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AVRDC - The World Vegetable Center



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FOREWORD

The projected increase in the world's population and competing demands for land and natural resources between agriculture and many other aspects of human development have made food security a current and future concern for most governments. The world is burdened with a large number of hungry and malnourished people, and the failure to achieve Millennium Development Goal 1 (Eradicate extreme poverty and hunger) is symptomatic of that fact. We are becoming increasingly aware of the costs of an even larger number of people (perhaps 2 billion) who have chosen to adopt food habits not conducive to their health; they are also malnourished and lack the required minerals and vitamins generally found in diets containing sufficient fruit and vegetables. Excessive consumption of carbohydrates, fats, sugars and oils by both the rich and the poor has contributed to the present global epidemic of type II diabetes and related severe metabolic syndrome, which in turn causes potentially fatal noncommunicable diseases such as strokes and heart attacks.

AVRDC has stridently argued over the last decade that addressing the issue of food and nutritional security is more complex than merely providing extra carbohydrates for consumption. Agricultural research and development needs to pay more attention to a wider range of agricultural products capable of contributing to a well-balanced diet. These include not only fruit and vegetables, but also pulses, coarse grains, tree crops, livestock products, fish, poultry, etc. Making such products available to malnourished households would be a major step forward in development and can result in substantive economic, health and social gains. The focus must shift from the extensive and intensive production of maize, wheat and rice to more biodiverse and productive landscapes that can support sustainable agricultural systems in developing countries.

If children, nursing mothers, the elderly, teenage girls, the sick, handicapped and other specifically vulnerable groups are often the most prone to malnutrition in society, then AVRDC in particular has



the duty to ask how our research and development programs can be specifically tailored to seek quick and sufficient redress of these imposed dietary constraints. We have to give serious thought to the issue that development is appropriate for all people and not just for rich farmers with large land areas of cereals.

All these issues must be reflected in future research and development activities—and at the same time, the work of AVRDC must aim to manage the uncertainties of climate change, rapidly mutating pathogens and viruses, the emergence of new insect challenges, and how to cope with these without imposing negative environmental consequences. How will we take into account rapid urbanization, ensuring good diets for children and teenagers in the face of a bombardment of advertisements that contribute to poor dietary choices among the young? How best to help governments set sensible policy to encourage an effective and profitable private sector vegetable seed industry? How to create a policy-friendly environment to encourage

ministries of Agriculture, Health and Education to work in a coordinated way to overcome the problems of malnutrition and dietary ignorance?

Some of our old enemies are still battling vigorously against us—late blight, bacterial wilt, leaf curl virus, whitefly, diamondback moth, *Maruca*, *Helicoverpa* and other fruit and shoot borers. We need to recognize that due to climate change, these biotic pressures are now coupled with additional abiotic constraints to growth. If we drop our guard even for one season it may be difficult to keep pace with rapid rates of unexpected mutation. The Center's research conducted in 2013 and reported here is designed to include elements of a fresh look forward, while at the same time recalling that what we seek now and in the future is prosperity for the poor and health for all.

J.D.H. Keatinge



Vegetable Production in Southeast Asia

A Vision for the Next 40 Years

J.D.H. Keatinge, J. d'A. Hughes, R.J. Holmer

Global production of common and traditional vegetables is steadily increasing, and traditional vegetables in particular are attracting the attention of farmers, researchers, policy makers and the public. However, it is unfortunate that national governments and international donors are not yet showing sufficient investment in research and development that this field of horticulture warrants if the UN Sustainable Development Goals are to be achieved in the foreseeable future (Keatinge et al. 2011; UN Sustainable Development Solutions Network 2013). Families must have year-round access to affordable and nutritious food for a balanced, healthy diet, which must include vegetables as a source of many micronutrients (Hughes and Keatinge 2013). Not only Southeast Asia but the world in general must now seek to maximize crop productivity and profitability while minimizing losses, wastage and the overall impact of those horticultural activities, which may impinge upon the sustainability and resilience of the environment.

Many factors currently constrain vegetable production, including climate change and extreme climatic events, increased urbanization and pressure on arable land, ever-present pests and diseases, an aging farming population, and adverse policies toward horticulture. Abiotic stresses may have an increasingly potent effect on vegetable crops, as they are often vulnerable to extreme events of wind and rainfall. Global vegetables such as tomato (*Solanum lycopersicum*) and sweet pepper (*Capsicum* spp.) are also quite sensitive to heat damage, waterlogging, drought and increasing salinity through their individual or combined effects on flowering and fruit setting. Increasing trends in abiotic stresses imposed on horticultural crops may be inferred to be increasing rapidly in East Asia (Keatinge et al. 2012). Biotic stresses are also expected to respond, perhaps more

rapidly that the general public and policy makers would expect, to predicted changes in air temperature, precipitation regimes and within-canopy relative humidity.

For example, bacterial pathogens responsible for major epidemic diseases in vegetables such as late blight (*Phytophthora infestans*), bacterial and Fusarium wilts (*Ralstonia solanacearum* and *Fusarium oxysporum*) are all likely to increase in their damage to production as temperature and rainfall levels increase. In addition, begomoviruses, which are also extremely damaging to a range of horticultural crops, are likely to be rendered more potent in their ill effects as the number of generations per year of whiteflies (their principal vector, *Bemisia tabaci*) increases with warmer temperatures. Additional generations of other highly damaging insect species such as the pod, fruit and shoot borers (*Leucinoides* spp., *Maruca* spp., *Helicoverpa* spp. etc.) will also potentially mean greater crop losses or over-spraying of insecticides, already a severe challenge to the wholesomeness of vegetables sold in the markets of Southeast Asia.

Asian populations are expected to increase markedly in the next 25-50 years, with a higher proportion of the overall population being urbanized. The inexorably aging farming population conducting horticultural activities, particularly in the peri-urban fringes, will need to cope with much greater pressure on land availability, rapidly increasing land prices, and the need for better quality produce and a more consistent supply of vegetables to markets.

How might productivity be enhanced given the continuing and new pressures being placed on the horticultural industry? First, it will be necessary to seek measures to increase vegetable quality/nutrient density, productivity and cropping intensity per unit

of land and labor; second, it will require a substantive reduction in crop losses in both the pre- and postharvest elements of the vegetable market chain; and third, it will require the human population to seek effective ways to reduce excessive levels of food wastage, understand the need for a balanced diet to obtain and maintain good health, and to process and cook vegetables to maximize the bioavailability of essential vitamins and minerals.

Solutions to improve productivity, profitability, and human nutrition include considerable expansion and mechanization of protected agriculture. This would include not only expansion of traditional technologies of green and net housing (at the likely expense of open field-style production) but should also include ways in which energy, nutrient, and water use efficiency can be achieved. For example, the next generation of more efficient and likely cheaper solar cells should be built into greenhouse design to cope with local power needs for mechanized heating, cooling and controlled fertigation. Robust, but very fine pored, netting capable of excluding all undesirable insects (virus vectors) such as whiteflies and thrips as well as pod, fruit and shoot borers must be made more widely available. In combination, such trends will greatly increase the quantity of marketable vegetables and increase their wholesomeness by largely eliminating pesticide residues. A parallel reduction in soil-based plant delivery systems in controlled environments for artificial or sterilized peat/compost based alternatives will help reduce risks to sustainability of protected production systems from the build-up of severe soil-borne diseases and nematodes.

Better production and environmentally-sensitive management technologies, investment in research to support global

and traditional vegetables, and improving all elements along the vegetable value chain will be required. For example, better understanding of in-house measures for integrated pest management and the maintenance and use of adequate in-house pollinator populations are disciplinary areas in horticulture demanding quick investment for the better exploitation and maintenance of overall system productivity and opportunities to improve profitability.

It is unlikely that in the near future public sector investment in horticultural research and development will be sufficient to provide all the seed and technological answers to some of the questions posed. This must then require a much closer engagement with the private sector (including postharvest value addition, food preservation technologies, and more efficient marketing performance), better information flow and management, and improved business skills, particularly for small-scale growers, distributors and marketers. It must also be mandatory for the private sector seed industry to wean itself off its present “free-rider” dependence on trait-specific germplasm provided by the public sector without effective compensatory re-investment — particularly for the fruits of AVRDC’s long term breeding investments. The present notion promulgated by the private sector that only hybrid vegetables—and within this group a very restricted set of global vegetables—will be available in the future to the human population is a short-sighted view. For adequate system resilience and balanced human diets, the public-private sector accord must ensure the continued availability of a wide range of vegetables species with improved, trait-specific, nutrient-dense germplasm (Keatinge et al. 2010).

It is also concomitant on the public sector to ensure needs are addressed for

enhanced consumer education to raise awareness about the value of vegetables for a well-balanced, healthy diet for all family members (Hughes and Keatinge 2013). Ever-rising costs of the global health sector resulting from unwise or uninformed food choices among people in both developed and developing countries must soon force governments to recognize the urgent need for adequate investment in consumer nutrition education. It will surely be much cheaper and a more effective policy in the long run to reduce poor human health resulting from imbalanced diets, and to avoid noncommunicable diseases that result from resource-driven or ignorance-driven malnourishment.

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1. AVRDC - The World Vegetable Center, Headquarters - Taiwan
 2. East and Southeast Asia (ESEA) - Bangkok, Thailand
 3. Project Office - East Java, Indonesia
 4. Project Office - Fiji
 5. Korean Sub-Center - Suwon, Republic of Korea
 6. South Asia (SA) - Hyderabad, India
 7. Project Office - Dhaka, Bangladesh
 8. Office for Central Asia and the Caucasus - Tashkent, Uzbekistan
 9. Central and West Asia and North Africa (CWANA) - Dubai UAE
 10. Regional Center for Africa (RCA), Arusha, Tanzania
 11. Office for West and Central Africa - Bamako, Mali
 12. Project Office - Yaoundé, Cameroon
 13. Oceania (through Headquarters, Taiwan)





OFFICES

Achievements

Safeguarding
a valuable
collection of
vegetable
germplasm



Conservation of plant genetic resources at AVRDC: What does it cost?

With 67,817 accessions and sub-accessions presently in its collections, the AVRDC genebank is the fifth largest international public genebank in the world. The ex situ conservation and dissemination of germplasm to researchers and breeders worldwide contributes to global food and nutrition security, but also carries considerable costs. A complete understanding of these costs is important for the effective management of the genebank. Costing data can be used as a benchmark against which other genebanks can compare their own cost structures.

Genebank costs were quantified for the 12-month period from September 2011 to August 2012 using the Decision Support Tool (DST) developed by the International Food Policy Research Institute (IFPRI). The results show that the present value of AVRDC's genebank assets (facilities and equipment) is USD 2.5 million. The table below shows that the total annual operating cost is USD 684,000, of which 74% is labor. The average cost per accession is USD 10.08 per year. Seed regeneration, seed processing, characterization, and seed dissemination are the four most costly operations of the genebank. The storage

itself only accounts for 17% of the cost. In comparison, the average cost per accession is USD 5.15 at ICARDA, USD 6.84 at CIMMYT, USD 8.62 at ICRISAT, USD 9.19 at IRRI, and USD 22.52 at CIAT (in 2012 US dollars). High labor costs in Taiwan increase

AVRDC's average cost, but the fact that more vegetable species are self-pollinating and thus less labor-intensive to regenerate than cross-pollinating species keeps the average costs in check.

Current annual cost of the AVRDC genebank by cost type and by operation type, in 2012 US dollar values

Cost Type	
US dollars '000	
Capital	107
Quasi-fixed	456
Variable labor	49
Variable non-labor	71
Total	684

Operation Type	
US dollars '000	
Regeneration and characterization	206
Seed processing and storage	256
Dissemination	86
Data and general management	136
Total	684

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Theme GERMPLASM

Germplasm conservation, evaluation and gene discovery

Output 1: Vegetable genetic resources (including wild relatives, breeding materials, genetic stocks and populations) collected, conserved and distributed

Outcome: Vegetable genetic resources preserved and made available globally for crop improvement

ACTIVITY 1.1

Collect/acquire and conserve vegetable and legume germplasm

Output Targets 2013

- 150 accessions collected/acquired at headquarters
- Impact of seed drying method and seed moisture content on germination rate of bitter melon determined
- 90 accessions/breeding lines collected/acquired from locations in sub-Saharan Africa for safety duplication at the Regional Center for Africa

Achievement

- A total of 1036 accessions of vegetable germplasm were assembled and registered.
- Data on impact of seed drying method and seed moisture content will become available in early 2014.
- A total of 130 accessions were acquired by the Regional Center for Africa in 2013.

ACTIVITY 1.2

Maintain effective regeneration of priority vegetable germplasm

Output Targets 2013

- 1000 accessions regenerated at headquarters
- 200 accessions regenerated at the Regional Center for Africa

Achievement

- 1705 accessions regenerated at headquarters.
- 347 accessions of 29 species regenerated at the Regional Center for Africa.

- Production and increase of good quality seed: 10 crops for nutritional seed kits; advanced lines for multilocation and on-farm trials; maintenance of breeder materials
- Produce seeds of recommended eggplant, chili pepper, tomato and fig-leaf gourd rootstocks for training and distribution
- Seed of 35 lines of 11 crops multiplied for different purposes; 1035 kg of seed produced. Ten accessions multiplied resulting in 5.5 kg of seed.

ACTIVITY 1.3

Distribute vegetable germplasm accessions and improved lines worldwide

Output Targets 2013

- 80% of vegetable germplasm requests served
- 5000 accessions/breeding lines distributed worldwide from headquarters
- 700 accessions/breeding lines distributed by the Regional Center for Africa to public and private partners

Achievement

- 79% of seed requests (286 out of 361) were successfully served.
- A total of 10,059 accessions (5292 genebank accessions and 4767 breeding lines) were distributed from headquarters.
- 604 accessions from the Regional Center for Africa and 97 accessions from headquarters of 13 crops were distributed by the Regional Center for Africa.
- 89 accessions of six crops were distributed from headquarters in Central Asia and the Caucasus
- New eggplant variety 'Feruz' (VI042320 from Zambia) has been released and 14 other new varieties are currently under state variety evaluation, including eggplant (3), sweet pepper (2), pea (1), bean (1), vegetable soybean (1), squash (2), lettuce (1), basil (2) and celery (1) in Central Asia and the Caucasus countries.

ACTIVITY 1.4

Safely duplicate AVRDC – The World Vegetable Center's germplasm in other genebanks

Output Targets 2013

- 800 accessions from headquarters duplicated at the National Agrobiodiversity Center, Korea and Svalbard Global Seed Vault, Norway
- 150 accessions from the Regional Center for Africa duplicated at AVRDC headquarters and Svalbard Global Seed Vault, Norway

Achievement

- Freshly regenerated accessions are kept in cold storage at headquarters for duplication at the National Agrobiodiversity Center, Korea and Svalbard Global Seed Vault, Norway.
- 150 accessions from the Regional Center for Africa will be sent for duplication at headquarters in March 2014 after amaranth and okra have been harvested.

ACTIVITY 1.5

Systematically store information on conservation and distribution of vegetable germplasm in AVRDC – The World Vegetable Center's electronic databases

Output Targets 2013

- 100% of acquisition and distribution data generated in 2012 entered into the Vegetable Genetic Resources Information System (AVGRIS) and Regional Center for Africa's database
- Characterization and evaluation data of the 2010/2011 regeneration cycle available in AVGRIS and Regional Center for Africa's database

Achievement

- 100% of acquisition and distribution data generated in 2013 entered into AVGRIS at headquarters.
- Characterization data of 742 accessions of the 2010/11 cycle and 1470 accessions of the 2011/12 cycle are ready for uploading to AVGRIS.

ACTIVITY 1.6

Develop effective seed health and quarantine program at AVRDC – The World Vegetable Center's headquarters and the regional centers

Output Targets 2013

- All seed shipments from AVRDC – The World Vegetable Center comply with host country regulations

Achievement

- All seed shipments from AVRDC – The World Vegetable Center complied with host country regulations.

Output 2: Germplasm characterized to enhance understanding and utilization of biodiversity in the vegetable germplasm collections

Outcome: Genetic diversity of AVRDC – The World Vegetable Center germplasm collections determined and marker-trait associations identified

ACTIVITY 2.1

Characterize morphological traits of vegetable germplasm maintained at AVRDC – The World Vegetable Center and its Regional Centers

Output Targets 2013

- 1000 accessions characterized at headquarters, based on standard morphological descriptors
- 200 accessions characterized at the Regional Center for Africa, based on standard morphological descriptors
- Seed of 50 GRSU *Cucurbita moschata* accessions multiplied and preliminary evaluation completed

Achievement

- 1114 accessions were characterized at headquarters based on standard morphological descriptors.
- A total of 229 accessions of ten vegetable crops were characterized at the Regional Center for Africa in 2013.
- A total of 12 accessions of *Cucurbita moschata* were multiplied and preliminary evaluation completed.
- A total of 89 accessions of 6 crops have been characterized in Central Asia and Caucasus during 2013.

ACTIVITY 2.2

Conduct molecular characterization, genetic relationship and diversity analysis of germplasm collection

Output Targets 2013

- Diversity analysis of *Abelmoschus* collection (~400 accessions) accomplished

Achievement

- A total of 450 accessions have been genotyped and, in addition, 373 accessions have been characterized morphologically. By 2014, the whole collection (918 accessions) will be characterized.

ACTIVITY 2.3

Develop, characterize, and validate AVRDC – The World Vegetable Center germplasm core collections

Output Targets 2013

- *Abelmoschus* core collection initiated at headquarters
- Mungbean core collection initiated

Achievement

- The morphological and molecular characterization of the collection is ongoing, and will be accomplished by 2014. Combination of molecular and morphological data will provide a sound basis to define a core collection of 100 to 200 genotypes representing about 70% of the genetic diversity present in this crop collection.
- Based on geographical origin and eight morphological parameters, a core set of 1490 accessions was established. No significant statistical differences were detected between the diversity present in the entire collection and the core collection, corroborating the representativeness of the selected germplasm panel.

ACTIVITY 2.4

Conduct studies to identify markers and genes linked to important agronomic traits

Output Targets 2013

- Seed quality traits in mungbean mapped

Achievement

- Three quantitative trait loci (QTL) were identified on chromosomes 1, 3, and 9, which are associated with 100-seed weight and explain between 20 and 29% of the total variance for this trait. Another 3 QTLs explaining between 24 and 33% of the total variation of the trait 'germination rate' were found.

Output 3: Trait-based characterization and screening to enhance vegetable germplasm for effective use of important horticultural traits in the development of new vegetable cultivars

Outcome: Superior sources of genes for important horticultural traits identified

ACTIVITY 3.1

Identify and characterize sources of resistance to viral diseases

Output Targets 2013

- Mungbean and hot pepper germplasm screened for resistance to local begomoviruses in the field in India, Thailand and Vietnam
- Inheritance of resistance to *Cucumber mosaic virus* from *Solanum habrochaites* (LA1033) determined
- AVRDC isolates of *Tomato mosaic virus* (ToMV; tobamovirus) characterized in relation to the different Tm-2 resistance alleles

Achievement

- AVRDC accessions NM92, NM94 and VC3960-88 had average scores of 2 or less, indicating reasonable resistance. All other accessions (mainly from the Vietnamese genebank) were susceptible, showing average severity scores greater than 4. Three mungbean accessions from the AVRDC/India collection (ML818, ML1299 and ML1628) showed the best resistance across three sites in India.
- Earlier work had identified *S. habrochaites* accession LA1033 as potentially carrying some resistance to both *Cucumber mosaic virus* (CMV) and late blight (*Phytophthora infestans*). This could not be confirmed in the current trials and it is hypothesized that the resistance breaks down at higher temperatures.
- A set of previously uncharacterized isolates of ToMV were screened for virulence by mechanical inoculation on a set of tomato lines carrying different Tm resistance genes to identify which race each isolate represented.

ACTIVITY 3.2

Identify and characterize sources of resistance to fungal and bacterial diseases

Output Targets 2013

- Resistance to late blight, early blight and black leaf mold in tomato characterized
- Resistance to anthracnose in pepper characterized

Achievement

- Five S3 lines of *S. habrochaites* were found to be resistant against aggressive *P. infestans* isolates. Five SSR markers on chromosome 1 were found to be closely associated with resistance to tomato black leaf mold.
- Five S3 lines of *Capsicum baccatum* were resistant to *Colletotrichum capsici* at the green and red fruit stage. PBC80, PBC81 and PBC1752 were found to be resistant to *C. gloeosporioides* at the red fruit stage and seem to have a broad resistance base.

<ul style="list-style-type: none"> • Eggplant accessions screened for stable bacterial wilt resistance 	<ul style="list-style-type: none"> • Five resistant accessions of <i>S. torvum</i> and 7 of <i>S. sisymbrium</i> with low wilting percentage (<20% incidence) were identified and selected.
<ul style="list-style-type: none"> • Cucurbit accessions screened for downy mildew resistance 	<ul style="list-style-type: none"> • Out of eight luffa cultivars evaluated, two tolerant lines of <i>Luffa acutangula</i> were identified based on both artificial and natural infection.

ACTIVITY 3.3
Identify and characterize sources of resistance to insect pests

<p><i>Output Targets 2013</i></p> <ul style="list-style-type: none"> • Mechanism and basis of resistance to aphids in selected okra accessions characterized 	<p><i>Achievement</i></p> <ul style="list-style-type: none"> • Out of 64 accessions screened, eight accessions were rated as resistant to aphid infestation. In advanced screening trials, five accessions were found to be moderately resistant. These five accessions will be tested in multilocation trials in farmers' fields for assessment of their resistance to aphids and yield performance during 2014.
<ul style="list-style-type: none"> • Okra accessions confirmed for resistance to leafhopper 	<ul style="list-style-type: none"> • 316 okra accessions were screened, resulting in 26 moderately resistant (hopper burn index ≤ 2) accessions. Among the 26 accessions, two accessions recorded a low hopper burn index of 1.5. One of these two accessions was confirmed to be moderately resistant.
<ul style="list-style-type: none"> • Onion accessions screened for resistance to thrips 	<ul style="list-style-type: none"> • Eight accessions were identified as resistant. In the second trial, three accessions were identified as highly resistant, whereas seven accessions were identified as resistant.
<ul style="list-style-type: none"> • Hot pepper accessions confirmed for resistance to insect and mite pests 	<ul style="list-style-type: none"> • CCA10904 showed low infestation by both thrips and broad mite, followed by one of its resistant parents, PBC 145. CCA10900 was moderately infested by both thrips and broad mite in Bangladesh.

- *Solanum galapagense* accessions screened for resistance to whitefly and red spider mite

- Out of five genebank accessions evaluated, two accessions (VI037241 and VI037869) showed high resistance to *Bemisia tabaci*.

ACTIVITY 3.4

Identify and characterize sources of tolerance to drought, heat, flooding and salinity stress

Output Targets 2013

- Salt tolerance screening method for vegetable crops established

Achievement

- No activities possible due to the absence of funding in 2013 to address this output target.

ACTIVITY 3.5

Evaluate vegetable germplasm for selected nutrition-related compounds

Output Targets 2013

- Lab work for nutrient content analyses and LCMS profiling of 30 popular vegetables in Taiwan continued; plant and nutrition databases for the 30 vegetables designed and developed
- Target anti-diabetic compounds for mass screening of bitter gourd germplasm searched

Achievement

- 1500 targeted phytonutrient data points, 1000 biosource data files and 35 untargeted LCMS profiles of 35 vegetable crops were assembled. This information will be used for the development of an open access vegetable metabolome database.
- Around 1200 – 1500 LCMS peaks of green bitter gourd and white bitter gourd samples were used for principal component analysis (PCA) modeling. Green bitter gourd samples were clearly scattered by three planting seasons while white bitter gourd samples from winter and fall season overlapped. The principal LCMS peaks as affected by season were identified through PCA modeling.

Output 4: Specialized genetic materials, molecular tools, and methods developed to enhance the creation of new varieties

Outcome: Genes conferring improved horticultural traits introgressed, genetically mapped, and DNA markers developed for marker-assisted selection

ACTIVITY 4.1

Develop mapping populations and identify QTLs for resistance to biotic stresses

Output Targets 2013

- Tomato gene Ph-4t associated with resistance to late blight mapped
- Mapping populations for begomovirus resistance mapping in mungbean and pepper available
- Begomovirus resistance loci identified and tagged with molecular markers in mungbean

Achievement

- Three F3 families fixed for Ph-3 and segregating for late blight resistance when challenged with a *P. infestans* isolate requiring both Ph-3 and Ph-4t were selected for mapping Ph-4t. It was concluded that the population under investigation did not contain the mapping target Ph-4t. A new segregating population has been constructed and is currently analyzed to map the Ph-4t resistance gene.
- A cross was performed between the *Mungbean yellow mosaic virus* resistant line NM94 and the susceptible line KPS2. Two hundred F2 plants were produced from one F1 plant and grown in the glasshouse. At least 200 seeds of each of 200 F3 families were produced and forwarded for resistance testing to partners. Genotyping of the population with simple sequence repeat markers and genotyping by sequencing is ongoing. Hybrids between putatively begomovirus-resistant pepper lines and the susceptible parent 9955-15 were produced and advanced to the F3 generation. 200 F3 families per cross were produced and for each F3 family at least 200 seeds were harvested. The seed was forwarded to resistance testing and for the production of recombinant inbred lines of selected cross combinations.
- Mapping *Mungbean yellow mosaic virus* resistance was first tried in the cross NM92 (resistant) x TC1966 (susceptible). One major QTL responsible for about 60% of the total variation found in the population was detected on chromosome 9, together with 3 minor QTLs on chromosomes 7, 8 and 9. The major resistance gene is linked with simple sequence repeat marker DMB-158. Segregation analysis of resistance in field trials in Vietnam using a different test population (NM94 x KPS-2) indicated that a single major gene is responsible for begomovirus resistance in this population as well.

ACTIVITY 4.3

Conduct fine mapping of QTLs and develop markers for marker-assisted selection (MAS)

Output Targets 2013

- Near isogenic lines developed for fine-mapping of qBwr6 gene
- Develop gene-based marker of *Bwr12*

Achievement

- Ten markers located in the *Bwr-6* QTL interval were designed and subsequently used for marker-assisted selection for recombinants in the *Bwr-6* interval. Additionally 2 markers flanking *Bwr-12* and 24 background markers (2 per chromosome) were used for generating NILs by marker-assisted selection.
- Virus-induced gene silencing and virus-mediated gene over-expression assays revealed the involvement of *12g520* and *12g550* in bacterial wilt resistance. The sequence diversity of these genes was analyzed in tomato cultivars and single nucleotide polymorphisms were identified that can be used as gene-based markers for bacterial wilt resistance.

ACTIVITY 4.4

Assemble and develop molecular marker sets for priority vegetable crop

Output Targets 2013

- A set of suitable markers developed for bulked segregant analysis in *C. moschata*

Achievement

- An F2 population derived from parents previously classified as resistant and susceptible to *Papaya ring spot virus* (severe Taiwan strain) was produced, in order to validate a bulked segregant method combined with massive sequencing of cDNA ends (MACE) to identify the location of a single major resistance gene against this disease. The population was challenged with a virus isolate and resistance assessment showed that both parents had intermediate phenotype, and resistance was not segregating in the population. Consequently, the population could not be used to validate the method. A new population derived from parents with recently verified virus resistance phenotype has been established and will become available by May 2014.

- A bioinformatics platform for single nucleotide polymorphism (SNP) detection and genotyping for vegetable crops established
- Two bioinformatics pipelines that combine open access software tools were established: One pipeline uses SOAP2 to map short sequencing reads to a reference sequence, identifies SNPs with the SOAPSNP software and annotates the SNPs in SNPEFF with regard to their location. The second pipeline is designed to produce SNP information for next generation reads obtained in genotyping by sequencing or restriction enzyme associated DNA sequencing experiments. This pipeline relies on the publically available STACKS software.
- Restriction site associated DNA (RAD) sequencing to rapidly obtain markers established for vegetable crops: Method tested and applied on mungbean and tomato
- Two parental lines (N M94 and KPS-1) were chosen for SNP identification in mungbean. Choosing highly stringent parameters, 1,500 different DNA fragments with one SNP between these parental lines were identified. Similar to the experiment on mungbean, 19 lines used in AVRDC tomato breeding program have been submitted to RAD sequencing. A total of 180 million 90 bp reads are available to identify SNPs between these genotypes.

Output 5: Genes affecting important horticultural traits isolated, validated, and functionally analyzed using genomics and molecular technologies

Outcome: Gene markers associated with important horticultural traits developed and pathogen-derived resistance to tomato yellow leaf curl viruses based on RNA interference explored

ACTIVITY 5.1

Allele mining to identify variation conferring superior traits

Output Targets 2013

- At least 200 M2 families of a tomato mutant population screened for putative loss of susceptibility to tomato yellow leaf curl viruses in ten candidate genes through next generation sequencing and TILLING

Achievement

- From a total of 12 candidate mutations identified by next generation sequencing, three could be corroborated by high resolution melting, while TILLING failed to identify these mutations. None of the confirmed mutations on the nucleic acid level caused an amino acid exchange on the protein level. The experiment showed that the combination of next generation sequencing, bioinformatics and high resolution melting can reliably detect mutations in pooled samples and is more reliable than TILLING.

ACTIVITY 5.3

Evaluate gene function and efficacy through genetic engineering

Output Targets 2013

- Evaluation of reaction of R₂ generation to tomato yellow leaf curl viruses

Achievement

- Thirty-eight confirmed transformants were advanced to R₁ generation for bi-tomato yellow leaf curl disease test. Only one line expressed symptom delay for both ToLCTWV (13 out of 96 plants) and TYLCTHV (12 out of 96 plants). These 25 plants were advanced to R₂ generation and tested for bi-tomato yellow leaf curl disease reaction. Sixteen and 12 plants each showed no symptom for TY11-TW(R₁)-TW(R₂) and TY11-TH(R₁)-TH(R₂) tests, respectively. The collection of R₃ seed for these lines is ongoing.

Output 6: Intellectual Property Rights strategy on germplasm, transgenics and genes implemented

Outcome: AVRDC – The World Vegetable Center, national agricultural research and extension systems and the private sector benefit from using the Center's germplasm accessions and improved breeding lines

ACTIVITY 6.1

Utilize, develop or improve Material Transfer Agreements (MTAs) for genebank germplasm, breeding lines and transgenic materials that support AVRDC's interests

Output Targets 2013

- All outgoing seed shipments comply with the Center's MTAs
- Incoming seed are accompanied by MTA, germplasm acquisition agreement, or letter of donation

Achievement

- All outgoing seed shipments comply with the Center's MTAs: MTA1 - for genebank accessions; MTA2 - for AVRDC-developed genetic material. Effective August 1, 2013, the use of the Standard MTA for all genebank accessions has been adopted, replacing MTA1.
- Germplasm entering the Center's premises is accompanied by appropriate documents such as a material transfer agreement, germplasm acquisition agreement and/or letter of donation, and a phytosanitary certificate. A sub-sample will be deposited into the genebank at headquarters or the germplasm repository at the Regional Center for Africa to avoid multiple requests of the same material from the same germplasm source.

Output 7: Capacity in germplasm conservation, evaluation, characterization, and gene discovery developed

Outcome: Skills of national agricultural research and extension systems' scientists in germplasm conservation, utilization and gene discovery enhanced

ACTIVITY 7.1

Train human resources in vegetable genetic resources conservation, management, and evaluation using conventional and advanced techniques

Output Targets 2013

- Training on germplasm conservation and management conducted

Achievement

- Two breeders from seed companies, one university staff, and six undergraduate summer students trained in germplasm and genebank management at headquarters. Four visiting scientists (Philippines – 1; Korea – 3) hosted, and 12 trainers (7 male; 5 female) from Afghanistan and three participants (all male) from Bangladesh trained in germplasm management at East and Southeast Asia office, Thailand. Twenty-five trainees (16 male, 9 female) from 11 countries received training concerning germplasm conservation and management during the 32nd International Vegetable Training Course held in Thailand.

- Training on use of molecular tools for biodiversity analysis and germplasm screening conducted
- A three-day symposium to promote the use of Molecular Breeding in the Asia Pacific region co-organized by AVRDC and the Asia Pacific Association of Agricultural Research Institutes (APAARI) was held at headquarters in October 2013. More than 60 scientists involved in germplasm conservation and breeding participated from India, Japan, Korea, Malaysia, Nepal, Pakistan, Papua New Guinea, Philippines, Thailand, Vietnam and Taiwan.
- Various vegetable accessions/lines, production technologies and vegetable nutritional information displayed in the demonstration garden for information dissemination to at least 300 visitors
- A total of 372 accessions representing 201 vegetable species, including 50 AVRDC improved lines, were planted in the Demonstration Garden. Production technologies including drip irrigation, grafting technology, rotation, rain shelter, net house, integrated pest management, farmscaping, mulching, staking, yellow sticky traps and pheromone traps are on display. A total of 1008 visitors from 51 countries visited the Demonstration Garden.
- Exhibit AVRDC's germplasm and technologies in Taiwan's annual Seed and Seedling Festival and other events
- AVRDC participated in the Mango Festival held at Tsou-Ma-Lai Farm, Tainan (29 June – 7 July) and joined the 17th Seeds and Seedling Festival held at Tainan District Agricultural Research and Extension Station on 29–30 November. A film crew from the Public Television Service, Taiwan shot footage about AVRDC for the television program "Follow Me," broadcast on 13 August. AVRDC germplasm and technologies were introduced to the general public during these events.

Mapping
markers to
locate traits
for breeding
superior
mungbean



Virtually unlimited access to markers for molecular breeding

In plant breeding, mapping the genetic location for traits of interest, such as disease or abiotic stress resistance, is usually done by crossing two parents with contrasting phenotypes (observable characteristics) and analyzing the offspring. Such analysis requires DNA markers that can be traced back to each parent's genome. However, obtaining sufficient markers has limited researchers' ability to map traits in plant populations. To increase the probability of getting enough markers for mapping, very distantly related cultivars are often chosen as parents. These genetically distant parents differ from each other in many aspects, making the characterization of a specific trait very difficult—plus the experimental

populations derived from such wide crosses may have undesirable properties. Consequently, the traits identified in such experimental populations may be of only limited use for breeding. Overcoming restrictions concerning the choice of mapping populations strongly improves researchers' capacity to map traits and use marker-assisted selection in breeding.

Traditionally, marker development and genotyping (determining differences in genetic makeup) of populations were two separate working steps. Cheaper DNA sequencing and advances in bioinformatics resulted in methods that can accomplish marker discovery and genotyping in only

one step, significantly reducing the time and labor required for identifying markers and genotyping.

AVRDC has applied genotyping by sequencing methods on vegetables including tomato (*Solanum lycopersicum*) and mungbean (*Vigna radiata*). This method yields large numbers of markers for many applications, such as diversity analysis, linkage mapping or genome-wide association mapping. For example, microsatellite markers differed by less than 10% in important mungbean mapping populations, making the production of markers for these populations very laborious and time-consuming. Through genotyping by sequencing, more than 1500 markers were produced in a cost- and time-efficient manner.

Genotyping by sequencing works by reducing the complexity of the genome. Genomic DNA is cut with restriction enzymes and sequencing is confined to regions surrounding these sites. Cut genomic DNA from different individuals is bar-coded and pooled, allowing sequencing of a large number of individuals in parallel, which greatly reduces costs. Open source bioinformatics programs are available to process sequence data and extract useful markers for downstream applications. No reference sequence is required for this technology, making genotyping by sequencing the method of choice for obtaining a large number of markers for any vegetable species, including those that currently lack genomic resources, such as African traditional vegetables.

Theme BREEDING

Genetic enhancement and varietal development of vegetables

Output 1: Varieties and lines of vegetables with improved disease resistance, stress tolerance, quality and nutritional traits developed

Outcome: Lines adopted directly as varieties or used in public/private sector breeding programs

ACTIVITY 1.1

Develop heat tolerant and disease-resistant tropical tomato with desirable horticultural and quality traits

Output Target

- 10-15 F7 fresh market/dual purpose lines with multiple begomovirus resistance genes, bacterial wilt, early blight and good horticultural traits evaluated in replicated yield trial, and seed multiplied for international distribution
- High carotenoid (high pigment and crimson gene) lines advanced to F6
- High flavonoid tomato lines selected for good horticultural traits and advanced to the F6

Achievements

- Four F7 lines with late blight, tomato yellow leaf curl disease, bacterial wilt resistance were included in the online seed catalog.
- The F6 lines have the high pigment gene and some have crimson. The selected lines will have high carotenoid content.
- High flavonoid F6 lines were selected but most suffer fruit cracking. New crosses are underway.

ACTIVITY 1.2

Develop and distribute disease-resistant chili and sweet pepper varieties (targeting anthracnose, Phytophthora, bacterial wilt, *Cucumber mosaic virus*, *Chili veinal mottle virus*, and/or begomoviruses)

Output Target

- 10-20 AVRDC improved pepper lines/germplasm accessions systematically screened for begomovirus resistance in Taiwan and other locations
- Sources of anthracnose resistance assessed by field and micro-injection and spray inoculation techniques and new crosses created using resistant lines
- Seed of 7-12 new multiple disease resistant lines distributed to collaborators and 5-10 promising pepper lines increased for international distribution

Achievements

- More than 30 improved and germplasm accessions are being screened in Taiwan, India, Thailand and Vietnam.
- Three new resistance sources (8602, 8603 and 8610) were identified and crosses, backcrosses and F2 seeds were developed.
- Seeds of ICPN22 set (containing ten lines) multiplied and more than 500 seed samples of 75 old and newly developed improved resistance lines were made available.

ACTIVITY 1.3

Develop heat tolerant tropical sweet pepper

Output Targets 2013

- 5-10 promising heat tolerant pepper inbred lines and hybrids tested on-farm in Taiwan and selected inbred lines directly released to international collaborators
- Crosses made to develop inbred lines combining heat tolerance and two or more disease resistances

Achievement

- On-farm trials involving three AVRDC hybrids and commercial checks were conducted at two locations. 34 ISPN sets (containing five lines) were multiplied for distribution.
- 40-50 F2 plants resistant to *Pepper mild mottle virus* (PMMoV), *Potato virus Y* (PVY) and bacterial spot selected.

ACTIVITY 1.4

Develop short-day red onions and yellow onions for improved yield, extended shelf-life, and/or *Stemphylium* resistance

Output Targets 2013

- 5-10 promising heat tolerant pepper inbred lines and hybrids tested on-farm in Taiwan and selected inbred lines directly released to international collaborators

Achievement

- On-farm trials involving three AVRDC hybrids and commercial checks were conducted at two locations. 34 ISPN sets (containing five lines) were multiplied for distribution.

<ul style="list-style-type: none"> • Seeds of local selected varieties and AVRDC elite lines reselected in Mali produced for regional and international trials • Regional <i>Allium</i> network established and multilocation trials conducted at regional and international level 	<ul style="list-style-type: none"> • Seeds of 39 AVRDC onion lines and 25 local purified selections were produced during the cold dry season at Samanko, Mali. • Regional network established in Burkina Faso, Niger and Senegal. Trials evaluating three lines from headquarters and eight local purified selections from West Africa are on-going in Burkina Faso and Mali.
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ACTIVITY 1.5
 Develop and distribute heat-tolerant broccoli and Chinese cabbage varieties

<p><i>Output Targets 2013</i></p> <ul style="list-style-type: none"> • Test new broccoli hybrid combinations and promising lines evaluated and multiplied • Test new Chinese cabbage hybrid combinations and promising lines evaluated and multiplied 	<p><i>Achievement</i></p> <ul style="list-style-type: none"> • Six promising broccoli hybrids identified from advanced yield trials; seed multiplication is ongoing. • Seven promising Chinese cabbage hybrids identified; seed multiplication is ongoing.
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ACTIVITY 1.6
 Develop improved vegetable soybean and mungbean with improved nutritional and flavor qualities

<p><i>Output Targets 2013</i></p> <ul style="list-style-type: none"> • 10-15 vegetable soybean lines promoted in South Asia and sub-Saharan Africa • Improved mungbean lines for methionine content confirmed by HPLC • Markers for <i>Mungbean yellow mosaic virus</i> (MYMV) resistance in mungbean developed 	<p><i>Achievement</i></p> <ul style="list-style-type: none"> • Elite vegetable soybean lines were distributed to ten countries for regional testing. • 45 mungbean lines identified with high methionine content in BC1F5 population (NM 94 x GB No. 3-1). Methionine content not detected in F2 population of NM 94 x VM 2164. New crosses are being tried. • One SSR marker associated with MYMV resistance derived from NM92 has been made available.
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- 10 elite mungbean lines promoted in sub-Saharan Africa

- 15 elite mungbean lines were sent to Kenya and Tanzania. Seed multiplication of these lines was undertaken in both countries.

ACTIVITY 1.7

Develop cucumber lines for improved horticultural traits, disease resistance, good fruit quality, and high gynoecy

Output Targets 2013

- 10-15 F7 entries evaluated in replicated trial and characterized for key horticultural traits and disease resistance
- 20-30 hybrid combinations of South and Southeast Asian types evaluated for key horticultural traits in targeted countries along with 5-8 improved lines

Achievement

- 15 F7 lines were evaluated in a preliminary yield trial, six lines selected for advanced yield trial.
- Seeds of 16 hybrid combinations harvested for further evaluation.

ACTIVITY 1.8

Develop disease resistant and high quality pumpkins (*Cucurbita moschata*)

Output Targets 2013

- 15-20 F7 entries evaluated in preliminary yield trial and characterized for key horticultural traits and nutritional components and field resistance to diseases
- Develop 20-30 F1 hybrids using ZYMV resistant lines and high quality F8 lines derived from elite hybrids
- 20-30 F5 families derived from elite hybrids evaluated and advanced to F6 and 15-20 F6 lines evaluated and advanced

Achievement

- Preliminary yield trial of 17 F7 lines was completed and seven lines selected for advanced yield trial.
- No action taken in 2013.
- 17 F5 families were evaluated to develop and evaluate 14 F6 lines.

ACTIVITY 1.9

Develop bitter melon possessing improved yield, earliness, good fruit quality and resistance to diseases/insects

Output Targets 2013

- 20-30 F6 lines derived from elite hybrids evaluated and advanced and a set of 15-20 F7 lines evaluated in preliminary yield trial
- Multilocation trial of commercial lines in India conducted to evaluate environment, ripening stage, local postharvest management on level of nutrients and anti-diabetic compounds in bitter melon investigated

Achievement

- 24 F6 lines evaluated and further 27 F7 lines derived and evaluated in advanced yield trial.
- Multilocation trial conducted at Punjab Agricultural University, India and the Regional Center for Africa, Tanzania.

Output 2: Traditional vegetables improved for productivity, quality, and nutrient content

Outcome: Lines potentially beneficial to farmers and consumers

ACTIVITY 2.1

Develop traditional vegetables with superior horticultural traits

Output Targets 2013

- 97 Malabar spinach genebank accessions evaluated for horticultural traits and seed multiplied of about 50 accessions for yield and flood tolerance trials.
- Priority setting leading to selection of 1-2 African traditional vegetable crops for improvement at the Regional Center for Africa

Achievement

- Completed seed propagation and horticultural traits survey of 98 Malabar spinach accessions (95 genebank accessions and three accessions from local market). 20 promising accessions were selected from a preliminary yield trial for yield and flood tolerance trials.
- Amaranth (leafy vegetable) and African eggplant *Solanum aethiopicum* (fruit type) were selected as priority crops based on nutritional security and/or income generation.

ACTIVITY 2.2

Evaluation, seed multiplication, and distribution of elite traditional vegetables

Output Targets 2013

- Elite traditional vegetables evaluated for horticultural, nutritional, and anti-nutritional traits and seed of selected lines/accessions increased for international distribution

Achievement

- Seed of 16 lines of five traditional vegetable crops were increased at the Regional Center for Africa. A total of 379 kg seeds of advanced lines were produced.

Output 3: Vegetable variety testing networks and improved seed systems developed
Outcome: Improved distribution, evaluation, release, and seed production of AVRDC-bred varieties leading to (1) better understanding of genotype-environment interactions, (2) traits critical for particular agroecosystems and markets (3) streamlined variety release procedures, and (4) more efficient vegetable seed production

ACTIVITY 3.1

Assemble and internationally distribute elite vegetable lines

Output Targets 2013

- Global distribution and testing of AVRDC chili pepper, sweet pepper, tomato, vegetable soybean, mungbean and other AVRDC-developed lines conducted

Achievement

- Seeds of 32 sets of ICPN22 and 34 sets of ISPN were distributed in 14 countries.

ACTIVITY 3.2

Analyze and review of multi-environment testing of AVRDC – The World Vegetable Center's improved germplasm

Output Targets 2013

- Vegetable variety trials and implications for breeding and variety release analyzed and summarized

Achievement

- Analyzed tomato and chili trial data received from Bangladesh and tomato yellow leaf curl disease data from Cambodia.

ACTIVITY 3.3

Develop on-line seed catalog to facilitate seed requests for AVRDC-improved vegetables

Output Targets 2013

- Online seed catalogs for tomato, pepper, soybean and leafy Brassica updated

Achievement

- Updates of tomato and grain soybean in the online seed catalogs carried out.

- Online seed catalogs for Chinese cabbage, shallot, root stocks, elite African traditional vegetables and cucumber developed

- Seed catalogs for shallot and Chinese cabbage developed.

ACTIVITY 3.4

Monitor and assess variety release, commercialization and adoption of AVRDC-bred lines

Output Targets 2013

- Release and commercialization of AVRDC varieties by NARES and seed companies in Africa, Asia, and Central America monitored

Achievement

- Variety releases: One high beta-carotene tomato (CLN2366B or CLN2366C) was released in Malawi. One tomato variety was released by Ethiopian Institute of Agricultural Research and one African nightshade (*Solanum vilosum*) variety was registered in Kenya by East African Seeds. AVPP0408 sweet pepper was released in Uzbekistan and 5 kg breeder seeds of five potential hot pepper lines produced.
- Commercialization: East African Seed Company produced and marketed about 9 tons of seeds each of 'Tanya' and 'Tengeru 97'. Alpha Seeds produced and marketed 3-4 tons of seeds each of 'Tanya' and 'Tengeru 97'. Africasia produced and commercialized 2.5 and 4.5 tons of 'Tanya' and 'Tengeru 97', and produced 300 kg of each of African eggplant ('DB3') and African nightshade (variety name not labeled, but an AVRDC lines), and 500 kg of amaranth (variety not labeled) in this first season of production.
- Breeder seed produced of released AVRDC lines at AVRDC headquarters and regional centers
- 250 kg breeder seed of ten released varieties from five vegetable crops, tomato, amaranth, African nightshade, Ethiopian mustard (*Brassica carinata*) and cowpea (*Vigna unguiculata*) were increased at the Regional Center for Africa.

ACTIVITY 3.5

Use male sterility to improve the efficiency of hybrid vegetable seed production

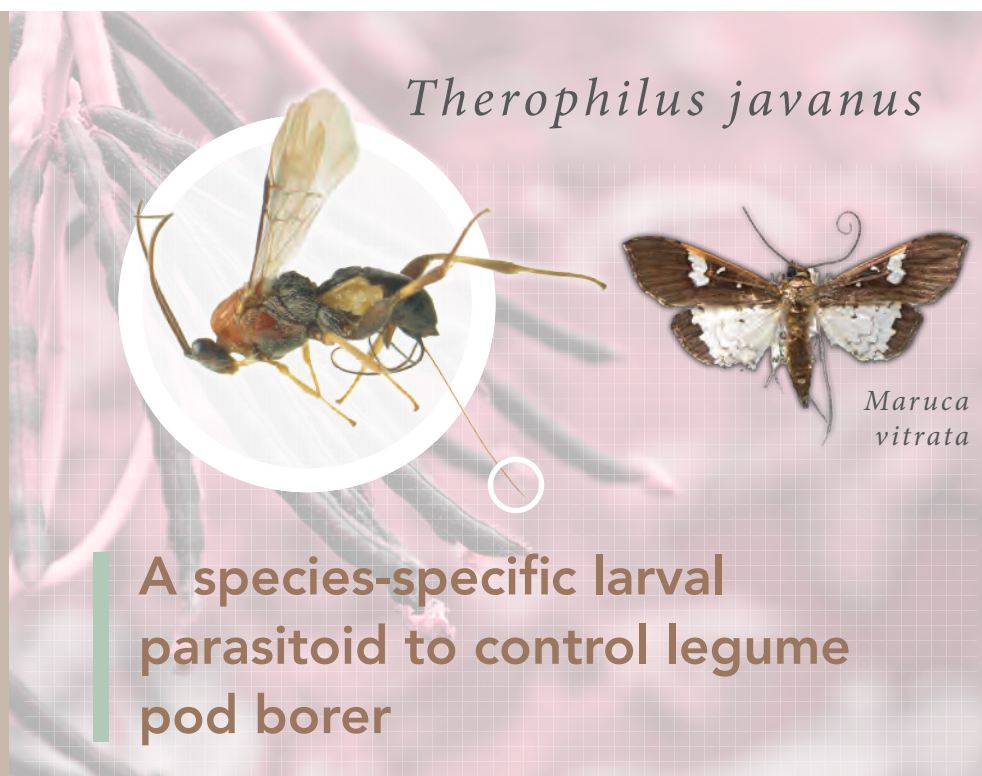
Output Targets 2013

- Advance of BC1F3 generations segregating for fertility restoration using molecular marker-assisted selection
- Crosses developed to evaluate efficacy of sweet pepper restorer lines possessing Rf gene from hot peppers
- Seeds of available CMS chili pepper increased under net house and role of bumblebees to facilitate cross pollination examined

Achievement

- Nine BCF3 families were advanced.
- 25 test crosses were developed using restorer plants and marker-assisted selection conducted.
- Seeds of five pairs of CMS sets were increased for distribution.

Pest predators
are partners
in safe plant
protection



Legume pod borer, *Maruca vitrata* (F.) is considered the most serious pest of food legumes in tropical Asia, sub-Saharan Africa, South America, North America, Australia and the Pacific. Several parasitoid species have been reported to parasitize *M. vitrata* in tropical Asia and Africa. However, they have not been exploited in biological control programs due to low levels of parasitism or because they are not species-specific. AVRDC has identified a species-specific *M. vitrata* larval parasitoid, *Therophilus javanus*, through exploratory surveys in Lao PDR, Malaysia, Taiwan, Thailand and Vietnam. Earlier, the parasitoid species was also found in Indonesia. It belongs to the Braconidae, a large family of parasitoid wasps. The most preferred parasitism stage for *T. javanus* females is the second instar larvae of *M. vitrata*; a female parasitoid parasitized about 35% of *M. vitrata* larvae under laboratory conditions. The optimum temperature for mass production of *T. javanus* is 25-35°C. Hence, *T. javanus* has the potential to

control *M. vitrata* populations in the tropics. Parasitoids such as *T. javanus* can dominate legume production systems, and have completely replaced the previously known dominant parasitoids such as *Apanteles taragamae* on *M. vitrata* in Taiwan. This confirms the dominance of the species-specific *T. javanus* over the generalist parasitoids such as *A. taragamae*.

A. taragamae has already been introduced into Benin, a West African country where *M. vitrata* is a serious production constraint on cowpea; *Therophilus* spp. have not been reported from Africa. A sister species, *T. marucaae*, is present in Malaysia and Vietnam. Although *T. marucaae* is not as widely present in other Southeast Asian countries, it could complement the performance of *T. javanus*. Introduction of *T. javanus* and *T. marucaae* into the countries where they are absent in South and Southeast Asia as well as sub-Saharan Africa might help manage *M. vitrata* in food legume production systems.

Theme PRODUCTION

Safer and sustainable vegetable production systems

Output 1: Integrated pest management technologies developed/validated

Outcome: Integrated pest management technologies and related information to manage major vegetable pests ready to be disseminated to national agricultural research and extension systems, nongovernmental organizations, and small-scale farmers

ACTIVITY 1.1

Diagnose and characterize major insect pests

Output Target

- Most common species of aphids associated with okra (*Abelmoschus* spp.) in Cameroon catalogued
- Major whitefly species / cryptic species associated with tomato, pepper and mungbean in Southeast Asia characterized

Achievements

- The most common aphid species in Cameroon has been identified as cotton aphid or melon aphid, *Aphis gossypii*. It is genetically similar to the Asian populations.
- Whitefly species collected from tomato, pepper and/or mungbean fields in India, Thailand and the Philippines were examined. The populations from India and Thailand are *Bemisia tabaci*, whereas *Aleurodicus dispersus* is in the Philippines. The *B. tabaci* populations from India and Thailand formed different clades in the phylogenetic tree based on cytochrome c oxidase I (coxI) gene sequence. The fixation index is relatively small (0.36), which indicates the two clades have a close genetic relationship.

ACTIVITY 1.2

Develop integrated pest management technologies for major insect pests

Output Target

- Efficacy of an integrated pest management strategy based on sex pheromone, biopesticides and parasitoids for legume pod borer validated in Southeast Asia and sub-Saharan Africa
- Efficacy of an integrated pest management strategy to manage aphids on okra determined in West Africa (Cameroon)
- Efficacy of an integrated pest management strategy to manage major insect pests on vegetable brassicas determined in lowlands of Bangladesh and Taiwan

Achievements

- Field trials were conducted in Lao PDR, Malaysia, Taiwan, Thailand and Vietnam to evaluate the control efficacy of commercially available biopesticide against *Maruca vitrata* on yard-long bean and cowpea. *Bacillus thuringiensis* formulations were found to be highly effective against *M. vitrata*. In open field trials in Kenya, a biopesticide formulation based on *Beauveria bassiana* strain ICIPE 69 (Campaign®) significantly reduced pod damage caused by *M. vitrata* and thrips, and increased cowpea yield. A combination of MaviNPV and neem oil reduced the *M. vitrata* damage significantly in cowpea in west Africa, and the yield increase was on par or much better than the chemical pesticides.
- Multilocation trials to evaluate resistant varieties were on-going. Integration of the selected varieties with other IPM components will be conducted in the future.
- An integrated pest management strategy based on pheromone lures and parasitoids has been evaluated against *S. litura* on cabbage in Barisal and Jessore, Bangladesh. Damage to cabbage heads was reduced by 66-83% with IPM treatment, resulting in a 26-44% yield increase. In Taiwan, application of a pesticide window strategy resulted in significantly higher marketable yield of cabbage. AVRDC lures either alone or in combination with allyl isothiocyanate attracted significantly higher number of diamondback moth (DBM) adults. Application of pheromone lures or Indian mustard as a trap crop alone did not reduce DBM infestation nor yield increase. Pheromone lures could be used as a monitoring tool, but not as the only component in an IPM strategy for DBM.

- Efficacy of an integrated pest management strategy for eggplant fruit and shoot borer validated in Nepal

- An IPM strategy to manage eggplant fruit and shoot borer was validated in Parwanipur, Nepal. Although the IPM treatments resulted in significantly less shoot damage, neither the fruit damage nor the marketable yield differed significantly among the treatments.

ACTIVITY 1.3

Diagnose and characterize major bacterial and fungal pathogens

Output Target

- Survival capacity of phylotype IIB-1 strains of *Ralstonia solanacearum* in lowland tropics determined
- *Ralstonia solanacearum* from tomato in Eastern Africa and from pepper and eggplant in Taiwan characterized
- *Colletotrichum* species associated with chili pepper anthracnose in Oceania identified and the application of FTA® card in molecular diagnosis evaluated

Achievements

- The presence of higher soil microbial population and absence of weeds did not favor the survival of phylotype IIB-1 strains, according to a greenhouse trial. Nevertheless, the pathogen could still survive for 105 days under this condition.
- DNA samples of *R. solanacearum* were to be received from Tanzania and Kenya for characterization. Studies on the variation of the pathogen on pepper and eggplant in Taiwan were not conducted as the subject was removed from the approved project proposal.
- A diagnosis protocol based on the FTA® card was established and validated for pepper anthracnose pathogens. The diagnosis is based on specific restricted fragment patterns of the ITS region of *Colletotrichum* species. Using the method, thirteen isolates collected from Fiji were identified as *C. simmondsii* (12) and *C. truncatum* (1).

- Pathotypes of cucurbit downy mildew in Taiwan identified

- Pathotype profiles of *Pseudoperonospora cubensis* isolates in Tainan were determined using a set of differential varieties using the leaf-disc method. Pathotype Pc 1/0/0 was the predominant pathotype (13 out of 24 isolates). Overall, *P. cubensis* population in Tainan displayed a high virulence variation. Its virulence was lower compared with those reported in Israel, Japan, Thailand, USA, and Europe.

ACTIVITY 1.4

Develop and validate integrated disease management technologies for major bacterial and fungal diseases

Output Target

- Control efficacy of plant activators on tomato and pepper foliar diseases evaluated
- Effect of biochar as an amendment in potting mixture on plant growth and induced resistance in tomato evaluated
- Rootstock varieties with good compatibility and flooding tolerance for sweet pepper production in hot-wet season identified

Achievements

- Preliminary evaluation on the efficacy of four plant activators against seven tomato diseases and four pepper diseases was conducted. Significant treatment effects were detected on nine diseases, including bacterial disease (bacterial spot) and fungal diseases (late blight, etc.) causing symptoms on leaves or vascular areas. However, the effect could be due to variety and/or pathogen isolate.
- Induced resistance on tomato plants against early blight was observed when amending biochar in peat moss or coconut fiber based potting mixture. The effect was additive with the addition of the biocontrol agent, *Streptomyces* sp.
- Resistance to bacterial wilt and Phytophthora blight of six hot pepper rootstocks with flood tolerance was re-evaluated. Results showed PI201234 was highly resistant to both diseases.

ACTIVITY 1.5

Detect, characterize and explore integrated management strategies for major viral diseases

Output Target

- The important viruses, especially begomoviruses, infecting or emerging in vegetable crops in Asia and Africa identified and monitored
- Genetic diversity of Solanaceae-infecting begomoviruses in Indonesia studied
- An infectious clone of a cucurbit-infecting begomovirus from Taiwan developed

Achievements

- *Pepper vein yellows virus* (PeVYV; Polorovirus) was shown to be present in leaf samples from six countries (India, Indonesia, Mali, the Philippines, Taiwan and Thailand) indicating that it has probably been present but unrecognized in these areas for a long time. Most tomato, pepper and eggplant showing symptoms of virus infection in Khon Khen and Kanchanaburi/Rachanaburi areas of Thailand were infected with begomovirus(es), though the peppers were often also infected with *Chili veinal mottle virus* (ChiVMoV; Potyvirus).
- Most of the tomato and pepper leaf samples were tested positive by PCR for infection with begomovirus. Preliminary phylogenetic analysis of 18 samples based on the partial DNA-A sequence (ca 1.5kb) indicates that most of these sequences are likely to be *Pepper yellow leaf curl Indonesia virus* (PepLCIV), while two may represent a previously undescribed begomovirus.
- Partial dimers of the full-length clones of DNA-A and DNA-B components of a Taiwan isolate of *Squash leaf curl Philippines virus* (SLCuPV) have been produced and separately transferred to Ti plasmids in *Agrobacterium*. Agro-inoculation of squash plants with a mixture of *Agrobacterium* carrying each of the components results in typical infection and symptoms of SLCuPV, but agro-inoculation with only DNA-A or DNA-B results in no infection, confirming that SLCuPV is a bipartite begomovirus.

Output 2: Integrated crop and soil fertility management technologies developed/ validated

Outcome: Integrated crop and soil fertility management technologies and related information to enhance and sustain vegetable productivity ready to be disseminated to NARES, NGOs, and small-scale farmers

ACTIVITY 2.1

Develop technologies to improve soil nutrient use efficiency and soil sustainability

Output Target

- Guidelines of soil health assessment suitable for smallholder vegetable production in Oceania developed
- Components of biochar briquette and its effects in soil studied
- Major soil constraints identified and long term trials to determine the benefits of soil management designed and started in Oceania

Achievements

- Field survey protocol and pictorial guideline of soil health assessment suitable for smallholder vegetable production in Fiji developed. Soil health status based on twelve selected indicators in major vegetable fields in Fiji was surveyed. Summarized soil health survey report completed.
- Components of rice husk biochar briquette (RHBB) were studied via manual-press machinery. Results of stability tests of the air-dried RHBB indicated corn starch at the amount of 5 or 6% was suitable to produce RHBB. Preliminary results indicated that RHBB could increase or sustain N retention in soil as compared to RHB application alone in soil column assays.
- Low fertility and low organic matter content were identified as the major soil constraints in Sigatoka valley and Koronivia in Fiji. Integrated soil fertility management with emphasis on starter solution technology (SST) and balanced fertilization is proposed in the long term trials to improve soil health condition in Fiji.

Output 3: Improved vegetable production technologies integrated, disseminated, and impact assessed

Outcome: Farmers adopt new technologies that result in improved farm productivity and sustainability, incomes, and farm livelihoods

ACTIVITY 3.1

Identify major constraints and determine site-specific dissemination strategies in targeted regions

Output Target

- Participatory appraisals of vegetable farming conducted in targeted countries, e.g. central Indian tribal areas and dissemination strategies determined for integrated crop management technologies

Achievements

- Participatory appraisal on commercial and homestead vegetable production was conducted in flood-prone areas of Odisha. Key findings included: crop management mostly by females, high price of vegetables during the rainy season, and key production constraints identified (seed availability, water supply during winter, and pest damage). Participatory appraisal on commercial vegetable production was conducted in three locations of Jharkhand and West Bengal to identify inter/alternate cropping systems for rice. Vegetable legumes are suitable crops for crop diversification, improved soil fertility and potential diet diversification.

ACTIVITY 3.2

Adapt integrated production technologies for targeted systems or regions

Output Target

- Integrated crop management technologies for tomato, pepper, and brassicas adapted in Indonesia (e.g. tomato grafting and late blight control), in Oceania (e.g. insect exclusion net), and in Uzbekistan (tomato grafting)

Achievements

- Field trials showed that using improved seedling management and a disease-resistant chili line (AVPP 1102-B) could suppress viral diseases, anthracnose and Phytophthora blight (*Phytophthora capsici*) in East Java; and by using H₃PO₃ compound, a significant reduction in pesticide use for controlling tomato late blight was observed without significantly reducing yield in the Bali highlands. A suitable potting mixture prepared from locally available materials for tomato was identified in Fiji. Tomato grafting has been adopted in Uzbekistan and Armenia for the first time. In India, nursery treatment with Carbofuran along with seedling treatment with Triazophos was shown to have significant effect in reducing root-knot nematode severity and yield increase on tomato.

- Effect of rain shelter and eggplant rootstocks on summer tomato yield and quality determined (USAID-Bangladesh)
- Field trials were conducted in Shanhua, Taiwan, and Gazipur and Jessore in Bangladesh to evaluate the effect of rain shelter and flooding resistant eggplant rootstock on tomato production during hot and wet season. Preliminary data analysis results of the Shanhua trial showed only the rootstock effect was significant on the total marketable yield. Data from the other two trials remained to be collected and analyzed.
- Appropriate vegetable crops, varieties, and their cultural practices identified for Kilombero, Tanzania and for direct seeded rice system in Jharkhand and for flood-prone areas of Odisha, India
- Four traditional vegetables—amaranth (*Amaranthus* spp.), Ethiopian mustard (*Brassica carinata*), African eggplant (*Solanum aethiopicum*) and African nightshade (*S. vilosum*)—and two tomato cultivars were identified and the recommended management practices were demonstrated at Arusha, Tanzania. Field trials are ongoing to evaluate the effect of intercropping and rotation vegetable legumes: vegetable soybean (*Glycine max*), cowpea (*Vigna unguiculata*), French bean (*Phaseolus vulgaris*), mungbean (*V. radiata*) and black gram (*V. mungo*) in the direct seeded rice system in Jharkhand and West Bengal, India. Five vegetable crops: kangkong (*Ipomoea aquatica*), basella (*Basella* sp.), summer amaranth, bitter melon (*Momordica charantia*) and moringa (*Moringa oleifera*), their varieties/types, and their cultural practices were selected and are under evaluation and demonstrations at flood-prone areas of Odisha, India.

ACTIVITY 3.3

Strengthen capacity of local partners and farmers to promote technology adoption

Output Target

- Extension and training materials published on various vegetable production technologies

Achievements

- A total of 20 extension publications and training materials developed/published on various vegetable production technologies, including Farmers' Guides, posters, technical pamphlets, video and training manual for numerous training activities conducted in five countries.

- Capacity of extension staffs, female nursery operators and vegetable farmers in Indonesia, Bangladesh, Jharkhand and Odisha in India, Oceania, Central Asia, Cameroon, and Tanzania strengthened through Training of Trainers, Farmer Field Schools, field days or group discussions
- Four issues of Feedback from the Field published and mature technologies database updated
- A total of 137 training courses conducted through various activities in 14 countries, including Indonesia, Bangladesh, India, Solomon Islands, Fiji, Armenia, Azerbaijan, Georgia, Kazakhstan, Uzbekistan, Kyrgyzstan, Turkmenistan, Cameroon and Tanzania. Total number of beneficiaries: 3142 (69% male, 31% female), including 30 female nursery operators trained in tomato grafting and healthy seedling preparation, 249 extension officers and farmers trained through training of trainer workshops on vegetable production, 2644 farmers that attended crop management, IPM, grafting and other trainings, and 219 farmers that attended field days on promoting traditional African vegetables and other new vegetable varieties.
- Four issues of Feedback from the Field with 13 articles contributed from 11 countries published on the AVRDC website and Facebook. Two technologies were updated to the mature technologies database.

ACTIVITY 3.4

Understand farmers' behavior, cost-benefit, and constraints/opportunities of technology adoption

Output Target

- Economic costs and benefits of integrated crop management technologies in Thailand, Vietnam, Indonesia, Bangladesh and Oceania analyzed and documented
- Farm-level opportunities and constraints in the adoption of IPM methods for *Maruca vitrata* documented for Thailand and Vietnam
- Farm-level opportunities and constraints in the adoption of virus-resistant varieties and IPM methods of vector control for mungbean, tomatoes and chilies documented for India, Thailand and Vietnam

Achievements

- Legume pod borer IPM: Surveys were conducted in Thailand and Vietnam among farmers participating in the on-farm IPM trial and a random selection of non-participating farmers. Results showed no significant ($p < 0.05$) differences in crop yield, profits and the number of pests observed. However, in Vietnam the quantity of synthetic pesticide was significantly lower for the IPM farmers. Tomato late blight: Partial budgeting analysis was used to assess the relative profitability of using phosphonic acid (H_3PO_3) to control late blight on tomato in Bali, Indonesia using an on-station experimental setup with 3 replications. Results showed that the use of H_3PO_3 gave 7-8 times higher profits compared with farmers' conventional practices of using fungicides.
- A baseline survey among 240 yard-long bean growers was conducted in Thailand (3 provinces near Bangkok) and Vietnam (4 districts in the Red River Delta near Hanoi). The results showed that the adoption of IPM methods might be constrained by a high satisfaction of farmers with synthetic pesticides, the absence of a price premium for pesticide-safe produce, and extremely small production areas ($\sim 800m^2$) in Vietnam.
- Farm level surveys were conducted in randomly selected villages in the major production areas of chili and tomato in Thailand and of chili, tomato and mungbean in Vietnam and Tamil Nadu, India to assess farm-level yield losses from plant viruses. The data collection for Vietnam will be completed in 2013. Data are currently being analyzed.

ACTIVITY 3.5

Understand the impact of improved technologies on production systems and livelihoods

Output Target

- The impact of AVRDC on tomato grafting in Vietnam is documented
- Data collected for the outcome evaluation of summer tomato production in Bangladesh (Barisal and Jessore districts) analyzed
- The impact of AVRDC-SRTT Project on vegetable production in Punjab and Jharkhand documented

Achievements

- The impact study on tomato grafting was completed. It showed a very high adoption rate of grafted tomato seedlings in Vietnam and an estimated 31% higher tomato yields.
- Data collection on summer tomato production in Jessore and Barisal has been completed; analysis is ongoing. The evaluation will assess the impact of summer tomato production on the net household income, pesticide use, and gender.
- Evaluation studies were conducted on commercial vegetable production and home gardens in Jharkhand and Punjab. A substantial increase in vegetable consumption in Jharkhand and an improved diet in Punjab were demonstrated as a result of the home gardens. However, half the households in Jharkhand gave up their home gardens after one year due to the problems with water supplies and livestock damage. Reports are being prepared.

New crops
improve diets
and incomes



Vegetable soybean finds favor in India

When a vegetable is popular with children, their parents and farmers alike, it's a good sign. The recent rapid growth of vegetable soybean production in India is an example of how a new crop can change lives for the better.

Khudiram Munda, a 31-year-old farmer from the tribal village of Uludih near Ranchi in Jharkhand is typical of many new vegetable soybean growers. He began with 4 kg of seed provided by AVRDC in 2010 that he sowed in a 400 m² field in July. He was able to harvest 250 kg of pods about 80 days later and most of these were sold at four local markets for INR 20/kg.

Mr. Munda's family consumed the green vegetable soybean seeds either fried or boiled like green peas—and even the children liked this new food. But they also found the dry seed could be very tasty if soaked overnight to remove the seed coat, then fried with spices and eaten with boiled rice. Mr. Munda said he likes vegetable soybean “because it contains vitamin A which is good for the eyes.” He kept enough seed for planting in successive

seasons, and the crop has become an important source of income and food for his family.

Vegetable soybean is a new crop for India. The introduction of various AVRDC lines led to the release of the variety ‘Swarna Vasundhra’ in 2008 by the Indian Council for Agricultural Research - Jharkhand. Vegetable soybean is a hardy and successful rain-fed crop with low labor requirements that is well-suited to the sandy and often shallow soils of Jharkhand, one of the poorest states in India.

Demand for seed has expanded rapidly from the 60 farmers who grew it in the first year. By the third year more than 3000 farmers were growing the crop and by the fourth year demand for seed from 50,000 farmers greatly outstripped available supplies. The potential for the crop across the rest of the region is yet untapped, but as grain soybean is already the most widely grown legume there is huge potential for vegetable soybean to make a significant contribution to improving the diets and incomes of smallholder farmers.

Theme CONSUMPTION

Balanced diets through increased access to and utilization of nutritious vegetables

Output 1 : Knowledge of consumer behavior and nutritional properties of vegetables enhanced

Outcome: Research communities become aware and better understand consumers' attitude towards health, food safety and vegetable consumption as well as the nutritional and functional values of vegetables.

ACTIVITY 1.1

Assess consumption nutrition related outcomes of vegetable gardeners and consumers in Asia and sub-Saharan Africa

Output Targets 2013

- Study on production, consumption and marketing of bitter gourd and ex-ante analysis of its use in managing type 2 diabetes in India and Tanzania documented conducted
- Baseline yield gap, diagnostic and consumption patterns survey of intensified rice-vegetable systems in Tanzania and Ghana conducted
- Household survey conducted and data analyzed for food and nutrition gap in target areas of Sikasso region in Mali

Achievement

- Synthesis survey reports of production, consumption and marketing of bitter gourd from Punjab and Tamil Nadu (India) and Arusha and Moshi regions (Tanzania) available. Further studies are required to fill data inconsistencies (India) and correct for sample size representation (Arusha).
- Study for Tanzania was not undertaken due to the pull out of a major implementing partner (AfricaRice) from the project as a result of internal institutional reasons. A new proposal for an integrated maize-based vegetable systems study in Tanzania was later approved and a corresponding baseline study implemented. The study for Ghana was conducted with preliminary characterization reports available.
- Partial household survey was conducted for the purpose of collecting target project related indicators but studies on food and nutritional gaps was not possible during the reporting period due to staff turnover and political instability in Mali.

- Interactive GIS-based platform established for data exchange and visualization urban and peri-urban vegetable production, consumption and marketing in Greater Bangkok, Thailand
- Data collection completed by University of Freiburg graduate students in collaboration with AVRDC and Kasetsart University staff. Analysis and report writing in progress.

ACTIVITY 1.2

Study nutritional and functional values and benefits of vegetables from sub-Saharan Africa and Asia

Output Targets 2013

- Anti-hyperglycemic effect of bitter melon validated in insulin-resistant patients in India and Tanzania

- Phytochemical and nutrient databases of common vegetables designed

Achievement

- The first phase of the clinical trial began for 56 subjects at the Avinashilingam University for Women (AUW) in India. The crossover study has been completed. Another phase of the study involving 26 subjects was started in September and will be completed in 2014. In Tanzania, the Kilimanjaro Christian Medical Centre (KCMC) and Justus-Liebig University, Giessen team confirmed 60 participants for the intervention study after screening in the previous months. The intervention trial commenced with a total of 60 subjects. Results of the first intervention study for both India and Tanzania will be completed by the end of 2013 with a second intervention (crossover) to commence in early 2014.
- More than 15 nutrient compounds and LC-MS profiles per vegetable were documented for 30-35 most popular vegetables in Taiwan (tropical Asia). A web-based interactive database was designed for testing.

Output 2: Dietary strategies and food based interventions developed, validated and implemented

Outcome: AVRDC – The World Vegetable Center, national agricultural research and extension system and nongovernmental organizations promote home, school and community gardening, distribute seed kits to disaster affected areas and advocate more nutritionally effective use of vegetables.

ACTIVITY 2.1

Design, validate and implement home, school and community garden interventions for enhanced access to and consumption of vegetables by poor household, especially women and children in Asia and sub-Saharan Africa

Output Targets 2013

- School and community gardens in target locations in Indonesia and Cameroon established and functional with appropriate cropping schedule/sequence, pilot schemes in sub-Saharan Africa and Asia explored
- Protocols for collecting baseline and follow-up data on 30 school vegetable gardens in Bhutan, Burkina Faso, Indonesia, Nepal, Philippines and Tanzania; and for home vegetable gardens in Bangladesh developed; baseline data collected.
- Training of Trainers workshop for establishing school vegetable gardens in Bhutan, Burkina Faso, Nepal and Tanzania conducted.
- Data on the outcomes/impact of home gardens on poverty and food consumption in Jharkhand, India analyzed and documented.

Achievement

- 40 school gardens have been established in East Java and Bali. The school garden model has been adopted by other schools to improve the performance of schools under the local "green school" concept.
- Draft protocol and tools are available. Baseline data about schools and communities and pre-intervention data from school girls and boys will be collected at the start of the school year before the gardens are established.
- A Training of Trainers workshop was held in Taiwan from 18 August to 13 September. There were 18 participants from 6 countries.
- Outcome evaluation study conducted in collaboration with a graduate student from Justus Liebig University Giessen (Germany). Data entry completed. Analysis and report writing in progress.

ACTIVITY 2.2

Develop and distribute nutritious vegetable seed kits as disaster response and to other vulnerable groups in tropical and sub-Saharan Africa and Asia

Output Targets 2013

- Existing seed stocks in Taiwan, India, Tanzania and Mali made available for distribution in response to future disasters in sub-Saharan Africa, Asia and Pacific in exchange for funding to replenish seed stocks
- Easy-to-understand instructions on cultivation, field management and food preparation in various languages prepared, published and disseminated to vulnerable groups or possibly as disaster response in sub-Saharan Africa, Asia and Pacific

Achievement

- A total of 17,000 seed packs and 680 seed kits were prepared and distributed to victims affected by flood, war and cyclone in India, Mali and Fiji; 2000 seed kits containing five crops were prepared in Indonesia for future disaster response.
- Easy-to-understand instructions on cultivation, food preparation and nutritional contribution were developed and published in English, Kiswahili, Bambara (local language in Mali), Assamese (local language in Assam, India) and Russian and distributed to vulnerable groups and disaster affected victims along with seed packs.

ACTIVITY 2.3

Develop dietary strategies, nutrition-improved recipes and food preparation methods based on traditional diet and food practices for increased consumption of vegetables and nutritious/healthy diets by poor households in Asia and sub-Saharan Africa

Output Targets 2013

- Dietary strategies for bitter gourd consumption for low income and high diabetic prevalent regions in India and Tanzania developed
- Dietary options identified and strategies developed using locally available vegetables for promotion in target areas in south Bangladesh, Cameroon, selected areas of Mali and Central Asia distributed to target beneficiaries

Achievement

- Several bitter gourd recipes were developed and tested in Taiwan, India and Tanzania. The recipes were drafted and ready for formatting to be published in 2014.
- A demonstration vegetable garden with six crops comprising a total of ten varieties was set up at the National University of Uzbekistan. Nutritional seed kits were prepared and distributed to beneficiaries at Bostanlyk and Buhara colleges. This has facilitated promotion of home, school and community gardening as well as cultivation of vegetables in disaster, drought and high-saline affected areas, as well as advocacy for the nutritional importance of vegetables in human diets.

- Recipes designed for promotion in school garden program in Mali, Cameroon and selected regions in Central Asia

- New recipes developed for Uzbekistan and a brochure entitled “Dishes from vegetable soybean and girasol” was prepared for publication in 2014.

ACTIVITY 2.4

Develop, validate and implement promotion strategies for increased consumption of vegetables and nutritious/diverse diets by poor households emphasizing on women and children in Asia and sub-Saharan Africa

Output Targets 2013

- Innovative multiple communication tools developed and tested to promote good nutritional practices and increased vegetable consumption in rural and urban areas of selected areas of Mali
- Approaches on effective communication and dissemination strategies tested for promoting indigenous vegetable nutrition and utilization in Central Asia, Bangladesh and Cameroon
- Community-based promotion campaigns conducted for enhanced vegetable consumption in south Bangladesh

Achievement

- Recipe-led nutritional promotional strategies in Mali conducted. Recipes developed have been displayed at public and social gatherings, disseminated via mass media and even through songs. Innovative communication tools used included Women’s Secrets (recipes), food pyramids, and an annual calendar of availability of vegetables among others. Staffing shifts and political instability limited progress on this output target.
- Information on traditional vegetables aimed at promoting nutrition and utilization was collected in Uzbekistan, Bangladesh and Cameroon. Dissemination strategies on tomato grafting and summer tomato cultivation were tested in Bangladesh and Indonesia. Staffing changes in Cameroon limited progress on testing of the effectiveness of different dissemination approaches.
- Strategies for nutrition and social marketing promotion for increased vegetable consumption in Bangladesh were started. Links were forged with Lal Teer Seed to strengthen the nutritional impact pathway of vegetable production in Bangladesh. Collaboration with IFPRI in the project was made to focus on a market or field laboratory behavioral experiment, studying the types of information that most increase vegetable demand.

Output 3: Approaches to enhanced market efficiency and access developed, post-harvest losses minimized and vegetable supply chains strengthened

Outcome: Small-scale farmers and other actors in Africa, Asia and the Pacific benefit from improved market coordination along vegetable supply chains, improved post-harvest practices as well as from enhanced research capacities and networks.

ACTIVITY 3.1

Analyze components of supply chains, marketing systems and postharvest handling of vegetables in sub-Saharan Africa, Asia and Pacific

Output Targets 2013

- Needs assessment of vegetable postharvest handling and storage in Bangladesh and Mali; and study on postharvest losses assessment in Tanzania, Kenya and Ghana conducted
- Stakeholder consultation workshops conducted to understand local needs, constraints and opportunities of postharvest management in Ghana, Kenya and Tanzania
- Market survey conducted in Tanzania among growers and consumers of indigenous vegetables and their demand for seed and for produce

Achievement

- Needs assessment study in Bangladesh conducted. Baseline surveys on physical and economic postharvest losses were conducted and documented for Tanzania, Ghana and Kenya. Research outputs from studies were presented at various postharvest scholarly society meetings.
- Consultation workshops: in Tanzania, conducted in May with 34 participants from 23 organizations; in Ghana, held in June with 36 participants from 12 organizations; in Kenya, held in August with 29 participants from 10 organizations. Workshop reports served as the basis for development of 2013/14 program workplans.
- Market survey conducted and two peer-reviewed draft manuscripts in progress. Research outputs from studies presented at various scholarly society meetings.

- Results of vegetable value chain and market opportunities study in East Java and Bali, Indonesia documented

- Value chain analysis conducted with draft reports available. The study identified issues related to marketing of vegetables in Bali and East Java. In East Java, the major target outlets for vegetable marketing are food processing companies and wholesale markets in Java and other major islands in Indonesia. In Bali, the main outlets for vegetable marketing include hotels and restaurants within the province, making the marketing channels comparatively shorter than in East Java. A major critical issue in East Java involves options to sustain levels of production to fulfill consumer market demand. In Bali, the major issue involves maintaining high quality of produce as per demand by hotels and restaurants.

ACTIVITY 3.2

Facilitate the establishment of enhanced market coordination mechanisms for vegetable supply in sub-Saharan Africa, Asia and Pacific

Output Targets 2013

- Value chain groups based on the participatory market chain approach established for summer and winter tomato production systems in Bangladesh
- Pilot participatory guarantee system for high value vegetable crops in Fiji and Solomon Islands developed and monitored.

Achievement

- A participatory market chain workshop on tomato was held in Barisal and Jessore in April. The workshop was attended by 52 and 20 participants, respectively, and was combined with training on postharvest handling of tomatoes.
- Two farmer groups practicing a participatory guarantee system (PGS) in Solomon Islands were evaluated. Training on business skills that required further strengthening was provided. In Fiji, a total of four farmer groups were established and willing to register as private companies. A trial shipment was made in August by the farmer group in Qereqere in Sigatoka valley to the Shangri-La Fijian Resort. This allowed the growers to understand the market process and requirements, and the new value chain practices that will result in higher returns.

- Linkages and value chain enhancing activities forged between indigenous vegetable seed and produce growers and private seed companies in Tanzania
- Evaluation and promotion of improved vegetable packaging materials conducted via on-farm demonstrations in Tanzania
- Effective linkages along vegetable value chains enhanced through demand creation activities in Tanzania, selected areas of Mali and Cameroon
- Linkages forged between more than 40 vegetable seed growers in four communities in the Arusha region of Tanzania. Further dissemination activities and value chain linkages via radio were conducted in collaboration with Farm Radio International.
- Improved packaging materials in Tanzania were identified including stackable plastic crates. On-farm trials were not conducted due to unforeseen changes in project contractual arrangements (partners and project sites).
- Demand creation activities such as the Seed Fair and African Child Day among others were conducted in Tanzania and Mali. Due to staff turnover, only limited activities were undertaken in Cameroon.

ACTIVITY 3.3

Develop and enhance training curricula and materials on proper postharvest management and marketing skills for trainers in Asia, sub-Saharan Africa and Pacific

Output Targets 2013

- Curricula and training materials reviewed and updated annually for the International Vegetable Training Course (IVTC) held in Thailand, and for Onion Production, Storage and Marketing Training Course in Cameroon
- Training materials developed and related standard operating procedures completed for use at Postharvest Training and Services Center in Tanzania for capacity building programs

Achievement

- IVTC curricula and lecture/training materials on vegetable postharvest, marketing and nutrition reviewed and updated in the course of the year. Training curricula for onion reviewed and delivered to 28 new participants in northern Cameroon.
- Training materials developed for introductory postharvest course for farmers and more advanced handling course for postharvest practitioners in Tanzania. One day and two day training programs at the Postharvest Training and Services Center conducted and course evaluation forms utilized.

- Training materials translated into local languages of selected countries in sub-Saharan Africa, Asia and Oceania and adapted for dissemination to beneficiaries in targeted locations

- Training materials translated into Swahili, Bambara (local language in Mali), Assamese (local language in Assam, India) and Russian and direct training of farmers in vegetable agronomy, marketing and postharvest practices undertaken at various locations.

ACTIVITY 3.4

Strengthen postharvest research capacity of national partners through trainings and awareness raising on postharvest losses and postharvest research in national and regional level in Asia, Africa and the Pacific

Output Targets 2013

- At least 25 participants from Asia trained on vegetable production, postharvest and marketing
- At least 20 participants from northern Cameroon trained on onion production, storage and marketing
- At least 250 participants for the Training of Trainers and farmer training courses from Tanzania and Bangladesh trained in postharvest handling practices

Achievement

- 40 women farmers were trained in tomato grafting and new variety cultivation in Uzbekistan on 21 November 2013. 25 participants from East and South East Asia were trained in the 32nd IVTC course in Bangkok.
- 28 participants from northern Cameroon were trained in onion production, storage and marketing
- 184 participants trained so far: 72 farmers received postharvest training in Bangladesh in April; 149 amaranth farmers attended a postharvest demonstration in Arusha, Tanzania in June; and 63 diploma students received TOT training in May in Tanzania.

ACTIVITY 3.5

Adapting available technologies and developing new technologies to meet the needs of the target value chain actors and stakeholders in selected countries in Asia, Africa

Output Targets 2013

- Research trials conducted on use of evaporative coolers for short term vegetable storage to reduce postharvest losses in Tanzania

Achievement

- Trials were conducted at Arusha station. Preliminary results show that evaporative coolers produced temperatures 5-10 °C lower than ambient conditions and increased storage period of leafy vegetables from four to five days.

- Preliminary evaluation of packing crates for tomato transportation conducted
- A study was conducted at Arusha station. Simulated transport of tomatoes in packing crates reduced damage from 52% for the standard wooden crates to 22% for improved plastic crates.
- Evaluation of the shelf-life performance conducted of newly introduced vegetable varieties in Bangladesh
- Preliminary selection of important vegetable varieties under the USAID Postharvest program in Bangladesh conducted in collaboration with the USAID-Horticulture project.

Output 4: Policy recommendations with an aim to increase vegetable consumption developed, capacity strengthened and technology and knowledge disseminated
Outcome: Consumers are aware of the health-promoting benefits of increased utilization of vegetables through better access to nutritional education information, enhanced capacities of national agricultural research and extension systems and nongovernmental organizations, and improved policy support.

ACTIVITY 4.1
 Conduct training courses and other capacity building and knowledge sharing platforms to increase awareness and capacity of vegetable value chain actors and stakeholders to increase production, utilization and consumption of nutrient-rich vegetables in Asia, sub-Saharan Africa and Pacific

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| <p><i>Output Targets 2013</i></p> <ul style="list-style-type: none"> • Senior government staff from Bhutan, Burkina Faso, Indonesia, Nepal, Philippines and Tanzania trained in design and implementation of vegetable school garden programs via workshops • 3-5 day training courses on vegetable production, processing, consumption and conservation delivered to 15-20 target youth and women groups in Tanzania | <p><i>Achievement</i></p> <ul style="list-style-type: none"> • The Vegetables Go to School Policy Workshop was held in Taiwan in September 2013. It was attended by ToT participants, international project partners, AVRDC staff and four policy makers who worked with their country teams to develop realistic action plans for establishing school garden programs in their countries. • A total of 102 women and 125 men farmers and extension workers from Ukerewe island district in Mwanza region and Arusha region in Tanzania were trained. The training focused on traditional African vegetables not only as income generating commodities but also as subsistence crops to bridge food shortage seasons. |
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- 1-2 farmer field days in Central Asia and the Caucasus and Cameroon conducted to promote increased production and consumption of vegetables
- Multi-stakeholder platforms established for intensified rice-vegetable production systems in Tanzania and Ghana
- Farmer field days were conducted in seven countries in Central Asia and the Caucasus. A total of 250 farmers participated. Farmers in Tanzania were also facilitated to participate in the 2013 national agricultural show.
- A platform for Tanzania was not established due to the pull out of a major implementing partner (AfricaRice) from the project for internal institutional reasons. A new proposal for an integrated maize-based vegetable systems study in Tanzania was later approved but had no specific activity requiring establishment of a multi-stakeholder platform.

ACTIVITY 4.2

Develop data collection protocols and policy briefs on outcome and impact assessment of program interventions in sub-Saharan Africa, Asia

Output Targets 2013

- Generic monitoring and evaluation framework and scaling-up strategy of technology dissemination published
- At least one policy brief on impact assessment of tomato grafting technology in Vietnam and on economic cost quantification of postharvest losses in sub-Saharan Africa and Asia published
- Framework for centralized monitoring and evaluation data collection tools and databases for Center developed

Achievement

- A draft framework is ready for editing and printing. It needs updating to incorporate gender mainstreaming aspects.
- A full impact assessment study of tomato grafting in Vietnam was published and is available online and in the AVRDC Library. A policy brief extract is in progress. A postharvest policy brief also is in progress. An overview of postharvest losses of vegetable crops presented during stakeholder workshops was published in *Coast Week* and *The Star* newspapers in Kenya and on the GHANAWEB news site in Ghana: <http://www.ghanaweb.com/GhanaHomePage/NewsArchive/artikel.php?ID=278281>
- VegOne version 1.0 was launched in October 2013 after beta testing. The internally hosted system can be accessed from vegone.worldveg.org. An orientation meeting was held at headquarters and similar sessions will follow in the regions. More than 110 indicators were entered in the system by the end of 2013.

Projects in 2013

Project Title	Donor Name	Duration
Integrated omics on exploring bruchid resistance and improvement of sprouts quality in mungbean (<i>Vigna radiata</i> (L.) Wilczek)	Academia Sinica, Taiwan	2013-2016
Vegetable Strategy for AGRA	Alliance for a Green Revolution in Africa	2013-2014
Multilocation evaluation of tomato lines carrying different combinations of Ty genes for resistance against begomovirus infection	Asia and Pacific Seed Association	2013-2014
Developing an integrated participatory guarantee scheme in the Pacific Islands in support of sustainable production of high-value vegetable crops.	Australian Centre for International Agricultural Research, Australia	2012-2014
Strengthening integrated crop management research in the Pacific Islands in support of sustainable intensification of high value-crop production	Australian Centre for International Agricultural Research, Australia	2011-2016
Increased resiliency of vulnerable communities in Puri district, Odisha to recurrent floods	COFRA Foundation, Switzerland	2012-2014
Integrated systems in the humid tropics	Consultative Group on International Agricultural Centers	2012-2013
Development of the molecular diagnostic marker and inoculation technology for tomato mosaic virus	Council of Agriculture, Taiwan	2013
Exploring the nutritional potential of selected indigenous vegetables and legume crops at different growth/ consumption stages	Council of Agriculture, Taiwan	2012-2013
Strengthening cooperation between AVRDC - The World Vegetable Center and Taiwan on vegetable research and development	Council of Agriculture, Taiwan	2013
Attraction in Action: Using pheromones and other safe and sustainable management strategies to reduce losses from insect pests and plant diseases on vegetable legumes and leafy brassicas in Southeast Asia	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany	2013-2016
Beating Begomoviruses: Better livelihoods for farmers in tropical Asia with begomovirus-resistant tomato, hot pepper and mungbean and integrated disease management	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany	2012-2015

Project Title	Donor Name	Duration
Better Bitter Gourd: Exploiting bitter gourd (<i>Momordica charantia</i> L.) to increase incomes, manage type 2 diabetes, and promote health in developing countries	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany	2011-2014
Enhancing horticultural productivity, incomes and livelihoods through integrated management of aphid pests on vegetables in sub-Saharan Africa	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany	2011-2014
Enhancing the Livelihood Opportunities of Smallholder African Indigenous Vegetable Producers through the Development and Implementation of IPM Measures for Arthropod and Nematode Pests	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany	2013-2016
Less loss, more profit, better health: reducing the losses caused by the pod borer (<i>Maruca vitrata</i>) on vegetable legumes in Southeast Asia and sub-Saharan Africa by refining component technologies of a sustainable management strategy	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany	2010-2013
Overcoming conservation and germination problems of selected indigenous vegetables	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany	2012-2014
Vegetable cucurbits for nutrition-sensitive home and school gardens in Southeast Asia	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany	2013-2014
Network for knowledge transfer on sustainable agriculture technologies and improved market linkages in South and Southeast Asia (SATNET Asia)	EuropeAid	2011-2014
Implementation of integrated thrips and tospovirus management Strategies in small-holder vegetable cropping systems of Eastern Africa	Federal Ministry for Economic Cooperation and Development, Germany	2012-2015
Safe and effective pest and crop management strategies to strengthen the vegetable value chain in the humid tropics	Federal Ministry for Economic Cooperation and Development, Germany	2012-2015
Understanding urban and peri-urban vegetable production and marketing systems through GIS-based Community Food Mapping in Greater Bangkok, Thailand	Federal Ministry for Economic Cooperation and Development, Germany	2011-2013
African-German partnership to enhance resource use efficiency in urban and peri-urban agriculture for improved food security in West African cities	Federal Ministry for Education and Research, Germany	2012-2015

Project Title	Donor Name	Duration
Diversifying food systems: Learning and innovation in horticultural value chains to improve the livelihood situation of rural and urban poor in Kenya, Ethiopia and Tanzania	Federal Ministry for Education and Research, Germany	2012-2015
RegenIntro: Introduction of accessions from the regeneration initiative into the international collections held by AVRDC	Global Crop Diversity Trust	Unspecified
Vegetable seed kits for flood-affected households in Fiji	Government of Fiji	2012-2014
Bhoochetana Plus	Government of Karnataka, India	2013-2017
Training, technical support and vegetable seeds for enhanced household food production	Helen Keller International	2012-2013
Develop a begomovirus-resistant and early blight tomato varieties that will help farmers increase production and income in South Asia and other parts of the tropics	Indus Seeds, India	2011-2013
Enhancing productivity, competitiveness and marketing of onion in the Sudano-Sahelian region of Cameroon	International Fund for Agricultural Development	2012-2016
Case Study; enhanced nutritional outcomes of populations through nutrition-sensitive agricultural promotion by a vegetable seed company in Bangladesh	International Fund for Agricultural Development, Italy	2013-2014
Good seed initiative	Irish Aid, Ireland	2012-2013
Screening for development of begomovirus-resistant processing tomato hybrid	Kagome Co. Ltd., Taiwan	2010-2013
Lal Teer seconded scientists to AVRDC for breeding program	Lal Teer Seed Ltd., India	2013-2014
Biotechnology-Assisted Development of Virus-Resistant Varieties and Populations of Squash for Climate Change Adaptation	National Science Council, Taiwan	2010-2013
Characterize and map late blight resistance in wild tomato accessions	National Science Council, Taiwan	2010-2013
Fine-mapping of quantitative trait loci on tomato chromosome 6 associated with resistance to phylotype I and II strains of <i>R. solanacearum</i>	National Science Council, Taiwan	2012-2013
Identification of virus resistance genes in pumpkin and development of the associated marker-assisted selection tools	National Science Council, Taiwan	2012-2014
Local adaptation of <i>Ralstonia solanacearum</i> phylotype IIB sequevar 1 strains in Taiwan and identification of their resistance sources in tomato	National Science Council, Taiwan	2012-2013
Studies on durability of resistance trait loci against <i>Ralstonia solanacearum</i> and efficiency of marker-assisted selection	National Science Council, Taiwan	2012-2013

Project Title	Donor Name	Duration
Training Induced Local Lesions IN Genome of tomato for multiple virus resistance	National Science Council, Taiwan	2010-2014
Development of Breeding Techniques and Selection of Disease Resistant Germplasm in Cucurbits	Rural Development Administration, Korea	2013-2016
Development of Breeding Techniques and Selection of Virus Resistant Germplasm in Pepper and Tomato	Rural Development Administration, Korea	2013-2015
Screening and collection of anthracnose-resistant pepper germplasm and development of high temperature-resistant pepper lines for abnormal climate	Rural Development Administration, Republic of South Korea	2012-2013
Improving vegetable production and consumption for sustainable rural livelihoods in Jharkhand and Punjab, India	Sir Ratan Tata Trust, India	2008-2013
Vegetables go to School: Promoting food security and nutrition through school-based approaches	Swiss Agency for Development and Cooperation, Switzerland	2013-2015
Production of tomato plants genetically modified to resist Tomato leaf curl Taiwan virus for biosafety assessment and evaluation	Taiwan Food and Drug Administration, Taiwan	2012-2013
Tomato heat tolerance trials in Taiwan	Takii & Co. Ltd., Japan	2013-2014
Value addition of indigenous food crops by low cost sustainable processing: towards poverty reduction, food and nutrition security in sub-Saharan Africa	The Africa Australia Food Security Initiative, Australia	2011-2014
Training of Trainers Course on "Vegetable cultivation and consumption"	United Nations Food and Agricultural Organization	2013
Vegetable seed kits for flood affected urban and peri-urban farming household in Dar es Salaam, Tanzania	United Nations Food and Agricultural Organization	2012-2013
Growing vegetables for improved nutrition, empowerment of women and a healthy vegetable value chain in southern Bangladesh	US Agency for International Development, Bangladesh Mission	2012-2013
Extension of appropriate postharvest technology in sub-Saharan Africa: A postharvest training and services center	US Agency for International Development, Horticulture Collaborative Research System Program	2012-2014

Project Title	Donor Name	Duration
Sustainable African Indigenous Vegetable (AIV) Production and Market-Chain Development for Improved Health and Nutrition and Income Generation by Smallholder Farmers in Kenya, Tanzania and Zambia	US Agency for International Development, Horticulture Collaborative Research System Program	2013
Mobilizing vegetable genetic resources and technologies to enhance household nutrition, income and livelihoods in Indonesia	US Agency for International Development, Indonesia Mission	2010-2014
Improving nutrient supplies and diet diversity with vegetables in Mali	US Agency for International Development, Mali Mission	2012-2013
Improving vegetable production and consumption in Mali	US Agency for International Development, Mali Mission	2013-2014
Africa RISING: Dietary diversification: integration of vegetables into maize based systems of Babati	US Agency for International Development, USA	2013-2014
Africa RISING: Sustainable intensification of cereal-based farming systems in the Sudano-Sahelian zone	US Agency for International Development, USA	2013
Postharvest program in Asia and sub-Saharan Africa	US Agency for International Development, USA	2012-2013
Urbanization and its impacts on the use of the natural resources in Africa	Volkswagen Foundation, Germany	2013-2014
Enhancing productivity, competitiveness and marketing of traditional African (leafy) vegetables for improved income and nutrition in West and Central Africa	West and Central Africa Council for Agricultural Research and Development	2012-2014



Global Action

Connecting farmers and seed producers through seed fairs



Regional Center for Africa

In 2013, the Africa region continued to witness increased project funding, allowing for reasonable expansion in personnel and activities at all locations, as well as further infrastructure upgrades such as the completion of a seed processing and storage facility at Samanko Station in Mali.

Deliberate efforts were devoted to diversifying the sources of funding, resulting in one project funded by the Australian Centre for International Agricultural Research (ACIAR) through the Australian International Food Security Research Centre (AIFSRC) for implementation, one project funded under the World Bank-coordinated Multi Donor Trust Fund managed by the West and Central Africa Council for Agricultural Research and Development

(CORAF/WECARD) and another supported by the Volkswagen Foundation, adding to the support obtained from traditional donors such as the US Agency for International Development (with three AVRDC-led projects from bilateral missions and central sources) and Germany's Federal Ministry for Economic Cooperation and Development/Society for International Cooperation BMZ/GIZ (with two new projects).

Positioning the Center as a leading reference and partner for vegetable research and development in the region was vigorously pursued, as evidenced by the Center's contribution to the Consultative Group on International Agricultural Research's Humidtropics Research Program

and the USAID Africa RISING program, both led by the International Institute of Tropical Agriculture. Likewise, the Center honored a request from the private sector (African Seed Trade Association) for AVRDC to guide the development of their Special Interest Group on Vegetables, and another request from the Alliance for a Green Revolution in Africa (AGRA) for AVRDC to assist in formulating a strategy for AGRA's support to vegetable research and development in the region.

A major effort to assess postharvest losses was launched in the region, but the main activities of the Center remained focused on varieties and seed, with fast-tracking improved varieties and seed in conjunction with training of trainers and communities. The Center developed a model for tackling the disconnect between research and practice whereby (i) testing and deployment of varieties and associated technologies to boost the availability of vegetables would link to (ii) education on postharvest

strategies and food preparation to boost market access and consumption while (iii) building the capacity of producers as part of project exit strategy and legacy. This model is currently being tested in southern Mali and northern Cameroon and is proving to be compatible with the small size of the AVRDC team in the region, allowing for both the pursuit of core activities on improved varieties and seed systems, good agricultural practices for increased nutrition and income, supportive policies, and the rapid dissemination of resulting outputs through networks.



Demonstrating vegetable processing methods to add value



East and Southeast Asia

In 2013, 26 staff members were based at AVRDC East and Southeast Asia in Thailand. Seven are located at AVRDC's Administrative Office in Bangkok, Bangkok, 18 at AVRDC's Research and Training Station in Kamphaeng Saen, Nakhon Pathom, and one at AVRDC's USAID project office in Malang, East Java, Indonesia. Forty-two percent are male and 58% female. In addition, a Ph.D. scholar from the Philippines joined the team in May to investigate AVRDC's impact on the development of the vegetable seed sector in Thailand in collaboration with staff from headquarters and Kasetsart University. Two master's students from the University of Freiburg, Germany, stayed at the Bangkok office for three months to work on their master's theses on urban food resilience and on peri-urban vegetable production in Bangkok, respectively. The regional office hosted 20 interns. An undergraduate dietetics student from McGill University, Canada, and a World Food Prize International intern from the United States stayed for two months to work on social and nutritional outcomes of an agricultural therapy program for disadvantaged youth operated by a Thai NGO and field

evaluation of AVRDC's global bitter melon germplasm for various horticultural traits, respectively.

Another 18 geography students from the University of Freiburg, Germany, stayed for one month in Bangkok to conduct a number of surveys for the Gesellschaft für Internationale Zusammenarbeit (GIZ)-funded project "Understanding urban and peri-urban vegetable production and marketing systems through GIS-based Community Food Mapping in Greater Bangkok, Thailand (vegGIS)" together with Thai students from Kasetsart University and staff from AVRDC. The 18-month project, which looked at different components of the overall food system of Bangkok, concluded in September 2013 with the final workshop being held in Bangkok. A pilot Collaborative Research Environment (CRE) was developed to better understand the linkages and importance of each of these components. To capture areas under cultivation within the city boundaries as accurately as possible, an object-based classification approach was implemented using eCognition software. As vegetable production sites usually have distinct



spectral as well as textural characteristics that can be easily detected, object-based classification methods produced highly accurate results in this study. In five different locations, 30 surveys took place and a total area of about 12 km² was mapped. Results show that Bangkok's peri-urban area contributes significantly to the food system of Greater Bangkok by supplying it with fresh fruit and, in particular, perishable leafy vegetables. Market demand and prices, growers' skills and habits, as well as soil and water conditions influence growers' decisions on which leafy vegetables to grow. Plant diseases and pests as well as unfavorable weather conditions were identified as major challenges for vegetable producers.

The regional office continued to host AVRDC's crop improvement program for bitter melon (*Momordica charantia*) and pumpkin (*Cucurbita moschata*). One of the highlights of AVRDC's global cucurbit breeding program was the celebration of Bitter Melon Field Week from 25 July to 2 August 2013 in Kamphaeng Saen. Twenty-six researchers from 11 seed companies visited the Center's bitter melon trials,

which comprised 27 advanced breeding lines of different market segments along with seven check cultivars from seed companies and national agricultural research centers. The first sets of advanced breeding lines have been distributed for evaluation to collaborating research centers in different Southeast Asian countries under the ASEAN-AVRDC Regional Network for Vegetable Research and Development (AARNET), with other advanced breeding lines of AVRDC's tomato, chili pepper and legume crop improvement programs.

The GIZ-supported project "Less loss, more profit, better health: Reducing the losses caused by the pod borer (*Maruca vitrata*) on vegetable legumes" came to an end with the final project workshop being held in Kamphaeng Saen in October 2013. A third German government supported project "Beating Begomoviruses: Better livelihoods for farmers in tropical Asia with begomovirus-resistant tomato, hot pepper and mungbean and integrated disease management" is in its second year, with a number of field trials conducted in collaboration with Kasetsart University. The United States Agency for International

Covering all aspects of vegetable production, from the field to the table



Development (USAID)-funded research and development project “Mobilizing vegetable genetic resources to enhance household nutrition, income and livelihoods in Indonesia” is in its third year. Several variety trials for chili and tomato were conducted in the districts of Kediri and Blitar in East Java, and Tabanan and Bangli in Bali. The best-bet lines from researcher-managed variety trials were tested in farmer-managed variety trials and preferred lines were identified. The project partner Assessment Institute for Agricultural Technology (AIAT) developed school garden programs at elementary, junior high and senior high schools and established 30 school gardens in Bali and five in East Java. The project produced brief field guides on different production technologies for use in Training of Trainers and Farmer Field Schools.

In partnership with the Economic and Social Commission for Asia and the Pacific of the United Nations (UN-ESCAP) and with financial support of the European Union

(EU), AVRDC East and Southeast Asia is implementing the SATNET Asia project, which focuses on supporting innovation by strengthening South–South dialogue and intraregional learning on sustainable agriculture technologies. Under this project, AVRDC organized two in-country training courses on “Sustainable Vegetable Crop Production Systems” and “Postharvest Technology and Marketing Systems for Small-Scale Farmers” in Yangon, Myanmar. SATNET further provided scholarships for participants from Cambodia, Laos, Indonesia and Myanmar to attend the 32nd International Vegetable Training Course (IVTC), which was held at AVRDC’s Research and Training Station in Kamphaeng Saen. In collaboration with the Food and Agriculture Organization of the United Nations (FAO), AVRDC organized a one-month training of trainers on “Vegetable Cultivation and Consumption for Better Nutrition” in Kamphaeng Saen for extension workers from Afghanistan and Bangladesh.

The regional office organized the 8th AARNET Steering Committee meeting, which was attended by delegates from all 10 ASEAN member countries. More than 50 participants attended the subsequent AARNET Expert Consultation on Vegetable Research and Development Priorities in Southeast Asia," organized with financial support of the Ministry of Foreign Affairs (MOFA), Taiwan.



Technologies
adapted to
local situations
and needs



South Asia

Staff numbers in the region almost doubled, to 21, during the year and new projects were launched in Pakistan, Nepal, Bhutan and India (Karnataka, Odisha and Jharkhand,) while project work continued to expand in Bangladesh. Some key administrative and infrastructure initiatives were undertaken, and a large number of extension publications developed.

The first Regional Review meeting was held in April with participation of staff of all regional projects and three senior scientists from headquarters. It was successful in identifying overlapping areas of interest and common regional support services. Similar activities are planned to improve regional coordination in the future. Productive discussions continue with the Indian government on the completion of a

Memorandum of Understanding with good support from the new Deputy Director General – Horticulture of the Indian Council of Agricultural Research. Discussions regarding the stalled MoU have been reopened with the government of Sri Lanka and a past MoU with Pakistan has been useful in starting the new project funded by the United States Agency for International Development (USAID) there.

New infrastructure was implemented in the regional headquarters in Hyderabad with installation of a new seed cold storage, and the move to a new and larger (1.36 ha) experimental field on the International Crops Research Institute for the Semi-Arid Tropics campus that expands our facilities for seed production and experimental work.

In India, extension publications in Hindi, English and Punjabi were completed on healthy seedling production, composting, and home gardening and 21,000 distributed in Jharkhand. A recipe book was printed in English and Punjabi and 2,500 distributed in Punjab.

A collaborative low-cost project to improve the testing and introduction of improved open pollinated lines from AVRDC headquarters was started with Hindustan Insecticides Ltd. An Indian government agency will implement multilocation trials across India for tomato, chili and vegetable soybean to assist in final official release of the best performing lines.

A consultant appointed through the Sir Ratan Tata Trust (SRTT) project found many limitations to technology transfer through nongovernmental organizations. We identified opportunities to develop regional training programs focused on NGOs with a potential funding stream if a separate series of training courses were also developed for the commercial and government seed sectors.

Evaluations were completed for the SRTT project in Jharkhand and Punjab to assess the impact on improving vegetable production and home gardening. An evaluation was also conducted in Bangladesh to assess needs for postharvest training and development in vegetables.

Good relationships built with university and commercial partners are creating new project opportunities. A strong relationship with Punjab Agricultural University has developed through the SRTT project and ongoing joint breeding work, and we propose to involve them in supporting the protected cultivation work in the USAID-funded project in Pakistan and in other proposals for protected cultivation still under development. A good relationship

has also been built with the Food 360 Foundation, a consortium of large Hyderabad businesses seeking investment opportunities in agricultural research and development. A MoU has been signed with them and pilot projects in protected cultivation project and home gardening are under development.

Several other project proposals were submitted and are still under consideration. These included the SRTT Phase II proposal for Central India and Punjab, a proposal on global mungbean work with the Australian Centre for International Agricultural Research, and a proposal to JSW Foundation in India for integrated development work on vegetables in western India.

Introducing improved crops and production methods for income generation



Oceania

In 2013, the Center focused on locating a newly recruited scientist in Fiji and making progress on the requirements for a Memorandum of Understanding with the Government of Fiji with the support of a consultant. While progress on this was slow due to changes in the government, some positive signs have been seen. Activities in Oceania are currently coordinated from offices in the Solomon Islands (located in Honiara) and Fiji (located within the Ministry of Agriculture's Sigatoka Research Station).

Research and development activities focused on sustainable intensification of high-value vegetable crop production. The goal is to improve the livelihoods of smallholders and their communities by increasing income through vegetable production. Major production constraints

considered by farmers in the Sigatoka valley, the main vegetable production area of Fiji, were documented. They were severe losses due to insect pests and diseases, poor seed and seedling quality and supply, and low soil fertility. The findings confirm the objectives being addressed in the Center's research and development activities in the region. A diagnostic protocol using Flinders Technology Associates (FTATM) cards (a paper-based system designed to fix and store nucleic acids directly from fresh tissues pressed into the treated paper) was developed and used to confirm that the pathogen causing anthracnose in Fiji is *Colletotrichum acutatum* genetic group 2; the same genetic group also predominates in Taiwan and Indonesia. A set of AVRDC chili lines has been selected

and will be evaluated for field resistance to anthracnose in 2014. Introduction and evaluation of AVRDC improved breeding lines started in 2012. Confirmation trials of selected tomato lines have been conducted in Fiji, Samoa and the Solomon Islands in 2013. CLN2585, which was introduced to the Solomon Islands in 2010, was found to be the best line, while CLN3241I, CLN3213A, CLN3150A-5 and CLN3205A were found to be promising in Fiji based on the acceptance of farmers, input suppliers, hotel chefs and local agriculture experts. A total of ten AVRDC sweet pepper lines were evaluated in Fiji, Samoa, and the Solomon Islands, following a protocol developed by AVRDC. Data are still being assessed.

To improve seedling production in Fiji, potting mixtures prepared from locally available materials suitable for a plug tray system were evaluated. The mixture consisting of soil, coconut husk dust, and compound fertilizer in the ratio of 1:1:1 showed the best results. The system will be validated and transferred to the Ministry of Agriculture and local nurseries in 2014. A trial in collaboration with the Secretariat of Pacific Community (SPC) is in progress to evaluate the best method to integrate *Bacillus thuringiensis* biopesticide in combination with insect exclusion nets to control insect pests of cabbage.

A series of pilot-level integrated participatory guarantee systems (PGS) have been implemented in the Solomon Islands and Fiji as a model to improve vegetable supply into high-end domestic markets, such as resorts and hotels. Three farmer groups were organized in the Sigatoka valley. Through a trial shipment in July and a series of follow-up workshops, the farmer groups better understood the PGS concept as a quality assurance system to promote quality produce, and to establish market arrangements that are reliable, consistent and able to meet volume

requirements. The trial shipment allowed farmers to understand the market process and requirements, and confirm adoption of new value chain practices that would result in higher returns. Documents and fees for registering the farmer groups as limited liability companies have been collected and submitted to the local authority. In both countries, business skills training has been provided to the group leaders and members. Regular visits to advise PGS farmer groups on vegetable production practices were made. Mentoring the groups to practice business skills and follow planting plans will be continued both in Fiji and the Solomon Islands.

In collaboration with SPC, AusAID, and French Pacific Fund, a meeting on *Abelmoschus manihot* was held in Suva. *A. manihot*, known as bele in Fiji, aibika in Papua New Guinea, or slippery cabbage in the Solomon Islands, is one of the most popular traditional vegetables in the Pacific. Representatives from Fiji, New Caledonia, Papua New Guinea, the Solomon Islands and Vanuatu agreed on the need to continue germplasm collection and characterization of this important species, especially on genetic diversity and virus indexing. The workshop provided the Center the opportunity to establish contacts and network with scientists in the Pacific working on this traditional vegetable.

New variety releases stimulate economic activity



Central Asia and the Caucasus

In 2013 major activities within the Central Asia and the Caucasus Regional Network for Vegetable Systems Research and Development concentrated on the following core activities: collaborative research with partner institutes to provide new germplasm from AVRDC; conducting regional varietal trials; evaluating and developing new vegetable crop varieties; addressing issues on vegetable consumption; promoting adoption of tomato grafting technology; conducting promotional events; capacity building; and collecting and establishing baseline data on vegetables.

AVRDC regional variety trials were conducted in different agro-ecological zones of eight countries (Armenia,

Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan). A total of 89 accessions of six vegetable crops were introduced. All accessions were evaluated and promising ones (early maturing, high yielding, resistant to diseases, good fruit quality, etc.) were selected in each country for further research work. Seeds of promising lines were multiplied in 2013 to conduct competitive trials in 2014.

Thirty-eight varieties of 14 crop species including tomato, sweet and hot pepper, eggplant, cucumber, vegetable soybean, mungbean, snap bean, pea, custard squash, marrow, lettuce, basil and celery were under State Variety Trials in the region. Four AVRDC new varieties of three

crops have been released and included in State Registers including tomato varieties 'Zolotaya businka' (CLN 2071D) and 'Solnechnaya jemchujina' (CLN 2070C) in Kazakhstan; sweet pepper variety 'Sabo' (PP0437- 7031, Bell, LYO-Y) and eggplant variety 'Feruz' (S00691) in Uzbekistan.

AVRDC conducted tomato grafting studies with the State Agrarian University (TSAU), Uzbekistan. Tomato grafting also was used for the first time with four tomato rootstocks for greenhouse production in Armenia.

School gardens and home gardens were initiated with the Bostanlyk College of Agriculture and Business (mountain area), a boarding school in Ramitan district of Bukhara region (steppe area), the National University and in 20 households in Uzbekistan's Tashkent region. A total 35 kg seeds of 10 new vegetable varieties were distributed for the gardens.

A number of nutritious vegetable recipes were developed and presented at various workshops and training sessions jointly organized with the Chefs Association of Uzbekistan. The new recipes will be published in a brochure in 2014. Approaches for effectively promoting traditional vegetable use and overall vegetable consumption in Central Asia were explored and information was collected.

Two postdoc students continued their research on AVRDC vegetable soybean and hot pepper germplasm, and one master's student is working on his thesis on tomato in Uzbekistan. Two master's students have started research on soil fertility improvement through legume crop (vegetable soybean, mungbean and yard-long bean) cultivation at the National State University of Uzbekistan. To improve the ability of staff members to communicate in English, 11 specialists from partner

research institutes have been studying the language in courses sponsored by AVRDC. Two specialists have received certificates of completion.

Information dissemination was conducted through demonstration plots at research institutes and farmer fields, exhibitions, farmer field days, publications, and mass media. A total of 19 publications, including journal articles, a book chapter, posters, extension and training materials have been published. Partners were motivated to publish ten articles in collaboration with AVRDC. Additionally, AVRDC participated in the Republic ExpoCenter Exhibition on Innovations in Uzbekistan in April 2013 and presented new varieties of vegetable soybean, mungbean and yard-long bean for soil improvement and production.

Global Support

Celebrating
40 years of
service with the
support of host
country Taiwan



Office of the Director General

Office of the Deputy Director General – Research

The Deputy Director General for Research leads and has oversight of the Center's global thematic research and development activities. The Center has four global themes: Germplasm, Breeding, Production and Consumption, each led by a theme leader who reports to the Deputy Director General for Research. The regional offices, each led by a director or coordinator, have geographical oversight and form a matrix with the four themes. The regional offices cover East and Southeast Asia, South Asia, Africa, Central and West Asia and North Africa, and Oceania. This cross-cutting matrix is supported by Biometrics, Communications and Information, Grants and Partnership Development, Information

Technology Services, Intellectual Property and Global Technology Dissemination. In 2013, splitting the Regional Center for Africa into two smaller regions—Eastern and Southern Africa, and West and Central Africa—was conceptualized and recruitment of the new director for Eastern and Southern Africa completed. The incumbent director of the Regional Center for Africa will become the Director of AVRDC West and Central Africa. This organizational change will allow greater focus in each of the two regions, which are also closely aligned to the sub-regional organizations Association for Strengthening Agricultural Research in Central Africa (ASARECA) and the Southern African Development

Community (SADC) in the east and south, and Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles / West and Central African Council for Agricultural Research (CORAF/WECARD) in the west.

The Office of the Deputy Director General for Research was strengthened toward the end of 2013 with the appointment of a Coordination & Relationship Assistant. The office had a central role in the development of the VegOne indicators database, designed to collect and collate gender-disaggregated data on numerous indicators such as the number of individuals receiving short-term training in productivity or food security and the number of technologies under research; the database facilitates reporting to donors and to the Board of Directors. The office coordinated thematic displays for the 40th Anniversary Celebrations, which were attended by more than 80 VIPs and other visitors. Theme Germplasm highlighted the diversity of the AVRDC genebank collection; Theme Breeding displayed globally distributed tomato cultivars; Theme Production highlighted net houses, grafting, integrated pest management and fertigation; and Theme Consumption promoted small vegetable gardens as a means to good family nutrition. The Deputy Director General for Research presented "A 'Fresh' Look Forward for Tropical Vegetables," one of three keynote speeches during the 40th Anniversary Colloquium.

With AVRDC East and Southeast Asia, the Deputy Director General for Research coordinated Science Day during the 2013 Board of Directors meeting, which was held at AVRDC's Research and Training Station on Kasetsart University's Kamphaeng Saen Campus in Nakhon Pathom, Thailand. The day's theme, Vegetable Value Chains in East and Southeast Asia, was broadly focused on the cucurbit value chain, which highlighted the activities and successes of the Center's

cucurbit breeding team in Thailand.

The Deputy Director General for Research chaired the Institutional Research and Development Committee, the Institutional Biosafety and Ethics Committee, the Institutional Research and Development Committee and the Center's Assets Committee. The DDG-R was a member with an active role in the Institutional Management Committee, the Global Risk Management Committee, Green@AVRDC Committee, the 40th Anniversary Committee, the SEAVEG2014 Organizing and Scientific Committees and the 2014 International Society for Horticultural Science (ISHS) Meeting Committee. The Office of the Deputy Director General for Research is also responsible for ensuring all documents required for the External Program and Management Review, which will begin in 2014, are compiled. Planning for this process started toward the end of 2013.

The annual Writing Week was held 8-12 April 2013. In 2013, Center scientists published 76 peer-reviewed publications, comparing favorably with 52 in 2012 and 49 in 2011. The Deputy Director General for Research has oversight of the Communications and Information team, ensuring quality publications through internal peer-review and quality control.

The Deputy Director General for Research was on the working group of the United Nations the Sustainable Development Solutions Network Thematic Group 7 on Sustainable Agriculture and Food Systems, which developed the goals and indicators for Sustainable Development Goal 6: Improve Agriculture Systems and Raise Rural Prosperity. The Deputy Director General for Research accepted an invitation to be the guest editor of a special edition of the journal Sustainability entitled "Underutilized plant species: leveraging food and nutritional security and income generation."

Connecting partners from around the world to link agriculture, nutrition and health



The Office of the Deputy Director General for Research led interaction with many donors and partners. The Center's Vegetables Go to School project funded by Swiss Development and Cooperation held a Training of Trainers and policy workshop in the second half of the year; with six countries and an incoming project manager, this was particularly challenging.

The Office of the Deputy Director General for Research coordinated the Center's annual review response to the UK Department for International Development (DFID) and also interacted closely with the United States Agency for International Development (USAID) to ensure continued project funding and delivery of postharvest outputs from part of the USAID contribution to AVRDC core funds. In the past, AVRDC has successfully competed for numerous small projects from the Council of Agriculture, Taiwan. These were consolidated into one Center-wide project, which reduced the transaction

costs supporting much of the Center's work of direct interest to Taiwan. It also gave the opportunity for the Center to initiate work on fertigation in glasshouses at headquarters to complement previous work in Central and West Asia and North Africa.

As a result of interactions with our partners and donors, AVRDC has worked hard to strengthen its monitoring and evaluation capacity as well as to ensure that gender is part of every Center activity and process. This ensures that the Center's outcomes and eventual impact are properly guided and quantified, the role and needs of both women and men are understood, and the Center's outputs and outcomes assure not only equity but equality. A gender workshop was held at the end of 2103 to make sure Center staff understand the opportunities and challenges of embracing a gender framework.

Office of the Deputy Director General Administration and Services

The overall goal for the Office of Deputy Director General for Administration and Services is to provide leadership and guidance to administration and service offices to ensure efficient and harmonious services for the implementation of research and development programs, and to support the Director General in host country relations.

Risk management

- Headquarters

The fire alarm system was improved by increasing the volume of the warning sound. A fire-fighting demonstration was provided by the Shanhua Fire Brigade in August 2013 to demonstrate fighting a fire in a kitchen/dining area and familiarizing staff with the use of fire-fighting equipment. A vehicle accident involving a staff member resulted in the fatality of the other party. After a lengthy court process, the staff member was found to be not guilty of fault over the accident. An accident in a net house resulted in the amputation of part of three toes of a field laborer; he was hospitalized, discharged and is now recuperating.

- AVRDC Mali

In November 2013, an accident involving an AVRDC vehicle took place near Sikasso in southern Mali. The driver was alone and fortunately did not suffer any injury. The Center is awaiting an official report from the police regarding the particular circumstances of the accident.

- Regional Center for Africa, Tanzania

In September 2013, the Finance Officer at AVRDC's office in Arusha was the victim of an armed robbery at his residence.

The robbers took an office laptop and injured the finance officer. The robbery was reported to the police; the victim received treatment and is now in good physical and psychological condition.

Host country relations

- Visits of host country VIPs

- Mr. Wu Den-Yih, the Vice President of the Republic of China (Taiwan),
- Ms. Vanessa Yea-Ping Shih, Vice Minister, the Ministry of Foreign Affairs
- Mr. Sing-Hwa Hu, Deputy Minister of the Council of Agriculture
- Mr. Kelly Wu-Chiao Hsieh, Director General of the Department of International Organizations, the Ministry of Foreign Affairs
- Dr. Yuan Tseh Lee, President, International Council for Science; Nobel Laureate (Chemistry)

- Events held to support the host country's interests

- 2013 Open Day, 17 May 2013
- Visits of Directors General from international agricultural research centers to AVRDC and Taiwan
- Asia-Pacific Symposium on Molecular Breeding at AVRDC HQ, 1-3 October 2013

- 2013 core contribution

The host country core funding support is significant, as it pays national staff salaries, ensures continuity of the Center's basic activities, and provides opportunities to collaborate with Taiwan's agricultural community as well as to enhance partnerships with the international agricultural community.

The Taiwan core contribution for 2013 was NT\$153,311,000 (ca. US\$5.14 million) from which 20% was frozen with conditions for eventual disbursement. The Economic Committee of the Legislative Yuan reviewed the Center's performance in mid-2013. The review went satisfactorily and the frozen 20% of the core contribution was released to the Center in October 2013.

- **2013 Center-wide special project funded by the Council of Agriculture (COA)**

Despite a 10% cut in Taiwan's 2013 core contribution compared to its 2012 contribution, COA initiated a special project entitled "Strengthening the cooperation between AVRDC – The World Vegetable Center and Taiwan on vegetable research and development" to make up for the reduction and also to address concerns and interests of legislators. This project is part of the Center's research and development project portfolio.

- **Special project supported by the Ministry of Foreign Affairs (MOFA)**

In 2012, MOFA granted the Center a special project of US\$780,000 entitled "Networking to Enhance International Cooperation in Vegetable Research and Development" with an implementation period from June 2012 to December 2013. The project includes three subprojects:

- Subproject 1: Linkages with international agricultural research centers
- Subproject 2: ASEAN-AVRDC Regional Network (AARNET)
- Subproject 3: Vegetable Network for Oceania

Under the project, leaders from five international agricultural research centers were invited to visit the Center and Taiwan in 2013:

- Dr. John Beer, Director for Research and Development, Center for Tropical Agricultural Research and Education (CATIE)
- Dr. Michael Hermann, Global Coordinator, Crops for the Future
- Dr. Ismahane Elouafi, Director General and Dr. Fiona Chandler, Director for International Cooperation and Partnerships, International Center for Biosaline Agriculture (ICBA)
- Dr. Christian Borgemeister, Director General, International Centre of Insect Physiology and Ecology (icipe)
- Dr. Nteranya Sanginga, Director General and Dr. Ylva Hillbur, Deputy Director General for Research, International Institute of Tropical Agriculture (IITA)

In Oceania, consultant Dr. Jacqueline Kami was recruited in December 2012. Dr. Kami has been efficient; she provided ideas and made many contacts to enhance the Center's and MOFA's visibility in the region, and also promoted the Center's project in the region funded by Australian Centre for International Agricultural Research.

- **ROC MOFA's special project support for 2013**

MOFA granted the Center a special project of US\$500,600 entitled "Networking to Enhance International Cooperation in Vegetable Research and Development" with an implementation period to end on 31 December 2013. The project includes four subprojects:

- Subproject 1: 40th Anniversary celebrations of AVRDC – The World Vegetable Center
- Subproject 2: Enhancing the effectiveness and impact of AVRDC
 - The World Vegetable Center's genebank
- Subproject 3: Supporting activities

under ASEAN-AVRDC Regional Network (AARNET) Subproject 4: Supporting AVRDC – The World Vegetable Center’s activities in Oceania

AVRDC 40th Anniversary Celebration

AVRDC celebrated its 40th Anniversary from 16-18 October 2013. Around 83 scientists, diplomats and policymakers invited from around the world gathered at AVRDC headquarters to mark the event. The celebration commenced with a 40th Anniversary Ceremony, followed by a two-day Celebratory Colloquium entitled “AVRDC@40: A ‘Fresh’ Look Forward”. Four science display stands were set up to showcase the achievements and impacts of AVRDC’s research and development activities.

The anniversary ceremony on the afternoon of 16 October featured a congratulatory speech by Mr. Den-Yih Wu, Vice President of the Republic of China (Taiwan), who acknowledged the Center’s role in benefiting the health and incomes of small-scale farmers globally. Vice President Wu also stated AVRDC’s goal of “prosperity for the poor, health for all” is shared by Taiwan and every government in the world. Ms. Vanessa Yea-Ping Shih, Vice Minister, the ROC Ministry of Foreign Affairs, and Dr. Sing-Hwa Hu, Deputy Minister of the ROC Council of Agriculture, noted AVRDC’s influence on agricultural development in Taiwan. The expansion of the genebank was symbolically unveiled during the ceremony. The two-day colloquium commenced with a paper from Dr. Yuan Tseh Lee, President of the International Council for Science and Nobel Laureate in Chemistry (1986) entitled “Food Security in a Low Carbon Society.” During the colloquium, questions and challenges for the future of horticulture in the developing world inspired active discussions. AVRDC’s 40th Anniversary Celebration was successful, productive and enjoyable.

Administrative Services

Purchasing: About 2,042 purchase orders and payments were processed. Four customs clearances were applied for imported articles for research use. Shipments of personal effects for three new internationally recruited staff were handled. Bulk purchases were made for some regularly used items such as sliver/black plastic mulch, fiberglass sticks and printer paper.

Management of toxic and nontoxic chemicals: Various requests for approval of toxic chemicals at headquarters were submitted to the Environmental Protection Administration (EPA). Investigations were conducted to ensure the accuracy of data for online reporting to the EPA. The Center's standard operating procedures for management of toxic chemicals were revised to reinforce purchasing procedures, accurate recordkeeping, and safe handling. All custodians of toxic chemicals are being made aware of the importance of accurate recordkeeping to conform with EPA regulations and the Center's procedures. The Center's purchasing records with two chemical suppliers was verified monthly to ensure data were complete and consistent. Information on the procurement, consumption and storage of chemicals was reported online each month to the EPA. One infringement of the regulations was settled with the EPA. A purchasing staff member who deals with the Center's toxic chemicals attended an EPA-organized training course (and received certification), three lectures on the Toxic Chemical Substance Control Act, and one training course on how to control damage during toxic chemical accidents.

In the Center's early days, most laboratory chemicals were purchased in large quantities; over time, expired or obsolete chemical stocks have accumulated.

To ensure safe management, a physical inventory of chemicals was conducted in the laboratories. Mechanisms have now been put in place to keep a chemical stock database up-to-date. Waste chemicals are divided into six categories: strong acid/base, weak acid/base, neutral waste, solid waste, toxic chemicals and heavy metal. Quotations were obtained from several accredited environmental engineering companies in Taiwan; two companies were selected to respectively handle the disposal of heavy metals and all the remaining chemicals (2,742 kg) except for mercury. Because no licensed environmental engineering company can handle waste mercury in Taiwan, the element will continue to be stored at headquarters and the Center is obligated to report online to the EPA monthly. The Center may approach other manufacturers who have EPA-issued licenses to use mercury, as they may be able to use the Center's unwanted mercury stock.

Travel: The Center booked and purchased 346 air tickets for staff members, board members, recruitment candidates, visitors and families of internationally recruited staff. Ninety-four high speed rails tickets were purchased. Forty-four Taiwan visas were applied for staff members at headquarters and 30 for regional scientists, recruitment candidates and visitors. Thirty-five entry visas to other countries were applied for international trips of staff members. Taiwan Ministry of Foreign Affairs granted 13 identity cards and Tax Exemption Cards for headquarters internationally recruited staff and spouses. Twelve insurance policies were purchased for the official travel of nationally recruited staff.

Biometrics

Working closely with the Center's staff members conducting research, the general outputs of the Biometrics office were:

- Advisory support by providing consulting services or general help in designing experiments, dealing with data, or other statistical issues
- Capacity building through in-country and in-house training courses aimed at improving the skills and understanding of scientists, researchers and collaborators from national agricultural research systems, who may be infrequent users of statistics
- Assurance of high quality data by putting in place a measure to assure quality of research outputs right from the start at the planning stage, through detailed evaluation of experimental plans which also assures proper recording and archiving of procedures used in each experiment
- Statistically reviewed reports, proposals, scientific manuscripts submitted for publications in international peer-reviewed journals
- Review of proposals for validity of statistical methodologies
- Maintenance of database of variety releases for different crops

Specific outputs in 2013 were analyses of agricultural and meteorological data to highlight the effects of climate on rural smallholder agricultural systems to minimize risk and maximize productivity.

Communications and Information

Influencing public perceptions of the Center through the creation of media strategies and promotional materials engages the eight members of the Communications and Information group (secretary, photographer, graphic designer, visitor services coordinator, three librarians, and a group head/editor).

To foster public awareness, the group sends out news releases to local and international media, handles press queries, and develops success stories for donors. Communications and Information published 13 issues of *Fresh*, the AVRDC newsletter, distributed to more than 3130 subscribers (a 25% increase since 2011); prepared promotional brochures and posters, videos, and PowerPoint presentations; and produced extension publications on various aspects of vegetable production. International press coverage about the Center in 2013 included television programs aired on stations in

Burkina Faso, Nepal, and Bangladesh; a children's documentary on Taiwan Public Television; reports on global aggregator websites SciDev Net, Huffington Post and Food Tank; articles published in the Guardian, Christian Science Monitor, Forbes, Appropriate Technology, Rural 21, and Green Lifestyle magazines; and radio broadcasts on Deutsche Welle, SBS Australia, and Radio Cameroon.

The Center's website (avrdc.org) receives approximately 9300 unique visitors each month, offering news, publications, video access, online ordering for seed, and other services. A new website was prepared for the Vegetables Go to School project (<http://vgts.avrdc.org>). Communications coordinates social media outreach through Facebook pages in English and Chinese (www.facebook.com/WorldVegetableCenter), Twitter (@go_vegetables), and a YouTube channel (www).

Strategies and methods to share important messages with diverse audiences



youtube.com/WorldVegetableCenter). The Facebook page has a weekly reach of approximately 3600 people.

The Center's editor reviewed more than 200 articles, abstracts, books, proposals, newsletters and other documents in 2013 for grammar, style and coherence. Major publications produced during the year included the *Annual Report 2012*, *Year in Review 2012*, *Medium-term Plan 2013-2015*, *Research in Action #7 and 8#*, *SEAVEG2012 Proceedings*, and the *APSA 2013 Proceedings*.

Open Day 2013, held on May 17, drew more than 80 visitors from Taiwan universities, research institutes, and seed companies to headquarters to view field trials and visit booths showcasing different aspects of the Center's local and global research and development work. Reporters from 14 local and national media attended.

Scientists, diplomats, and policymakers from around the world gathered at AVRDC headquarters from 16-18 October for a celebration and colloquium to mark the Center's **40TH Anniversary**. Among other duties, the Communications team designed a special logo; prepared banners, posters, signs, displays, and a commemorative program booklet; and coordinated media outreach for this special event in the Center's history. Video of the colloquium presentations and discussions can be viewed on the Center's website and YouTube channel.

Communications redesigned the AVRDC genebank lobby in 2013 to create a more informative and attractive visitor experience. Center headquarters welcomed more than 1000 visitors in 2013 from 36 countries; all visitors received briefings and tours tailored to their specific interests.

Financial Services

The Center continues to improve its financial health and long-term stability by ensuring that financial management processes, including financial planning, resource allocation, and monitoring and reporting are properly executed. A significant and increasing portion of the Center's revenue comes from (restricted) project financing. It is therefore important that the Center includes in all project proposals the full cost of the proposed actions to guarantee long term financial sustainability. The Center continues to build its financial reserves as part of its risk management strategy.

A re-orientation of responsibilities within the finance group began in 2013 providing a wider range of responsibilities to the finance officers and avoid over-specialization. An internal finance network

with a shared repository was set up to complement Maconomy, the Center's enterprise resource planning (ERP) system. This will make the Center more resilient and increase its capacity to cope with staff turnover and changing (donor) demands for financial information.

Maconomy offers a range of options for budget monitoring. A start has been made to streamline the use of these options to cope with the growing number of projects while continuing to meet the reporting requirements of donors and the Board of Directors.

Food and Dormitory Services

In 2013 FDS supported 1,415 participants of the Center's symposia and workshops (e.g. APSA-AVRDC Workshop; Training of Trainers and Policy Workshop for the Vegetables Go to School project; Asia-Pacific Symposium on Molecular Breeding and the AVRDC 40th Anniversary Celebration). Fifty-eight parties for approximately 1,609 people were arranged and 246 guests were accommodated in the Center's guest house. Food and Dormitory Services successfully provided a high quality of service to staff and guests and received positive feedback on the services provided.

Keeping the public informed about the Center's activities



Global Technology Dissemination

The Global Technology Dissemination (GTD) group conducted a range of activities in 2013 in the areas of capacity building, technology dissemination and agricultural development.

The group led or supported many activities in AVRDC projects in Asia, Africa and the Pacific. GTD led a research and development project in Indonesia, which included a Training of Trainers workshop with 49 participants, school gardens, a value chain study, farmer-managed variety trials of AVRDC and other lines, and Farmer Field Schools. A fertigation research project was initiated in 2013, which is expected to continue for 2-3 more years. Computerized fertigation systems from Taiwan and Israel are being compared for cost-effectiveness. Other projects supported by the group were Vegetables Go to School; CGIAR Research Program on Integrated Systems for the Humidtropics; the ASEAN-AVRDC

Regional Network on Vegetable Research and Development (AARNET); and the Network for Knowledge Transfer on Sustainable Agricultural Technologies and Improved Market Linkages in South and Southeast Asia (SATNET).

Various capacity building activities were conducted during the year: training in integrated crop management for participants from eight countries; healthy seedling preparation for off-season tomato farmers in Bangladesh; and grafting for staff members based in the Pacific and Africa. The group facilitated administrative issues and logistics for 58 trainees from 15 countries for capacity building activities at headquarters across a range of disciplines, and provided guidance for training in the regions. Data on the Center's accomplishments in capacity building and technology dissemination were collected worldwide.

GTD managed the Demonstration Garden at headquarters, which showcases more than 100 crop species or varieties and the Center's technologies to visitors and trainees. Nutritional and other information about each crop can be found on signs that are routinely updated. Tours of the Garden were provided to 1,008 visitors from 51 countries, including video crews from Taiwan and Haiti. GTD also coordinated the Center's exhibits at Taiwan's annual Seed and Seedling Festival and Exhibition of Agricultural Achievements and the Mango Festival, with the latter featuring AVRDC's promising tomato lines.

The group published four issues of *Feedback from the Field*, a quarterly bulletin that communicates technology applications and issues from the field to its readers. This publication is disseminated via the AVRDC website, email and Facebook. Other publications on protocols for sweet pepper field evaluation trials and grafting, and a video on how to build a low-cost grafting chamber, were also produced.

GTD coordinated the Center's Disaster Response Program, which features seed distribution of hardy, fast-growing and nutritious vegetable crops to disaster survivors. Ten thousand packets (133 kg) of amaranth, kangkong, Malabar spinach, okra and mungbean seeds were sent to Fiji to aid flood victims. Approximately 41 kg of seeds were multiplied to replenish stocks.

In collaboration with the breeding groups and Communications and Information, a web-based seed catalog was maintained, which greatly facilitates germplasm transfer; shallot and Chinese cabbage were added to the catalog in 2013.

The group had a critical role in development of project proposals, especially on development-oriented aspects. The group managed the Center's mature technologies database and training documents on the intranet to facilitate use by AVRDC staff, in addition to responding to many information requests worldwide.

GTD is coordinating a group of 34 AVRDC scientists worldwide who work on technology dissemination and capacity building, to provide a more unified and coherent effort to create outcomes and impacts.

Grants and Partnership Development

The institutional processes and procedures for resource mobilization and project management/administration laid down in late 2010 have been fully implemented. Proposals and projects now routinely follow the review/quality control process. Previous efforts to contribute substantially to a better understanding within the Center of full cost recovery from projects, as well as ensuring maximum full cost recovery is achieved in each individual situation, has been successful; most AVRDC scientists now understand and readily implement the full cost recovery principle.

The Office of the Deputy Director General - Research is the oversight office for the Center's research and development agenda and so it is crucial that the office receives relevant information in a systematic manner. Grants & Partnership Development ensures that all necessary information is immediately shared with the Office of the Deputy Director General - Research. Grants and Partnership Development participated in and contributed to all global theme meetings.

Maconomy, the Center's enterprise resource planning system, has been populated with concept notes/proposals, project data and agreements. The system has been improved to better support the resource mobilization process, as well as to simplify project management and administration processes. For risk management purposes, a generic archiving system that can be easily navigated has been created.

During the year, 54 concept notes and proposals were reviewed, edited and submitted to numerous donors. Twenty seven are funded, six rejected, six dropped (mainly due to lack of time by the lead writer) and 15 are pending. A total of 76 technical project reports to donors and partners were reviewed, edited and submitted.

All project-related agreements that the Center signs with donors and partners (currently the Center collaborates with more than 170 partners across the globe) pass through Grants and Partnership Development. The office supports negotiations, and has prepared, reviewed and edited many agreements.

Human Resources

The main focus of the year was talent management, bridging competency gaps, improving staff engagement and building a performance culture. The Center's staff were successful in securing several new projects that required additional competencies as well as optimization of existing human resources. These projects also brought opportunities to work in new locations. The Center recruited new staff members, both international and national, for specific countries, regions and disciplines. These recruitments have strengthened the project management, socioeconomics, monitoring & evaluation, genetic resources, breeding and management competencies. There are challenges in locating staff in new countries, as the Center is yet to secure legal status; some were addressed through negotiating hosting arrangements with other international centers.

The Center also improved its recruitment and induction processes. Many candidates commended the Center's recruitment process as more elaborate, systematic and objective when compared with their recruitment experiences in other organizations.

Analyzing donors' expectations and the need to serve stakeholders with better products and services, the Center created a set of performance indicators and communicated these to the staff. Staff members were encouraged to include them as part of their individual and group performance goals. With this the Center also reviewed and introduced a reward policy linked to staff performance outcomes. Monetary rewards are given as an annual salary increase as well as at the time of renewal of the contract term. To understand the motivation and challenges for publishing science

outcomes, the Center conducted a survey among its scientific staff. Using the feedback, interventions are planned for implementation in 2014.

During the Strategic Planning Meeting, the leadership team went through another round of learning exercises to understand organizational challenges, as well as how to synergize efforts to create better impact and efficiency in services. During the year, the Center put effort toward building gender research skills among its research and development staff through sensitization and intense training. These efforts will help the Center make gender more inclusive in its work and to document the outcome and impacts.

As an outcome of the strategic plan to increase focus and services to the stakeholders in the countries of sub-Saharan Africa, the Regional Center for Africa was reorganized into two regions. West and Central Africa is led by the previous incumbent regional director; the Center successfully recruited a director to head the Eastern and Southern Africa regional office. Staff requirements and optimization efforts for the two regions have started and will continue through 2014.

There is a continuous exercise to optimize staff costs by identifying and analyzing where the costs lie. All new staff requirements are examined carefully to find funds from projects or to identify existing resources. This resulted in a modest saving during the year.

On the policy front, the regulations manual for national staff was reviewed for relevance to current practices, simplicity, and harmony with other policies in the Center. National staff salaries were reviewed for market competitiveness and to enhance motivation.

Information Technology Services

At headquarters, a new backup server was installed to be a redundant server and act as a failover for the current backup server. These servers copy headquarters users' data in "My Documents" automatically. A number of access points were installed to provide connectivity and boost signal strength in guest rooms and laboratory buildings.

For the Center's global locations, a one-year subscription to Adobe Connect provides users with cross-device and cross-platform communication services, with capability to upload and share documents and presentations during video and audio meetings. The IT infrastructure setup was observed and recommendations made at regional offices located in Thailand and Tanzania. ESET anti-virus software was standardized across offices. Working with Global Technology Dissemination, Information Technology Services (ITS) addressed the need to see live streams from the fertigation systems in the greenhouse using a web browser.

ITS provided advisory services to staff both proactively and on request, and regularly informed Center staff on security updates and software improvement. ITS helped Biotechnology set up STACKS software on Linux operation systems. Joint purchases of MS Office resulted in savings in excess of USD 20,000.

In conjunction with the Office of the Deputy Director General - Research, ITS disseminated directives covering purchasing, backup, functions of the group and smart phone usage.

The VegOne system to record the Center's performance indicators was launched on October 21, 2013. An orientation session was held to familiarize staff, scientists and researchers at headquarters with the use of VegOne. Similar orientations will be done in all regional locations in due course.

Internal Audit

The internal audit function assists AVRDC – The World Vegetable Center in maintaining good governance mechanisms, and ensures staff compliance with the Center's procedures, processes and regulations. Internal audit tasks include reviewing the Center's current regulations, amending standard operating procedures (SOPs) when necessary, and auditing operations and functions at regional offices and headquarters.

In 2013, Internal Audit audited Food and Dormitory Services at headquarters, financial data on current projects, the

Center's toxic chemicals management, and operations at the East and Southeast Asia (ESEA) regional office. Internal Audit also assisted in revising the Center's SOP on toxic chemicals management.

In the audit of financial data on the Center's research and development projects, Internal Audit found that some functions such as relocation of expenses between projects and assessment of overheads charged to donors need to be performed more prudently to avoid misunderstandings. At the ESEA office and field station, property management was improved to some extent;

maintenance of records of property disposal and property transfer need to be improved. There were no concerns with toxic chemical management. However, there were some toxic chemicals in stock that have not been used for more than four years and ESEA regional office staff were advised to handle them properly.

Internal Audit found that staff at headquarters were not diligently compliant with the procurement procedure for toxic chemicals. The Center has re-emphasized the importance of compliance with regulations in the newly released revised SOP on toxic chemicals management.

■ Technical Services Office

In 2013 electricity costs of NT\$37,552 were saved monthly throughout the year, except in the summer when NT\$50,310 was saved monthly as a result of reducing the Center's power capacity contract from 980 kw to 755 kw. The Technical Services Office collected weather data weekly from the Center's newly installed and upgraded weather data facilities. The data were uploaded into the Center's shared network folder.

The Green@AVRDC Committee was provided with relevant data for the Center's carbon footprint calculation. Through the year, Technical Services constructed an additional 160 meters of field irrigation and drainage ditches.



Staff

A Diverse Workforce

In 2013, AVRDC – The World Vegetable Center staff members came from 24 countries, including Taiwan. Women occupy 31% of the 52 senior staff positions



24 countries including Taiwan



52
Senior Staff



16 WOMEN
(30.77 percent)

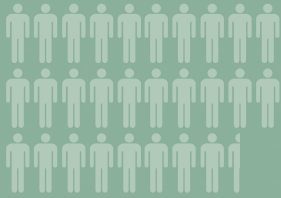
Staff Name	Position Title	Location	Nationality
Afari-Sefa, Victor	Scientist - Socioeconomics and Global Theme Leader - Consumption	Arusha, Tanzania	Ghana
Ahmad, Shahabuddin	Vegetable Sector Leader (Bangladesh)	Dhaka, Bangladesh	Bangladesh
Ali, Mansab	Horticulture Project Leader (AIP Pakistan Project)	Islamabad, Pakistan	Pakistan
Chang, Jan	Postdoctoral Fellow - Molecular Entomology	Shanhua, Taiwan	Taiwan
Chang, Rollen	Manager - Technical Services	Shanhua, Taiwan	Taiwan
Chang, Yin-Fu	Deputy Director General - Administration & Services	Shanhua, Taiwan	Taiwan
Chen, Huei-Mei	Associate Specialist, Biotechnology/ Molecular Breeding	Shanhua, Taiwan	Taiwan
Chen, Willie	Assistant Specialist, Global Technology Dissemination	Shanhua, Taiwan	Taiwan
Cho, Myeong-Cheoul	Scientist - Pepper Breeding (seconded scientist from RDA/Korea)	Shanhua, Taiwan	Korea
Dhillon, Narinder	Vegetable Breeder - Cucurbits	Bangkok, Thailand	India
Dinssa, Fekadu Fufa	Vegetable Breeder	Arusha, Tanzania	Ethiopia
Easdown, Warwick	Regional Director, South Asia	Hyderabad, India	Australia

Staff Name	Position Title	Location	Nationality
Ebert, Andreas	Genebank Manager and Global Theme Leader - Germplasm	Shanhua, Taiwan	Germany
Ghai, Tilakraj	Consultant	Punjab, India	India
Hanson, Peter	Plant Breeder (Tomato and Indigenous Vegetable Research) and Global Theme Leader for Breeding	Shanhua, Taiwan	USA
Holmer, Robert	Regional Director, East and Southeast Asia	Bangkok, Thailand	Germany
Hsu, Sylvia	Manager - Food and Dormitory Services	Shanhua, Taiwan	Taiwan
Hughes, Jacqueline d'Arros	Deputy Director General - Research	Shanhua, Taiwan	United Kingdom
Inukonda, Nagaraj	Director of Human Resources	Shanhua, Taiwan	India
Iramu, Ellen	Project Coordinator - Pacific Islands	Honiara, Solomon Islands	Solomon Islands
Keatinge, J.D.H.	Director General	Shanhua, Taiwan	Ireland
Kenyon, Lawrence	Plant Virologist	Shanhua, Taiwan	United Kingdom
Krishnan, Bharath	Manager - Information Technology Services	Shanhua, Taiwan	India
Kumar, Sanjeet	Scientist - Pepper Breeding	Shanhua, Taiwan	India
Kwazi, Nadine	Executive Assistant to the Director, Regional Center for Africa	Arusha, Tanzania	Zambia
Ledesma, Dolores	Board Secretary and Biometrician	Shanhua, Taiwan	Philippines
Lin, Chih-Hung	Associate Specialist, Bacteriology	Shanhua, Taiwan	Taiwan
Lu, Vincent	Internal Auditor	Shanhua, Taiwan	Taiwan
Luther, Greg	Technology Dissemination Specialist	Shanhua, Taiwan	USA
Luther, Kartini	Assistant to Deputy Director General - Research	Shanhua, Taiwan	USA
Ma, Chin-Hua	Associate Specialist, Bacteriology	Shanhua, Taiwan	Taiwan
Macharia, John	Project Manager (Income and Nutrition through Vegetables Project)	Arusha, Tanzania	Kenya
Mak, Adrienne	Manager - Management Support & Human Resources Services	Shanhua, Taiwan	Taiwan

Staff Name	Position Title	Location	Nationality
Manickam, Ravishankar	Research Site Coordinator	Jharkhand, India	India
Mariyono, Joko	Project Site Coordinator (Indonesia)	Jawa Timur, Indonesia	Indonesia
Mavlyanova, Ravza	Regional Coordinator for Central Asia and the Caucasus	Tashkent, Uzbekistan	Uzbekistan
Mecozzi, Maureen	Head of Communications and Information	Shanhua, Taiwan	USA
Nair, Ramakrishnan	Vegetable Breeder - Legumes	Hyderabad, India	India
Nenguwo, Ngoni	Postharvest Specialist	Arusha, Tanzania	Zimbabwe
Öberg, Annelie	Manager - Grants and Partnership Development	Shanhua, Taiwan	Sweden
Overweg, Dirk	Director of Finance	Shanhua, Taiwan	The Netherlands
Palaniswamy, Usha	Project Manager (Vegetables Go to School Project)	Shanhua, Taiwan	USA
Rajendran, Srinivasulu	Post-Doctoral Scientist - Agricultural Economics	Arusha, Tanzania	India
Ramasamy, Srinivasan	Entomologist	Shanhua, Taiwan	India
Rouamba, Albert	Vegetable (Onion) Breeder	Bamako, Mali	Burkina Faso
Schafleitner, Roland	Head - Molecular Genetics	Shanhua, Taiwan	Austria
Schreinemachers, Pepijn	Agricultural Economist	Shanhua, Taiwan	The Netherlands
Stoilova, Tsvetelina	Scientist - Genetic Resources	Arusha, Tanzania	Bulgaria
Tenkouano, Abdou	Regional Director, Africa	Bamako, Mali	Burkina Faso
Tsai, Wen-Shi	Associate Specialist, Virology	Shanhua, Taiwan	Taiwan
Wang, Jaw-fen	Plant Pathologist and Global Theme Leader - Production	Shanhua, Taiwan	Taiwan
Yang, Ray-yu	Nutritionist	Shanhua, Taiwan	Taiwan
52 senior staff	16 women (30.77 percent)	24 countries including Taiwan	

RESEARCH FOR DEVELOPMENT

In 2013, Center researchers shared their knowledge and results in international peer-reviewed journals, at conferences, and in partnership with scientists from developing countries.



28.5 Number of scientists

*The number of scientists is calculated as follows: each internationally hired scientist counts as 1; the Director General, Deputy Director General - Research, Regional Directors, and Biometrician each count as 0.5. Scientists who leave the Center before the end of July are counted in the year's calculation. Newly recruited scientists are counted only if they joined the Center before the end of July.

2.84

Total externally reviewed publications per scientist (journal articles, books, book chapters)



1.08

Publications per scientist in journals listed with Thomson Reuters



74%

Percentage of scientific papers in refereed journals and books published with partners from developing countries

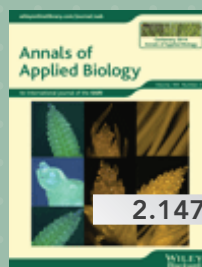
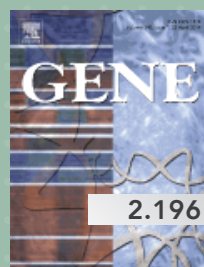
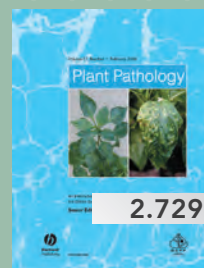
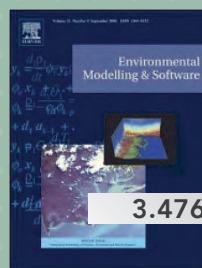


50%

Percentage of scientific papers in refereed journals and books published with female authors from developing countries

TOP 10 Journals

The top 10 journals (as rated by Thomson Reuters impact factors) in which Center researchers published during 2013



Publications

Journal Articles (50)

1. **Abang A**, Kouame CM, Abang M, Hannah R, Fotso AK. 2013. Vegetable growers' perception of pesticide use practices, costs and health effects in the tropical region of Cameroon. *International Journal of Agronomy and Plant Production* 4(5): 873-883.
2. **Afari-Sefa V**, **Chagomoka T**, Karanja DK, et al. 2013. Private Contracting versus Community Seed Production Systems: Experiences from Farmer-Led Seed Enterprise Development of African Indigenous Vegetables in Tanzania. *Acta Horticulturae* 1007: 671-680.
3. Ahn Y, Swati T, Cho YI, **Cho M-C**, et al. 2013. De novo transcriptome assembly and novel microsatellite marker information in *Capsicum annuum* varieties Saengryeg 211 and Saengryeg 213. *Botanical Studies* 54: 58-68.
4. Baiyeri KP, Ndukwe OO, **Tenkouano A**. 2013. Manure placement method influenced growth, phenology and bunch yield of three *Musa* genotypes in a humid zone of Southern Nigeria. *Communications in Biometry and Crop Science* 8(1): 1-9.
5. Boukary H, Haougui MB, Toudou A, **Rouamba A**, Saadou M. 2013. Evaluation agro-morphologique des variétés et/ou écotypes locaux d'oignon du Niger. *International Journal of Biological and Chemical Science*. 6(6): 3098-3106.
6. Bui TMH, **Schreinemachers P**, Berger T. 2013. Hydropower development in Vietnam: Involuntary resettlement and factors enabling rehabilitation. *Land Use Policy* 31: 536-544. doi:10.1016/j.landusepol.2012.08.015.
7. Chavdarov P, **Stoilova T**. 2013. Study on the reaction of local and introduced bean accessions (*Phaseolus vulgaris* L.) to causal agent of common blight under field and laboratory conditions. *Plant Science* 50: 70-73 (in Bulgarian).
8. Chavdarov P, **Stoilova T**. 2013. Reaction of local and introduced accessions of lentils to Fusarium wilt (*Fusarium oxysporum* f. sp. *lentis*). *Plant Science* 50:73-75 (in Bulgarian).
9. **Chen C-H**, **Wang J-F**. 2013. Control efficacy of plant activators and tolerant variety on tomato late blight. *Plant Pathology Bulletin* 22(2): 198.
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Financial Health

Total revenues increased significantly in 2013 to a level of US\$ 17.6 million. Unrestricted revenues increased slightly in 2013 and were obtained mostly from national governments. Compared to 2012, restricted revenues increased by US\$ 4 million.

	AVRDC	CGIAR** recommended range
Cash management on restricted operations*	0.2	less than 1
Adequacy of reserves	131 days	75-90 days
Short-term solvency	187 days	90-120 days

* Restricted accounts receivable divided by restricted accounts payable expressed as a ratio

** Consultative Group on International Agricultural Research

2013 Revenues (in '000 USD)

Unrestricted grants	9,225	52%
Restricted grants	8,277	47%
Other revenues	91	1%
Total	17,593	100%

Unrestricted Grants	
Republic of China (ROC)	5,211
UK Department for International Development (UK/DFID)	2,368
United States Agency for International Development (USAID)	1,000
Germany	271
Thailand	151
Asia and Pacific Seed Association (APSA)	150
Korea	50
Japan	24
Sub-total	9,225
Other revenues	91
Total	9,316

Restricted Grants	
United States Agency for International Development (USAID)	2,890
Republic of Germany / BMZ / GIZ	1,357
Consultative Group on International Agricultural Research (CGIAR)	933
Republic of China / Council of Agriculture	686
Republic of China / Ministry of Foreign Affairs	603
Australia/Australian Centre for International Agricultural Research (ACIAR)	520
Swiss Development Cooperation (SDC)	343
Sir Ratan Tata Trust Foundation	136
Republic of China / National Science Council	127
European Union	124
Korea/Rural Development Administration (RDA)	94
Alliance for Green Revolution in Africa (AGRA)	93
Australian Government Overseas Aid Program (AusAID)	46
West and Central African Council for Agricultural Research and Development (CORAF/WECARD)	37
Government of Karnataka	25
COFRA Foundation	21
Kagome Co., Ltd.	16
Others	226
Sub-total	8,277

Total Revenues	17,593
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Acronyms & Abbreviations

AARNET	ASEAN-AVRDC Regional Network
ACIAR	Australian Centre for International Agricultural Research
AGRA	Alliance for a Green Revolution in Africa
AIAT	Assessment Institute for Agricultural Technology
AIFSRC	Australian International Food Security Research Centre
AIRCA	Association of International Research and Development Centers for Agriculture
APAARI	Asia-Pacific Association of Agricultural Research Institutions
ASARECA	Association for Strengthening Agricultural Research in Central Africa
ASEAN	Association of Southeast Asian Nations
AUW	Avinashilingam University for Women
AVGRIS	AVRDC Vegetable Genetic Resources Information System
BMZ	Federal Ministry for Economic Cooperation and Development/Society for International Cooperation
BYVMV	<i>Bhendi yellow vein mosaic virus</i>
CACV	Capsicum chlorosis virus
CAPSA	Centre for Alleviation of Poverty through Sustainable Agriculture
CATIE	Tropical Agriculture Research and Higher Education Center
CFF	Crops for the Future
CGIAR	Consultative Group on International Agricultural Research
ChiVMoV	<i>Chili veinal mottle virus</i>
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CMS	Cytoplasmic male sterility
CMV	<i>Cucumber mosaic virus</i>

COA	Taiwan Council of Agriculture
CORAF/ WECARD	Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles / West and Central Africa Council for Agricultural Research and Development
CRS	Catholic Relief Services
CWANA	AVRDC Central & West Asia and North Africa
DAAD	German Academic Exchange Service
DFID	UK Department for International Development
ERP	Enterprise resource planning system
ESEA	AVRDC East and Southeast Asia
FAO	Food and Agriculture Organisation of the United Nations
FSC	Food Security Center, University of Hohenheim, Germany
GAA	Germplasm Acquisition Agreement
GIS	Geographic information system
GIZ	Gesellschaft für Internationale Zusammenarbeit
GRSU	Genetic Resources and Seed Unit
GTD	Global Technology Dissemination
HortCRSP	USAID Horticulture Collaborative Research Support Program
HPLC	High performance liquid chromatography
ICARDA	International Center for Agricultural Research in the Dry Areas
ICBA	International Center for Biosaline Agriculture
ICIMOD	International Center for Integrated Mountain Development
<i>icipe</i>	Africa Insect Science for Food and Health
ICIS	International Crop Information System
ICPN	International Chili Pepper Nursery
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund of Agricultural Development
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
INBAR	International Network for Bamboo and Rattan
IRRI	International Rice Research Institute
ISHS	International Society for Horticultural Science
ISPN	International Sweet Pepper Nursery
ITS	Internal transcribed spacer
IVTC	International Vegetable Training Course
JIRCAS	Japan International Research Center for Agricultural Sciences

KCMC	Kilimanjaro Christian Medical Centre
KGKV	Krishi Gram Vikas Kendra
KU	Kasetsart University, Thailand
LC-MS	Liquid chromatography – mass spectrometry
MACE	Massive sequencing of cDNA ends
MAS	Marker-assisted selection
MGD	Millennium Development Goals
MaviNPV	<i>Maruca vitrata</i> nucleopolyhedrovirus
MOFA	Taiwan Ministry of Foreign Affairs
MTA	Material Transfer Agreement
MYMV	<i>Mungbean yellow mosaic virus</i>
NARES	National agricultural research and extension systems
PCR	Polymerase chain reaction
PepLCIV	<i>Pepper yellow leaf curl Indonesia virus</i>
PeVYV	<i>Pepper vein yellows virus</i>
PGS	Participatory guarantee systems
PMMoV	<i>Pepper mild mottle virus</i>
PVMV	<i>Pepper veinal mottle virus</i>
PVY	<i>Potato virus Y</i>
QTL	Quantitative trait loci
RAD	Restriction site associated DNA
RCA	AVRDC Regional Center for Africa
RHB	Rice husk biochar
RHBB	Rice husk biochar briquette
RIL	Recombinant inbred line
RNAi	RNA interference
SADC	Southern African Development Community
SDC	Swiss Agency for Development and Cooperation
SNP	Single nucleotide polymorphisms
SPC	Secretariat of the Pacific Community
SLCuPV	<i>Squash leaf curl Philippines virus</i>
SRTT	Sir Ratan Tata Trust
SSR	Simple sequence repeats
SST	Starter solution technology
ToLCTV	<i>Tomato yellow leaf curl Taiwan virus</i>
ToMV	<i>Tomato mosaic virus</i>

TSWV	<i>Tomato spotted wilt virus</i>
TYLCTHV	<i>Tomato yellow leaf curl Thailand virus</i>
TYLCV	<i>Tomato yellow leaf curl virus</i>
UN-ESCAP	Economic and Social Commission for Asia and the Pacific of the United Nations
USAID	United States Agency for International Development
ZYMV	<i>Zucchini yellow mosaic virus</i>

