For example, AVRDC scientists have transformed tomato with a viral coat-protein gene in order to achieve CMV resistance. Our studies have shown that NPR1, an important regulatory gene in the defense mechanism in *Arabidopsis*, could enhance resistance to several pathogens. Such a strategy could be an efficient way to build up resistance to a broad spectrum of diseases.

Cultural control
Various cultural practices have been evaluated for controlling different pests. These include use of reflective mulches to control aphid-transmitted viruses of peppers, seedling protection to manage WTG in tomato, clean vegetable planting materials to manage various garlic and shallot viral diseases, use of soil amendments and disease resistant rootstocks to control soil-borne diseases. Growing vegetables under protective structures to shield them from insects is becoming increasingly common, especially for leafy vegetables in peri-urban production areas. Our studies have shown that 15 cycles of various leafy vegetables, free of any pesticide use could be grown over a span of two years using this technology. In many areas of West Africa tomato production is no longer possible because of WTG. AVRDC's Mali office is currently coordinating regional resistance screening trials in partnership with US universities and seven NARES from West Africa (Mali, Benin, Togo, Burkina Faso, Ghana, Niger, and Senegal). Sampling activities of tomato-infected leaves for virus identification is also being conducted. Cultural practices including tomato seed treatment, planting dates, the use of nets at the nursery level, and a host free period will be evaluated in conjunction with host plant resistance.

Biological control
Biological control has been effectively used to manage certain insect pests of vegetables. The larval parasitoid, *Diadegma semiclausum* and pupal parasitoid, *Diadromus collaris* have successfully controlled DBM, in highland areas of Asia. These parasitoids are currently being introduced in East and South Africa countries. In the lowlands, the less effective larval parasitoid *Cotesia plutellae* is present and research is ongoing to identify a high temperature-tolerant, pupal parasitoid for tropical lowlands. The AVRDC-developed IPM of EFSB *Leucinodes orbonalis* is being used to control the most important pest of eggplant in South Asia. IPM components include use of sex pheromone traps, removal of damaged shoots, and management of plant residues. The sex-pheromone of EFSB is now commercialized in South Asia and field days, farmer training, press releases, wall paintings and other activities have been carried out to popularize and promote these technologies in Bangladesh, India, and Sri Lanka. The success of this technology transfer resulted in a five times increase of sex-pheromone sales by two suppliers in Gujarat, India from 2002 to 2005. AVRDC is working with US and Ugandan universities to research IPM strategies for tomato fruitworm. GIS and GPS tools are being used to investigate fruitworm population densities, spatial distributions and natural enemy population characteristics. Biopesticides, such as Nuclear Polyhedrosis Virus (NPV) have also been explored for control of legume pod borer, *Maruca vitrata*.

Organic vegetable program
Weeds, diseases, and insect pest management are all subjects of the recently launched AVRDC organic vegetable program. Weeds are managed using plastic or rice straw mulch, tillers, mowers, and hand weeding. Soil-borne pests are managed by flooding the soil for a minimum of three days. Protection under nets is being used to exclude air-borne insect pests. Pheromone traps and sticky traps are utilized to monitor insect pest populations. Various lepidopteran larvae are controlled with *Bacillus thuringiensis* (Bt) products and sucking insect pests with neem products. The potential of botanical pesticides will be explored in the future. Disease-resistant/tolerant varieties are being evaluated under organic conditions.

Training and Information Dissemination
Plant protection training has been implemented via different methodologies. Lectures on plant protection are included in all vegetable production training courses conducted by AVRDC. Specialized training is provided for research interns coming from NARES as well as the private sector. Graduate student research is also supervised at AVRDC.

Besides scientific journal publications, AVRDC produces in-house publications related to plant protection subjects. A list of publications related to IPM can be found at
http://www.avrdc.org/pub_ipm.html.
Fact sheets on important vegetable pests can be found in the on-line Learning Center
http://www.avrdc.org/LC/home.html.

AVRDC is expanding its activities into more locations in the world, uncovering new challenges in the identification and implementation of more effective IPM tools. Collaborations with public and private partners are an essential component to effectively improving vegetable production in the developing world. Through such partnerships, AVRDC will strengthen its efforts and continue to play a leadership role in vegetable IPM worldwide.

For more information on our plant protection activities:

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IAPPS Mission: to provide a global forum for the purpose of identifying, evaluating, integrating, and promoting plant protection concepts, technologies, and policies that are economically, environmentally, and socially acceptable.

It seeks to provide a global umbrella for the plant protection sciences to facilitate and promote the application of the Integrated Pest Management (IPM) approach to a the world's crop and forest ecosystems.

Membership Information: IAPPS has four classes of membership (individual, affiliate, associate, and corporate) which are described **here**.

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