Proceedings of the APSA-AVRDC Workshop

1-2 May 2006
AVRDC, Shanhua, Taiwan

AVRDC
The World Vegetable Center

APSA
THE ASIA & PACIFIC SEED ASSOCIATION

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Shanhua, Tainan, Taiwan

AVRDC – The World Vegetable Center is an international not-for-profit organization committed to improved nutrition, job creation and food safety for the world's poor through research, development and training.

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Executive Summary

The Annual APSA-AVRDC Workshop held 1-2 May 2006, attracted 31 participants to AVRDC-The World Vegetable Center's Headquarters in Shanhua, Tainan, Taiwan, representing 20 of the 24 companies participating in the APSA-AVRDC Agreement. AVRDC staff and participants to the workshop were welcomed by Dr. T. A. Lumpkin, Director General, and Dr. J. Hughes, Deputy Director General for Research at AVRDC, gave an overview of AVRDC's experience in working with the private sector. The objective of the workshop was to continue to develop relationships between AVRDC and APSA and to present some ongoing research.

A highlight of the workshop was the signing of the AVRDC-APSA Agreement by Dr. K. Hatsuda, President of APSA and AVRDC's Director General, Dr. T. A. Lumpkin. The Agreement stipulates APSA will contribute US$150,000 per year for three years (US$450,000) to support AVRDC's core activities. This agreement is much appreciated by AVRDC and the pivotal roles of the APSA Secretariat (especially Dr. J. S. Sindhu) and AVRDC's Management must be acknowledged.

An Executive Committee chaired by Mr A. Tse was created as a mechanism to coordinate between APSA members and AVRDC management.

A series of presentations from AVRDC scientists included an update by Dr. R. De la Peña on the Ty-2 marker activities, which is currently being funded by some APSA member companies. The possibility of developing a proposal to extend these activities with additional funding was discussed. Dr. G. Kuo presented AVRDC's Central Asia and Caucasus Initiative, and some companies expressed interest in visiting the region to assess needs and possible entry points, particularly with respect to seed production and training. Models for private sector recognition of public sector products were presented by Dr. P. Gniffke and the APSA participants agreed this was a necessary part of public-private partnerships.

Dr. P. Hanson presented AVRDC's role in providing training to APSA members, and a prioritized list of training needs was identified during the meeting. Dr. L. Engle described the many accessions in the genebank at AVRDC Taiwan, Asian Regional Center and Regional Center for Africa. The mechanism for obtaining access to the germplasm was outlined.

A guest speaker, Dr. R. Naidu from Washington State University, discussed the challenges and opportunities in tackling the threat of tospoviruses. Strong interest shown by most participants will result in the development of a proposal to address the issue of tospos in vegetables.

Field tours of a demonstration plot and research fields together with a facilities tour allowed the APSA members to enjoy an afternoon of interaction with AVRDC's scientists before the farewell dinner. The firm relationship between APSA, the APSA members and AVRDC's management and scientists will lead to many fruitful interactions before we meet again in 2007.

Chapter 1

Program

1 May 2006

08:30-09:00	Registration
09:00-09:15	Welcome Remarks *T. Lumpkin*
09:15-09:30	AVRDC – Working with the Private Sector *J. Hughes*
09:30-09:50	Making the Most of Public-Private Partnerships *A. Tse*
09:50-10:00	Discussion
10:00-10:10	Signing of APSA-AVRDC Agreement *J. Sindhu and T. Lumpkin*
10:10-10:40	Group Photo and Coffee
10:40-10:55	Understanding the APSA-AVRDC Agreement *J. Hughes*
10:55-11:25	AVRDC's Central Asia and Caucasus Initiative *G. Kuo*
11:25-11:45	Discussion
11:45-13:00	Lunch

Chairman: T. Lumpkin
Rapporteurs: P. Ooi and M. Kaiser

13:00-13:20	Development of a PCR Marker Based Selection of the Geminivirus Resistance Gene Ty-2 in Tomato *R. de la Peña*
13:20-13:30	Discussion
13:30-14:00	International Tomato Variety Trials *P. Ooi*
14:00-15:00	Discussion
15:00-15:30	Coffee Break

Chairman: J. Sindu
Rapporteurs: J. Wang and P. Hanson

15:30-15:45	Models for Private Sector Recognition of AVRDC Improved Germplasm *P. Gniffke*
15:45-16:00	Discussion
16:00-16:30	APSA Training Priorities *P. Hanson*
18:00	Welcome Dinner

Chairman: W. Co
Rapporteurs: K. Weinberger

2 May 2006

09:00-10:00	A Global Approach to Tackle Tospoviruses in Vegetables: Challenges and Opportunities *R. Naidu*
10:00-10:30	Coffee break
10:30-11:00	Discussion
11:00-11:20	The Role of AVRDC in Facilitating Germplasm Exchange *L. Engle*
11:20-11:45	Discussion
11:45-13:00	Lunch

Chairman: J. Hughes
Rapporteurs: P. Gniffke and R. de la Peña

13:00-16:00	Field Tours
18:15	Farewell Dinner

AVRDC Field Tours

Group A
(accompanied by Jaw-Fen Wang)

Group B
(accompanied by Tien-Chen Wang)

13.30-1350	Genetic Resources and Seed Unit *V. Alcantara, J. Shieh*
13.50-14.10	Field #29 Germplasm Regeneration *Y. Huang*
14.10- 14.55	Field #95 Recently Released Pepper Varieties *P. Gniffke*
14.55-15.40	Field #62 New Tomato Breeding Lines

Chapter 2

Minutes

1 May 2006

Introduction

In his welcome address, Director General Lumpkin covered AVRDC effort in addressing the needs of APSA within the framework of private-public partnership. One of the strengths of AVRDC is its position to deliver public goods to meet AVRDCs' overall mission to alleviate poverty and reduce malnutrition. As such, AVRDC has expanded to address the declining food security in Africa and is taking a leadership role in the Global Horticulture Initiative. To promote a more interactive learning, AVRDC is also enhancing its internet media capability.

AVRDC- Working with the Private Sector Making the Most of Public-Private Partnerships

Hughes identified the platform for AVRDC working with the private sector and presented issues of collaboration. The strengths of public-private partnerships that allowed a complimentary relationship between AVRDC and APSA were then discussed by Tse. During the discussion, Naidu inquired about the prospect of other training besides conventional breeding and biotechnology and Tiko sought further clarification on whether the training mentioned by Tse should also include pest control, especially reducing pesticide residues. Lumpkin noted the need for training on open pollinated technology but pointed out the negative trends observed in major universities where education in horticulture science is actually declining and this may really pose problems in providing the resources to carry out training. Lumpkin suggested that this could be attributed to public perception about the eroding effect of agriculture on the environment thereby diminishing the name of agriculture.

Gniffke encouraged APSA to help AVRDC generate more public goods. Tse requested that APSA's contribution be committed to core funding at AVRDC and Lumpkin confirmed that APSA's contribution will be assigned to core funding. Hoop suggested that to address the impact requested by AVRDC, perhaps charging royalty for finished products produced from AVRDC's germplasm pool would be a way. However, in the case of indirect use of AVRDC germplasm, it was suggested that calculating royalty may be challenging.

Understanding the APSA-AVRDC Agreement

There was no active objection to the listing of the candidate areas of supported activities, as outlined in the 2005 APSA workshop summary. Discussion emphasized continuing interest in leafy brassicas, and cucurbits, including cucumber, melons, bittergourd, pumpkin, and watermelon. Cucumber was mentioned as a worthy focus as it is an extensive and economically important crop, in which relatively little work has been done. Target traits suggested included viruses (mapping incidence and screening for sources of resistance), resistance to downy mildew and powdery mildew, cold tolerance as well as heat tolerance, and reduction of bitterness.

In order to facilitate communication between the APSA members supporting the AVRDC research grant, and AVRDC, a coordinating committee was identified to coordinate among the APSA members, to serve as liaison with AVRDC principle researchers, and to forward recommendations to the APSA secretariate. Committee membership included: Tse, Anand, de Hoop, Singh, and Moriguchi.

Continued work on geminivirus resistance, and extending and expanding work with the TY-2 gene also received strong support, and it was recommended to extend and give this work greater priority. Phase 3 work of the current funded project will be completed, and a concept note to expand the work to stack multiple genes will be submitted by de la Peña. High interest was expressed in the challenges of geminiviruses, and the comments and suggestions included:

- The importance of stacking several genes to broaden resistance

- The need to validate the project result through cooperator testing of developed germplasm and markers generated in phase 2

- Possibilities of blending AVRDC and APSA plant materials during the validation phase, so that breeding progress can be made simultaneously with methods development

- Issues regarding advance reporting. As publications involve delays of a year or more, there should be little problem with APSA receiving advance access to reports and information; marker information may be restricted to the 13 funding members of the project, but germplasm/genetic material releases will remain unrestricted.

AVRDC Central Asia and Caucasus Initiative

Sindhu suggested that AVRDC contact persons in the Central Asia and Caucasus (CAC) region should be invited to the upcoming APSA meeting in November 2006 and asked whether AVRDC could assist in initiating the contact between resource persons from CAC and APSA. It was put forward that APSA members would be willing to collaborate with CAC partners on OP and hybrid seed production. Lumpkin stated that the CAC region has a huge potential for large scale vegetable seed production, as the climate conditions are excellent and the laborers are quite well educated. Kuo mentioned that there are language problems in the region as English is spoken only by a few people and any interaction would require the assistance of a translator. It was stated that AVRDC was pleased with Sindhu's proposal and will try to help identify people for the APSA November 2006 meeting.

Lumpkin asked APSA for assistance in requesting funds from the Asian Development Bank (ADB). ADB has a strong interest in the CAC region, but not in agriculture. Therefore, it was suggested that APSA and AVRDC should team up their efforts and convince ADB of the necessity to fund agricultural projects.

Pathak asked whether AVRDC can identify the value of vegetable crops produced in the CAC region. Kuo referred to the proceedings of the workshop held in Tashkent, Uzbekistan, which provides an excellent overview on the status of seed and vegetable production in the countries. The report can be downloaded from AVRDC website (http://www.avrdc.org/pub_workshop.html). Tse asked whether AVRDC could organize a study to the CAC region to enable APSA to familiarize themselves with the vegetable seed production in the region. Kuo replied that APSA members would be able to participate in upcoming conferences related to horticulture in the region.

Development of a PCR Marker Based Selection of the Geminivirus Resistance Gene Ty-2 in Tomato

Ravi, asked what strain was used to screen Ty-2 materials and Green responded it was the Taiwan strain. Ravi stated that both monopartite and bipartite strains of geminivirus are present in India and bipartite strains are present all over India, therefore, development of resistant lines needs to consider the virus strain variation. It was requested that de la Peña explain the progress of the Ty-2 contract to a 3-person technical committee headed by Anand in 7 to 10 days following the APSA meeting.

Tikoo asked what was the QTL approach to develop durable resistance to geminivirus and de la Peña stated, to develop lines with multiple resistance genes using markers. It was then suggested by Tikoo that developing markers for other resistance sources and pyramiding could be a new project. Sindhu responded that the current contract needed to be completed before initiating other projects.

Naidu asked what was the situation on vector (whitefly) resistance in tomato to which Hanson responded that *L. pennellii* provides broad spectrum resistance against many insects and the root knot nematode resistance gene, *Mi*, provides partial resistance to pupae of whitefly.

The progress on mapping of acylsugar on *L. pennelli* was asked by de Hoop. Hanson responded that Dr. Mutschler at Cornell University may have incorporated the trait into cultivated tomato background. Green stated that an Israel group may have incorporated the insect resistance into their lines already.

International Tomato Variety Trials

Tikoo asked about the objective of the international trials and whether the purpose was to determine market acceptance information or information on reactions of entries to abiotic and biotic stresses.

He stated that little market information would be gained from international eggplant trials as eggplant is a highly segmented market. Tomato fruit preferences also vary in the region. He suggested that the trials be designed to provide information on disease resistance, reactions to stress, etc. that would have plant breeding implications. Tikoo commented that it is important to consider season as well as location when establishing trials. Tse questioned the meaning of information from trials conducted over nine countries with such diverse climates and market preferences. Hanson and Suh suggested that the trials be targeted to major agro-ecological zones and trial locations be selected that are representative of different zones.

Arora thought that a tomato trial emphasizing processing types would be useful. Wang stated that the trials should focus on traits rather than market types. Tomato trials emphasizing geminivirus and bacterial wilt resistance was proposed by Anand, as these are traits that are needed for most countries in the region. Green and Wu added that extension of the trials to the Caucasus countries could gain information on market potential and varietal adaptation to local disease problems and climatic conditions.

Regarding the conduct of trials, Sindhu thought that both company collaborators and national programs could perform the trials. JK Agri Genetics volunteered to conduct the trial for free and encouraged other companies to do the same as this could reduce costs and the US$1500 entry charge. Careful selection of National Agriculture Research Systems capable of conducting the trials would be critical. Sindhu added that proper entry coding was very important. It was suggested by Green that each trial collaborator be given flexibility to add a local check in addition to the common check across trials which would be chosen by AVRDC. Several participants questioned the US$1500 entry charge, and it was generally agreed that entry cost should be calculated after modalities and protocols are worked out.

The question of local versus a standardized trial protocol was raised. While Ooi stated that uniformity of trial protocol over locations is important, Tikoo and several others questioned the value of imposing cultural practices not representative of local farmer practices. A critical mass of 10 companies each submitting two entries are required to initiate the tomato trial. Ooi will work out the protocol and procedures in consultation with an APSA sub-group and approach the APSA companies again in the future.

Models for Private Sector Recognition of AVRDC Improved Germplasm

It was requested by de Hoop that seed companies send in yearly progress report on sales, description of use, and trial reports, and to have APSA endorse this. Pathak stated this could be done at the time of AVRDC/APSA meeting.

Gniffke requested APSA to develop a format for details of business activity that they are willing to share on a group level, and not on an individual level and stated that APSA should take the lead in designing the questionnaire, which everybody who uses AVRDC material should send back to AVRDC. Kaiser suggested February would be the best time, so that it is ready for the board meeting. Weinberger stated a uniform/structured report is required that all companies using AVRDC material will complete. Hanson suggested including information in the seed catalogue, if possible. Sindhu summarized that use of AVRDC material should be acknowledged. Green suggested that since everybody is obliged to return the Material Transfer Agreement (MTA), the obligation to fill in such a questionnaire could be added into the MTA.

Pathak asked about the training that AVRDC offers. Hughes responded that the Scientists are primarily involved in research but that the advantage of long-term training is that they will fit into AVRDCs' research activities. It was also stated by Green that there is a role for short-term training, i.e. screening techniques; however, the current bench fee is too low. A list of topics of interest was identified and voted on by workshop participants. The results for each topic were as follows; Application of molecular markers/molecular characterization:18 votes; Screening techniques for diseases: 17 votes; Nutritional qualities: 9 votes; Management of vegetable germplasm: 1 vote; Vegetable breeding: 0 votes; Seed quality assessment: 0 votes; Hybrid seed production: 0 votes; Experimental design: 0 votes.

Addo asked about vegetable greenhouse production, but Hanson replied that there is no AVRDC expertise.

Sindhu announced a seed health training course, a collaboration between APSA and AVRDC, and funded by the Food andAgriculture Organization of the United Nations. Hughes stated AVRDC will work out a training program that will look at aspects of what, when, and who to involve.

Tickoo stated he would like to see a short progress report on AVRDC activities as in the past year and requested a copy of all presentations. Hamilton will make a CD ROM with the available presentations.

2 May 2006

A Global Approach to Tackle Tospoviruses in Vegetables: Challenges and Opportunities

APSA members discussed aspects of the tospovirus problem, including the reasons for expansion of the incidence in India. Naidu outlined the list of complex factors including the ability of vector and virus to expand host range. The increased production of tomato into the off-season provide's host refuge over a longer period, and reduces the seasonal breaks in the vector life cycle.

In order to facilitate collaboration of APSA members in tospovirus research, Sindhu appointed a committee to formulate recommendations; the committee includes Deshpande, Sumitra, Sandhiker, Ravi, and Angadi of APSA, as well as Hanson, Gniffke, and Srinivasan of AVRDC. Accessing the UC-Davis tomato collection (Roger Chetelat) was discussed, which has reported accessions of *L. chilense* with tolerance to tospovirus. It was suggested that APSA members with pathologists should collaborate in compiling crop lists, geographic patterns of incidence, candidate crop accessions, and virus isolates for further study. Also collaboration in developing good diagnostic methods for distribution and coperating in the screening of candidate germplasm in multiple locations was discussed. There was suggestion that transgenic approaches might be worthwhile, but candidate sequences for broad spectrum resistance have not been identified. Green felt that N-protein sequences were available and feasible, but that the key challenges lay in developing reliable screening methodologies and improved thrips rearing systems, to supplement mechanical transmission studies. Biological control strategies were also mentioned, including predators, which have been studied to some extent in the Philippines. There was discussion that bio-control of the vector will likely not be effective in the control of the virus, because infrequent feeding can still cause extensive disease transmission. Direct damage of thrips to crops (especially in combination with mites) can cause extensive economic losses in themselves.

The Role of AVRDC in Facilitating Germplasm

The germplasm collection of AVRDC's principal crops, facilities and management of plant genetic resources, and multilateral agreements and barriers to germplasm exchange were presented topics. The protocols for serving seed requests and sending seed shipments were discussed . Most of the discussion was on issues regarding acquisition and exchange of germplasm. The majority of AVRDC's mandated crops are not covered by the current treaty on germplasm collection and exchange. International meetings, such as the FAO meeting on plant genetic resources in Bangkok and a similar meeting in France are being held to address these issues. Different countries have different requirements for germplasm exchange which make it difficult to satisfy requirements before seed shipment from AVRDC. Seed distribution follows the AVRDC Guiding Principles on Intellectual Property Rights and are accompanied by Phytosanitary Certificates and a Material Transfer Agreement. Phytosanitary certificates are obtained from the Council of Agriculture office in Tainan. In cases where photosanitary certificates are not obtained due to inability of the local office to satisfy country requirements, a post-quarantine testing in the recipient county is required. The number of germplasm requests from AVRDC has been increasing through the years.

Chapter 3

Presentation Abstracts

AVRDC-The World Vegetable Center Working with the Private Sector

J. Hughes

As a not-for-profit international organization, AVRDC-The World Vegetable Center is increasingly working in partnership with the private sector to deliver international public goods to the developing world to alleviate poverty and malnutrition. The private sector plays an important role both as research and development partners, but also as part of a private sector technology delivery pipeline. AVRDC-WVC's partnerships include technology development, policy activities, ex-ante assessments, training, responding to urgent need, technology dissemination and impact assessments.

In all public-private partnerships, some key issues need to be resolved by both partners at the inception of the relationship. Intellectual property rights are often a major issue in discussions between private and not-for-profit organizations. However, if the responsibilities of the partners can be clearly described, and the benefits of the partnership to both parties well understood by all the participants from both the private and the public sector, these difficulties can be overcome. Issues of confidentiality must also be resolved at the beginning of the partnership to avoid misunderstandings at a later date. If these issues can be resolved early in any public-private partnership, there will be no unreasonable expectations which can lead to misunderstandings between the partners.

AVRDC-WVC has successfully negotiated effective partnerships on molecular marker development, intellectual property rights, baseline studies, developing appropriate training activities for our private partners, as well as working with entrepreneurs and larger companies on technology production and dissemination. In particular, private seed companies are seen as a crucial pathway to deliver AVRDC-WVC's technologies to the farmers. In addition, the role of the seed companies in partnering with AVRDC-WVC in responding to urgent need is a critical one that has impacted the lives of thousands of people recovering from the effects of natural disasters.

The relationships between AVRDC-WVC and the private sector, in this case APSA, are ones that are nurtured and which help AVRDC ensure that our vegetable research and development effectively alleviates poverty and malnutrition in the developing world.

Making the Best of Public and Private Partnership

A. Tse

Public sector has strengths in up-stream research such as biotechnology, in developing markers for marker assisted selection (MAS), and in plant pathology. They are strong in breeding elite material with disease resistance and other adaptabilities and are able to maintain large germplasm. Private sector has strengths in conventional breeding and developing varieties to meet the demand of a very diverse market. They are also strong in commercialization of their products through a sturdy sales network. The two sectors compliment each other and there are many opportunities for a strong partnership between the two. The private sector relies on the public sector to develop elite breeding material for them to finish as commercial products for the various diverse markets. The public sector also can develop and provide applied biotechnology methods to assist conventional breeding. On the other hand the private sector can provide funding for the research and help disseminate the research outcome to the market.

Since most public universities are withdrawing from conventional breeding it is important that public sectors that are still active in conventional breeding provide training for the next generation of breeders. At the same time as more biotechnology research is funded by private companies it is just as important for the private sector as a group to fund the pubic sector to develop bio-tech methods and keep their availability unrestricted.

Understanding the APSA-AVRDC Agreement

J. Hughes

The Asia Pacific Seed Association and AVRDC-The World Vegetable Center are both dedicated to improving the lives of farming communities and building up the agricultural sectors. As a regional forum for the seed sector, APSA will have a closer relationship with AVRDC through this Funding Agreement, which has been signed by Kazuo Hatsuda, President of APSA on behalf of the contributing APSA member companies.

APSA, on behalf of the contributing companies, will donate US$450,000 in three annual installments to AVRDC's core funds. Some advantages to APSA companies contributing to this Funding Agreement will include:

- Priority dissemination of key research results
- Targeted research to address contributing members needs
- Specific training courses
- Entry into new initiatives and involvement in new developments

This Funding Agreement between APSA and AVRDC will promote interaction between the contributing companies and AVRDC and will strengthen the collaboration. This Funding Agreement will enable the contributing companies to take advantage of new products and technologies from AVRDC before the non-contributing companies. Through this Funding Agreement, AVRDC will be better placed to alleviate poverty and malnutrition in the developing world through the increased production, marketing and consumption of safe vegetables.

AVRDC Initiative in Central Asia and the Caucasus

R. Mavlyanova and G. Kuo

The vegetable sector in Central Asia and the Caucasus is facing various constraints and challenges such as: 1) seasonal fluctuation (only 15% of total production is from November to March) due to extremes of temperature and water availability; 2) relatively low yield (14 t/ha) and per capita supply (99 kg/year); 3) high input costs and limited labor supply; 4) limited diversity (tomato, onion, cabbage and watermelon cover >60% of the total supply); 5) poor farm-to-market infrastructure and post-harvest handling; and 6) limited purchasing power of consumers. The solution to the aforementioned challenges have been delayed due to scarcity of funds for vegetable research and development (R&D), antiquated research facilities, limited human resources, and poor linkage among CAC countries. To respond to the needs of vegetable R&D in the CAC region, AVRDC has mobilized a regional network in the CAC region by launching an initial meeting in June 2003, at Almaty, Kazakhstan, for the five Central Asian countries. And in June 2004, AVRDC was accepted as a member of the CGIAR Collaborative Research Program for Sustainable Agricultural Production in Central Asia and the Caucasus (CGIAR-CAC). After that, AVRDC has set up a CAC regional office under the umbrella of CGIAR-CAC's Program Facilitation Unit in Tashkent, Uzbekistan. And the participants of the AVRDC-organized workshop on CAC vegetable R&D in April 2005, Tashkent, Uzbekistan recommended the following themes for collaborative efforts:

- Introduction of non-traditional and less-utilized vegetables
- Collection, characterization and conservation of indigenous germplasm
- Germplasm enhancement for a wider adaptation
- Coordinated trials of promising varieties
- Adoption of modern, low-cost technologies
- GIS for monitoring insect pests & diseases
- IPM for both open-field & protective productions
- GAP for safe vegetables
- Seed production systems for both open pollinated and hybrids of selected vegetables
- Policy analyses to promote processing and value chain
- Capacity building

Under the above premise, AVRDC is facilitating partners in Armenia, Azerbaijan, Kazakhstan, Tajikistan, Turkmenistan, and Uzbekistan to engage in coordinating regional trials of new vegetables for the region and promising varieties for the region's major vegetables. The vegetables include asparagus, cucumber, mungbean, non-heading Chinese cabbages, tomato of various types, vegetable soybean, yardlong bean, sweet pea, etc. In addition, surveys of viral diseases on major vegetables and training activities are on-going. To further advance this regional partnership, CAC partners and AVRDC view that there is an important role for APSA to play in this network. APSA may partake in the following areas of collaboration:

- Baseline information on agro-environment and marketing of vegetable seed production
- Training on conventional breeding and seed production
- Coordinated regional variety evaluation
- Collaborative research on specific topics
- Assist in establishing entrepreneurial vegetable-seed value-chain system
- Joint venture and/or contracted vegetable seed production

Development of a PCR Marker Based Selection of the Geminivirus Resistance Gene Ty-2 in Tomato

R. de la Peña

Diseases caused by whitefly-transmitted geminiviruses are major constraints in tropical and subtropical tomato production. Geminiviruses are highly variable and include monopartite and bipartite forms. High levels of resistance have been identified in wild relatives of tomato such as *Lycopersicon chilense*, *L. hirsutum*, *L. pimpinellifolium*, *L. cheesmanii*, and *L. peruvianum*. Some of these resistance genes were transferred and utilized in cultivated tomato, including *Ty-1* from *L. chilense* (Zamir *et. al*., 1994) and *Ty-2* from *L. hirsutum* (Kalloo and Banerjee, 1990; Hanson *et. al*., 2000). Both *Ty-1* and *Ty-2* have been mapped to chromosomes 6 and 11, respectively. Resistance conferred by these genes independently provides protection to some, but not all, strains of Tomato Yellow Leaf Curl Virus (TYLCV). Nevertheless, both *Ty-1* and *Ty-2* will be major components in developing varieties with multigenic resistance to geminiviruses.

Fine mapping and development of PCR-based marker for *Ty-2* is an ongoing APSA-AVRDC project. The project is divided into three phases: (I) Identification and development of molecular markers in the introgressed region of chromosome 11, (II) Development of a PCR protocol for MAS of *Ty-2*, and (III) Validation of marker-TYLCV resistance association in APSA's breeding materials. Phases I and II have been completed while Phase III is ongoing.

Two PCR primer sets showed robust amplification and polymorphism either through direct detection of PCR products or digestion by restriction enzyme. A *Ty-2* assay protocol based on direct PCR amplification was sent to the APSA project members. Linkage analysis showed that the DNA marker is closely linked to *Ty-2* within an approximately 10 cM region. Two AVRDC F2 populations and selected breeding lines were used to confirm the marker utility for MAS of *Ty-2*. Based on TYLCV incidence, at least 91% of homozygous marker lines were found to be resistant to the virus in the F2 populations. The reaction of heterozygous lines was variable indicating that *Ty-2* might be partially dominant. The close linkage with TYLCV resistance was also confirmed in 24 out of 26 resistant homozygous breeding lines.

AVRDC has screened and continues to screen materials from the participating APSA members to confirm applicability for MAS. AVRDC has received DNA from some APSA members and marker genotypes were generated and provided. Seeds of segregating populations were also received by AVRDC. These materials were planted, will be assayed for TYLCV resistance, and genotyped. Work is ongoing to identify additional markers linked to *Ty-2* and refine the position of *Ty-2* on chromosome 11. Markers developed in this APSA-AVRDC project will facilitate development of *Ty-2* resistant varieties and provide a tool in pyramiding virus resistance genes.

Recently, new sources of resistance from *L. chilense* have been identified, transferred to *L. esculentum* backgrounds, and mapped to regions on chromosome 6 (Agrama and Scott, 2006). A new project was proposed to map these resistance genes and utilize the *Ty-2* information to develop lines with multiple geminivirus resistance genes. Pyramiding resistance genes will provide a more stable management of geminiviruses across different geographic regions.

International Tomato Variety Trials

P. Ooi

As seed companies continue to develop new vegetable varieties for sale to farmers and the farming community, it is timely for an international varietal trial to be initiated to evaluate these varieties under different agro-ecological conditions in Asia. Three possible candidate vegetables were suggested, namely eggplant/brinjal, hot peppers and tomatoes. A total of nine testing sites, three from South Asia and six from South East and East Asia, were suggested. The objectives of such an independent varietal trial would include:

- Evaluate the performance of up to 20 varieties in a single site within a defined agro-ecological zone: e.g. medium level altitude upland environment in the tropics with equivalent environment in the northern parts of sub-tropics at certain time of the year, e.g. “winter”.

- Identify tolerance traits or otherwise to common diseases of tomato in each of the site, to be recommended by APSA member in addition to the three identified for Thailand below.

- Evaluate eating preferences of local farmers. Also note local preferences of different varieties. A scoring system will be developed.

Models for Private Sector Recognition of AVRDC Improved Germplasm

P. Gniffke

AVRDC-the World Vegetable Center continues to distribute information, technologies, and especially genetic materials, as unrestricted public goods. Vegetable seed samples may range from germplasm of related species, useful in basic research and upstream development, to advanced-generation selected inbred lines usable for direct commercialization. Our donors ask us to document these contributions, and to characterize the impact they may be having, particularly for our target beneficiaries, the small-scale farmer. Collaboration with private sector organizations is an important pathway for transferring our technologies to the beneficiaries, and we seek feedback from these cooperators regarding dissemination and impact of our efforts. Such feedback can be structured in several formats, and should be designed to provide an accurate summary of the effectiveness of AVRDC's work, while respecting the confidentiality and privacy expectations of private institutions. Recognition of AVRDC is required by clauses in our Material Transfer Agreements, when seed lines are received, exploited, and passed along to third party recipients. Several formats are outlined for acknowledgement of AVRDC's role on seed packets, in seed catalogs, and in licensing agreements. In situations in which extended collaborations are maintained, periodic reporting to AVRDC of utilization and impact of seed contributions can be structured to;

- Report on performance or behavior of lines provided by AVRDC
- Update on their use in breeding or commercialization; this could include data on seed production, seed sales, projected farmers/ hectares impacted, and tonnages produced
- Report on results of replicated trials as requested (e.g. pepper ICPN and ISPN)
- Notify AVRDC of publications involving distributed lines (provide copies, PDFs, press releases, etc.)

Because seed companies have developed extensive distribution networks, and intimate relationships with farmers in broadly dispersed production regions, use of AVRDC genetic materials in their business plans synergizes our research work, and can reach farmer recipients often underserved by National Agriculture Research and Extension Services. Businesses may wish to underwrite AVRDC's continuing R&D work through royalty-bearing licensing agreements, which would serve both to ensure continuing progress in solving vegetable production problems, and document the economic benefit of sustaining AVRDC's institutional leadership in vegetable research and development.

APSA Training Priorities

P. Hanson

Training of researchers at AVRDC headquarters caters to individual needs, emphasizes hands-on rather than classroom learning, with training duration ranging from a few days to a year. Over the years, seed companies have sent staff to AVRDC to improve the practical skills of new staff, update skills of experienced staff, receive training in particular laboratory protocols, or to become familiar with AVRDC research and researchers. However, comments from previous APSA workshops suggest that long-term training is time-consuming and not cost effective, and APSA members would be better served by short duration courses focused on particular topics. The objective of the presentation and subsequent discussion was to determine high priority topics for possible AVRDC short courses targeting APSA need.

In mid April a survey was emailed to companies registered for the 2006 workshop requesting them to score 16 topics ranging from plant breeding, pathology, molecular markers, statistics, etc. for interest (much, some, or none); respondents could also propose topics. Of the 11 responses, topics related to disease screening protocols and application of molecular markers garnered the most interest.

A Global Approach to Tackle Tospoviruses in Vegetables: Challenges and Opportunities

R. Naidu

Tospoviruses (family: Bunyaviridae, genus: Tospovirus) are a group of thrips-borne viruses infecting a broad range of vegetables, agronomic crops and ornamentals worldwide. They are cosmopolitan and infect more than 1000 plant species spanning dicotyledonous and monocotyledonous plants. It has been estimated that tospoviruses cause global yield losses up to $1 billion in a wide range of crops. The pleomorphic particles of tospoviruses contain three genomic RNA segments (designated as L-, M-, and S-RNA) and encode in a negative or ambisense strategy three structural and three non-structural proteins. The three genomic RNAs are individually packaged by many copies of the nucleocapsid protein and surrounded by a host-derived lipid envelope membrane in which the two viral-encoded glycoproteins are integrated. The glycoproteins are seen as spike-like projections covering the surface of the virus particle. Indeed, the tospovirus particles are hybrid structures, with proteins and genomic RNAs that are the product of virus genetic information while carbohydrate side chains on their glycoproteins and the lipid envelope membrane are derived from host cell synthetic machinery.

The life cycle of tospoviruses involves transmission from plant to plant by several species of polyphagous thrips (Thysanoptera: Thripidae). Thrips-mediated transmission of tospoviruses is unique among plant viruses because the transmission process is closely linked to the developmental stage of thrips vectors on plants.

It is now well established that successful transmission by adult thrips occurs only when the virus is acquired at the first-instar larval stage of the thrips life cycle. In addition, tospoviruses are among the few plant viruses that multiply in both plants and thrips vectors. Thus, tospoviruses have evolved a variety of elegant mechanisms to replicate in both plants and insects by devising "Trojan horse" strategies in order to overcome vastly different cellular and biochemical barriers of the two phylogenetically and biochemically disparate hosts and maintain a successful life cycle.

At least ten of the sixteen tospoviruses currently characterized worldwide have been found distributed in the South & Southeast Asia (S&SEA) 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. Among these ten viruses, three distinct tospoviruses have been severely impacting the production of vegetables in India. They are: Peanut bud necrosis virus on a broad range of vegetables and field crops, Watermelon bud necrosis virus in watermelons and Iris yellow spot virus in onion. Three distinct tospoviruses infecting vegetables have been documented in Thailand. They are: Capsicum chlorosis virus in chili peppers and tomato and Watermelon silver mottle virus and Melon yellow spot virus in melons/cucurbits. The distribution and economic impact of tospoviruses in other vegetable-growing countries of the S&SEA region, however, are not yet realized. It is likely that 'new' tospoviruses are widely prevalent in vegetables, but they might have been misdiagnosed as "non-viral diseases" due to similarities in disease symptoms between tospoviruses and those caused by other pathogens.

In recent years, diseases caused by tospoviruses have increasingly become a significant limiting factor in the sustainable production of vegetables in smallholder farming systems of S&SEA region. The minute size of thrips and their cryptic behavior, the increased worldwide movement of plant materials due to globalization and selection pressures imposed through the misuse of crop protection practices have enabled many thrips vector species to expand their geographic boundaries with unintended negative consequences to agricultural production. This has resulted in the spread of many tospoviruses across

the nations and, indeed, the continents. As a result, tospovirus diseases of minor importance have emerged into problems of agricultural significance and/or expanded from their original natural habitats and hosts to favorable new environments of valuable crops threatening sustainable crop production. Thus, tospovirus diseases, if left unchecked, will spread throughout any suitable ecosystem available to them, regardless of national boundaries. In fact, tospoviruses have assumed greater economic significance in rural and peri-urban agriculture in the S&SEA region due to continuous or overlapping cropping practices and intensified vegetable production.

The economic impact of diseases caused by thrips-borne tospoviruses in vegetable production in S&SEA has been well recognized in recent years. Because registered insecticides give poor control of thrips and the virus replicates in thrips vector and can be transmitted within a few minutes of feeding, efforts to control diseases caused by tospoviruses through insecticides have been mostly unsuccessful. This is further compounded by the lack of sources of resistance to tospoviruses endemic to S&SEA, making it difficult to develop durable resistance in vegetable crops. Thus, there are no 'one-size-fits-all' solutions applicable at the regional level to agricultural problems caused by tospoviruses. Consequently, a comprehensive understanding of each of the tospovirus pathosystem can bring long-lasting solutions for the management of diseases caused by tospoviruses in vegetables.

The Integrated Pest Management-Collaborative Research and Support Program of the United States Agency for International Development has recently initiated a multi-disciplinary and multi-institutional global project to provide science-based knowledge for developing sustainable and eco-friendly Integrated Pest Management strategies to minimize crop losses due to thrips-borne tospoviruses in the S&SEA region. Due to the complex nature of tospoviruses and the challenges involved in dealing with the diseases caused by these viruses, the project places special emphasis on strategic partnerships with a broad range of stakeholders to unearth new knowledge and technologies and develop innovative dissemination pathways to bear on the research for development continuum.

This consortium of global partnerships would involve research institutions with specialized talents in developed countries, international research centers (viz. AVRDC – The World Vegetable Center), public and philanthropic organizations seeking international public goods, national research organizations and universities, and private sectors (viz. the Asia Pacific Seed Association) seeking solutions to national/regional problems, and NGOs and extension agencies working directly with farmers and other target groups. Such a unified approach would provide a unique opportunity for better integration of global expertise and knowledge and pooling of scarce resources to maximize synergies with less overlap and redundancy, and helps to move from 'boutique' projects to partnerships for progress in economic growth and poverty reduction in developing countries in the region. These endeavors would lead to develop "solutions that cross national boundaries" and maintain quality environment for sustaining life Beyond Silent Spring.

The Role of AVRDC in Facilitating Germplasm

L. Engle

The presentation focused on the germplasm collection which AVRDC holds in trust for the global community, the conservation and regeneration facilities, management of plant genetic resources, and AVRDC's role on facilitating germplasm exchange. The conservation and utilization oriented role of the AVRDC genebank was emphasized. The Genetic Resources and Seed Unit employs strategies to enhance utilization of the collection e.g. having enough seeds in the active collection for distribution, detailed characterization of the accessions, and availability of the information on Internet. The protocols for serving seed requests and sending seed shipments were discussed.

AVRDC policies on germplasm exchange harmonize with international agreements such as the Convention on Biological Diversity and the International Treaty on Plant Genetic Resources. It also guided by the quarantine regulations of the host country and the destination country of seed shipments. Seed distribution follows the AVRDC Guiding Principles on Intellectual Property Rights. Seed shipments are accompanied by Phytosanitary Certificates and an MTA. The MTAs are based on the key principles that AVRDC subscribes to. These are unrestricted availability of the germplasm it holds in trust, and free access to materials developed by the center.

The number of germplasm requests from AVRDC has been increasing through the years. To be able to serve the needs of researchers all over the world, AVRDC is developing strategies to define representative sets of materials for distribution purposes.

Annex 1

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Annex 2

Photo Gallery