

## **Proceedings of the 'International workshop on Seed-and-Seedling-borne Diseases of Vegetable Crops'**

(Under NIPHM- USAID and IPM-IL collaboration)

2-5 June, 2014

An international Workshop on "Seed and Seedling-borne diseases of vegetable crops was organized by National Institute of Plant Health Management, Hyderabad in collaboration with The Integrated Pest Management Innovation Lab, a Feed the Future Collaborative Research program funded by USAID at NIPHM campus, Hyderabad, India, from **June 2 to 5, 2014**. The workshop objective was to analyse current status of seed and seedling-borne diseases with an added focus on international seed trade and SPS issues together with analysis of current regulations. Thirty six (36) participants, representing Seed industry, Government officials and scientists from India and scientists of IPM-Innovation Laboratory from USA, Indonesia, Bangladesh and Cambodia attended the Workshop.

IPM Innovation Lab plant pathologists and virologists and other invited speakers, including representatives from NIPHM, the IPM Innovation Lab host countries, local and international seed supply companies, and other stakeholders lead discussions on the current status of research, education, National regulations, seed chain and extension relevant to the management of virus and other diseases transmitted through seed. The findings of the workshop have wide-ranging implications for policy. In order to take full advantage of the wide range of perspectives, the presentations were brief, and the focus of the workshop was more on discussion which triggered the formation of concrete recommendations for improving current practices.

The day-wise proceedings are as under-

Day 1: 2<sup>nd</sup> June 2014

### Opening Session

*Dr. N. Sathyanarayana*, Director, Plant Biosecurity, NIPHM, Hyderabad welcomed the delegates and invited the chairperson Dr. K. Satyagopal, IAS, Director General, NIPHM and the dignitaries Dr. Muni Muniappan, Director, IPM-IL, USA, Mr. M. Prabhakar Rao, President, NSAI, India and Dr. Srivalli Krishnan, USAID Mission, New Delhi to the Dias to grace the inaugural session.

*Dr. Muni Muniappan*, Director, IPM-IL, VirginiaTech, USA delivered Keynote address to the participants of the workshop. He welcomed and thanked the participants and narrated the important role played by IPM-IL in developing IPM packages with non-pesticidal solutions as well as the lead role in Diagnostics of plant diseases caused by pathogens. He elaborated on how the technology recommended by IPM-IL has revived the Tomato industry in Mali under the diagnostic project in accurately identifying the cause for decline of Tomato production. Overall he threw a birds-eye-view on the ongoing projects of IPM-IL and its role in helping developing countries to achieve sustainable production of vegetables by adopting their technologies.

*Mr. Prabhakar Rao*, President, NSAI welcomed the participants to the Seed-Capital of India i.e. Hyderabad. In his talk, he put-forth the industry perspective related to the workshop. He stated that all the vegetable seeds (except the cool-season crops) are produced in Andhra Pradesh and Karnataka, and India has exported vegetable seeds to the tune of Rs.350 crores. The important requirement for the seed industry to compete better in the international market is the OECD membership. Mr. Prabhakar Rao also mentioned the scope for export of field crop seeds such as Rice, Corn, Sorghum and Pearl millet to other countries. He was hopeful that the workshop will address some of the problems faced by the seed industry in India, specifically with reference to seeds and seedling borne diseases.

*Dr. Srivalli Krishnan*, USAID Official thanked Director General, NIPHM, Hyderabad, for holding workshop. She gave a brief account on various activities of USAID to address the 'food-crisis' and the lead role in supporting the Farm development of the world. She said India has marched a long way from food-crisis to food security by increasing the production to meet the growing population. India is a strategic partner to USAID in the 'Feed-the-Future' project. She also reinstated the key role played by private sector for betterment of food security. She said that indiscriminate usage of pesticide has led to deterioration in quality of seeds and IPM is essential to ensure quality of seeds. Diversification of diet, especially fruits and vegetable has also lead to the spurge in farmer's income. She was hopeful that this workshop will provide means to increase income to the farmer. She appreciated the pivotal role played by NIPHM at Regional level instead of 'India-Centric'. She also was hopeful of continued relationship between USAID-NIPHM as strategic approach to move forward and achieve USAID's 'Feed-the-future' objectives.

*Dr. K. Satyagopal*, IAS, Director General, NIPHM delivered inaugural address. He welcomed all the eminent scientists and participants from various countries and India. He reiterated the need to have sustainable agricultural practices with minimum negative impact to environment/ecosystem. He emphasised on the utilization of bio-priming and the importance it is gaining in the recent times. Management of ecosystem plays major role is sustainable agriculture and he emphasised that chemical pesticides are making the farmers to 'spend money to lose money' in the way of pesticide residue and deterioration in nutritional value in the commodity. He emphasised the need to adapt to Agro Ecosystem Analysis and Ecological Engineering concepts to enhance the natural enemy population in the field to combat pest infestations. Further, he reiterated the need to use consortium of beneficial microbe's usage in management of seed and seedling-borne diseases.

## **Session - I: An overview of IPM Innovation Lab and an overview of Seed borne Fungal and Bacterial Diseases**

Chair-person: Dr. Naidu Rayapati

### *Overview of IPM-IL and objectives of the Workshop*

Overview of IPM - Innovation Lab and the objectives of the workshop were discussed by *Dr. Muni Muniappan*. He elaborated on the success stories of IPM-IL around the world. The IPM-IL works in tropical countries to develop IPM packages and to help farmers to enhance income. Currently the IPM-CRSP programmes are carried out in 17 countries in 6 Regions. They are South East Asia (Philippines, Indonesia & Cambodia), South Asia (Bangladesh, India & Nepal), Central Asia (Tajikistan), East Africa (Kenya, Tanzania & Uganda), West Africa (Mali, Senegal & Ghana) & Latin America and the Caribbean (Ecuador, Honduras & Guatemala). The IPM-CRSP has 5 important projects viz., (i) Invasive Weeds (*Parthenium*) in Ethiopia, Kenya, Tanzania & Uganda, (ii) International Plant Disease Laboratory, (iii) Plant Virus Disease, (iv) Impact Assessment & (v) Gender Knowledge and application in 16 countries. IPM-CRSP concentrates on region specific and country specific crops to address the disease problems by tailor made IPM packages to enhance production. To overcome the some virus disease problems, the IPM package also includes a technique host free period (i.e., not growing crops that are hosts of a virus disease for two to three months) and non-pesticidal solutions. Further, to bring down the pest population which might cause direct damage or act as vectors, various pheromones or use of trap crops were also suggested. Use of botanicals or bio-pesticides is widely recommended in the IPM packages. He emphasised the proactive role of international cooperation in addressing invasive pests by citing the control of Papaya mealybug infestation in India by supplying three parasitoids with the help of USAID. He also showed his concern of invasion by Tomato leaf miner (*Tuta absoluta*), which in 2006 entered into Spain from South America and later spread to all over Europe. The tomato leafminer is now spread to West Africa and North Africa, Iran and unconfirmed report from Afghanistan. He said that in a

matter of few years, the tomato leaf miner may move towards South Asia and South East Asia.

### ***Over-view of Seed-borne bacterial diseases***

An over-view of Seed-borne bacterial diseases was delivered by **Dr. Robert L. Gilbertson**, Plant Pathologist, UC Davis, USA. He delivered the lecture on behalf of Dr. Sally Miller, Plant Pathologist, Ohio State University, USA. Important seed-borne bacterial pathogens, economic importance of bacterial diseases, detection of bacterial infection in the seeds and bacterial disease management in seeds were covered in the lecture. The major crux of the lecture was on the bacterial diseases which are transmitted through seeds or vegetative propagative materials. He enumerated on bacterial pathogens transmitted through seed on various economically important crops. The economic damage caused due to important bacterial pathogens transmitted through seeds such as bacterial canker of tomato, black rot of crucifers were cited as examples to reinstate the untold damage in production as well as to the income of farmers. The bacterial infection which causes major damage to vegetative propagative materials such as Banana and Potato due to Banana *Xanthomonas* wilt and potato ring-rot, was elaborated to reinstate the importance of pathogen-free propagative materials. The congenial environment for multiplication and fast spread of bacterial infection in seed production and seedling nurseries were discussed. The detection methods such as direct testing by carrying out visual examination, grow-out test, seed wash or agar test were advised for identifying seed-borne bacterial infection. On the other hand the indirect testing by employing protein analysis or nucleic acid detection was also recommended for identifying the bacterial pathogens in seed. Use of diagnostic media either selective or semi-selective media is highly advised for accurate identification of the pathogens. Various management options such as sanitization of the seeds with sodium hypochlorite or peroxyacetic acid or hydrochloric acid, hot water treatment and their efficacy on various crop seeds was discussed. The importance of harvesting the seeds at high temperature zones, which is not congenial for bacterial pathogen, is also suggested as an alternate method for bacteria-free seed production.

### ***Over-view of Seed-borne fungal pathogens of vegetable crops***

**Dr. Barry J. Jacobsen**, Plant Pathologist, Montana State University, USA elaborated on seed-borne fungal pathogens infecting vegetable crops. The seeds serve as important source for long-distance dissemination of fungal pathogens from its origin. Even very low infestation of 0.01% in seed may result in 100% loss in seedling nursery. Hence, the fungal pathogens have the potential to cause great loss. The management depends on seed producer, who needs to take care at seed production field, detection at the appropriate time and proper seed treatment to manage fungal pathogens which are seed-borne in nature. He differentiated between seed-borne and seed-transmitted fungal pathogens and their mode of access to either embryo or surface of seed during seed-production in the field. He gave a list of important pathogens which are seed-borne on various vegetable crops. He threw some light on management aspects of seed-borne or seed-transmitted fungal pathogens, such as following national or international regulations while trading seed by seed producer and importance of field selection, sanitation, crop rotation, weed control, mulching etc., during growing season. Further, indexing of plants, fungicide treatment, hot water treatment and use of essential oil or biologicals were recommended to obtain pathogen-free seeds. Seed cleaning and seed testing methods were also recommended as management option to minimize fungal infection.

### **Session – II: An Overview of Seed borne Virus and Virus like diseases**

Chair-person: Dr. Muni Muniappan

#### ***An overview of Seed-borne virus and virus like diseases***

Dr. Sue Tolin, Plant Virus Disease Global Theme Leader, Virginia Tech gave a presentation on the Description, Detection and Diagnosis of virus and virus-like agents causing plant disease in vegetables. The presentation included the description of viruses/virus-like agents, practical detection approaches, Diagnostic methods and choices, Results from IPM-IL research and importance for the seed chain. A detailed account on virus classification and naming the viruses was given with added focus on frequency of seed transmission by different taxa. Further, facts about the virus

diagnosis were elucidated with special emphasis on the differentiation between detection and diagnosis. The detection methods such as Grow-out Test, Immunologic and Genomic Based Assays that use a molecular approach were recommended to detect Seed Transmission of a Virus. Besides, advantages and disadvantages of application of Immuno strips were highlighted.

### ***Dissemination/Distribution of Plant Viruses***

Dr. Naidu Rayapati, Associate Professor (Virology), Washington State University addressed the gathering on the topic “Dissemination/Distribution of Plant Viruses”. Plant viruses spread by different means such as insect species, seeds, vegetative propagules, pollen, contact, grafting, soil (nematodes & fungi) etc. However, the mechanism of spread of plant viruses through seed and vector was focussed in detail. The speaker emphasized that the rate of seed transmission will be very high in some hybrids compared to the open pollinated varieties. Furthermore, the presentation also enlightened the gathering regarding the dissemination of viroids through farming implements as contaminants and by contact. The speaker also pointed that the viroid cannot be transmitted by insects due to the lack of coat protein, which is essential for the insect transmission.

### ***Disease development, impact and management***

Dr. Robert Gilbertson, Plant Pathologist, UC Davis, USA, gave a detailed account on Disease development, impact and management. The speaker described the different modes of virus transmission with added focus on the seed transmission. In the field, virus diseases are recognized by symptoms, which also can mimic biotic problems, such as nutrient deficiency and herbicide damage. Although many more viruses are difficult to identify based on symptoms, there are some host/symptom combinations that are fairly easy to diagnose. These wide ranges of symptoms associated with virus infection were elaborated in detail by the speaker. Further, a brief account was given on inclusion bodies which are signs of viral infection and can be used to identify viruses. Further, seed contamination and infection were differentiated with special emphasis on mechanism of seed infection. It was enumerated that the precise identification often requires serological (e.g. ELISA and

lateral flow devices) or nucleic acid-based tests (DNA probes and PCR). The speaker stressed the need for management strategies such as integrated pest management in seed chain with special emphasis on management of viruses in Seed Potatoes in addition to having Standards for minimum acceptable levels of seed-borne pathogen during seed certification.

## **Day 2: 3rd June, 2014**

### **Session III: Country Specific Reports on seed-borne virus diseases**

Chair-person: Dr. Robert L. Gilbertson

#### ***Country Specific reports on seed borne virus diseases - Indonesia***

Ms. HendrastutiHidayat, Department of Plant Protection, Bogor Agricultural University (IPB), Indonesia gave perspectives of working partnership with IPM – CRSP – Global Theme and IPVDN, Indonesia. She gave an account of prevalent virus diseases of crops like Chili, Shallot, Yard long Bean, Cabbage, Tomato and Potato and explained that Gemini Group of Virus is the major concern in chili. However, Chili Mottle Virus, Chili vein mottle virus and Pepper yellow leaf curl begomovirus are also significantly damaging the chili crops in Indonesia. She elaborated the key findings of their research on seed borne viruses like BCMV on yard long bean, TuMV on chinese cabbage and SqMV on cucumber. She explained ELISA results and shown that BCMV, TuMV and SqMV are seed transmitted and have capability to cause 90-100% disease incidence in Yard long bean, chinese cabbage and cucumber.

The discussion was held on resistance sources of chili leaf curl virus, management options, strategy for farmers to manage virus disease, disease severity data, seed certification agency and options other than serological investigation in detection of viruses.

#### ***Country Specific reports on seed borne viroid diseases – West Africa***

Dr. Robert L. Gilbertson gave an account on status of Tomato infecting viroids and impact of seed borne Columnea latent viroid (CLVd) in Africa. He gave details of Tomato field surveys in Mali and Ghana in 2011-12 where Virus-like symptoms viz.,



stunted growth, epinasty and chlorosis of leaves, and necrosis of leaf veins and stems were recorded in 1-5% of tomato plants. Subsequent RT-PCR analyses revealed the presence of Columnea latent viroid in the infected tomato plants. He also stated that different viroids can also attack on same plants with similar symptoms for example TASVd, PSTVd and CLVd. He also emphasized role of RT-PCR in detection and differentiation of virus and viroid infection.

#### ***Country Specific reports on seed borne virus diseases -East Africa***

Dr. Sue Tolin gave presentation on IPM-IL (CRSP) East Africa IPVDN and Regional Site survey report. She stated that Passion fruit woodiness virus and Cowpea aphid-borne mosaic virus are the viruses of major concern and are managed by rouging, clean nursery stock, vector management and clean-up of seed from virus through selection and protected growth. She also discussed the tomato virus surveys which were carried out in collaboration with East Africa Regional Site and African Food Security Initiative, IPDN. They found that average field incidence of viruses was 64% and most common virus was CMV and ToMV.

#### ***Country Specific reports on seed borne virus diseases - Latin America and Caribbean***

Dr. Sue Tolin discussed the works carried out during 2009-2014 under IPM-CRSP in Latin America and the Caribbean (Ecuador, Jamaica, Dominican Republic, Honduras & Guatemala). She narrated that with collaboration of IPM-CRSP with Caribbean Agriculture Research and Development Institute (CARDI, Jamaica) and Universidad del Valle de Guatemala, capacity building programmes were organized. She also highlighted the major virus diseases of tomato in Guatemala and Ecuador.

#### ***Country Specific reports on seed borne virus diseases - Asia***

Dr. Naidu Rayapati gave a very informative presentation on Plant Virus Diseases and Diagnostics in India. He started his presentation with organizational chart of IPM - IL IPVDN. He emphasized on the work carried out during Phase IV IPM-IL (CRSP) 2009-2014 which comprises one project, six regions and 15 countries

including Asia. He explained the devastation caused by peanut bud necrosis virus in tomato in India, viruses of cucurbits in Bangladesh, epidemic of virus disease in yard long bean in Indonesia and Bhendi yellow vein mosaic virus disease in India & Bangladesh. He said that peanut bud necrosis virus is a major threat to tomato sustainability in India. He discussed the impact of PBNV on various aspects like market access, yield loss, nutritional value, short shelf life and socioeconomic effects. He listed objectives of the International Plant Virus Disease Network (IPVDN) IPM-IL Global Theme (2009-14) toward the effective integrated pest management of plant disease caused by viruses in developing countries. Following are the objectives as stated by Dr. Naidu –

- Documenting prevalence of economically important plant virus diseases and their vectors in regions of interest through surveys, and investigating associated bioecology in a perspective of cropping systems.
- Developing long-term institutional capacity building in host countries in; detection and diagnosis, resistance screening and monitoring and ecological research on virus-vector-host interactions in selected vegetable cropping systems.
- In cooperation with regional projects, design and implement applied research on specific virus diseases in selected crops in order to develop or improve IPM packages that employ results obtained in Objectives 1 and 2.

Further, he explained the detection of vegetable viruses using FTA® Classic Card technology which they are currently using for several DNA and RNA viruses from different countries in Asia and Africa.

### ***Seed Health Regulations in India***

Dr. N Sathyanarayana, Director, Plant Biosecurity, NIPHM, Hyderabad elaborated in detail about seed health regulations in India. He gave a chronological account of seed acts, regulations and bills, and the current status of seed health regulations in India. He discussed Seed Health aspects in National Regulations including restriction on export and import of seeds of notified species or varieties and

recognition of seed certification agencies of foreign countries. He also discussed provisions and clauses in Seeds (Control) Order, 1983, National seed Policy, 2002, the Seeds Bill, 2004, PQ Order, 2003 and Environment Protection Act, 1968. Further, he placed some specific recommendations to fill gaps identified in current regulatory frameworks viz., Need for proper infrastructure and expertise in Seed Testing, Seed health parameters (Important for Biosecurity & Market Access thereby impact on Imports and Exports) and Accredited labs of public & private sector for seed health testing.

#### ***Roguing for management of Peanut bud necrosis virus in tomato***

Dr. Naidu Rayapati elaborated various perspectives of tospoviruses mostly peanut bud necrosis virus including genome structure, transmission efficiency of thrips, natural host ranges of vegetable-infecting tospoviruses in India and management practices at farmer field level. He emphasized on critical diagnosis of viruses for perfect management. Further he suggested management aspects of diseases caused by tospoviruses PBNV in tomato in India. He explored management options like Vector control, Host resistance and Cultural practices like date of planting, crop density, crop rotation and host-free period etc. He also said that there is no silver bullet for management of PBNV and an integrated approach can be taken into the consideration. He emphasized on roguing as a significant management tactic to control the PBNV. He concluded that different components of IPM can have additive effect in reducing/suppressing disease incidence including Seed treatment with *Pseudomonas fluorescens* @ 10g/kg and *Trichoderma viride* @4g/kg of seeds, roguing virus infected plants up to 45 days post-transplanting, Soil application of *P. fluorescens*@ 2.5kg/ha and Installation of yellow sticky traps.

#### ***Round Table Discussion -***

The afternoon session of the Workshop followed a less traditional format. It was designed to elicit the maximum contribution from all the participants, and consisted of four main sections, each aiming in different ways to promote reflection and

deeper exploration of the themes emerging from the morning's presentations and discussions.

These four sections comprised:

1. Seed Treatment
2. Seed/Seedling certification/tolerance levels
3. Effectiveness of quarantine systems
4. Seed transmitted pathogens of high value vegetable crops

**1. Seed Treatment** - Dr. Sue Tolin was invited to discuss and opine about the seed treatment for the seed transmitted viruses. Dr. Tolin explained some of the research observations regarding seed treatment for virus free seeds. Following deliberations were noted during the discussions with participants -

- Seed industry participants suggested that thermal inactivation of viruses can be done in case of seed transmission of viruses. The seeds are exposed to 1 to 50 °C for one day with 8 per cent moisture. The temperature on second day will be raised up to 72 °C and same will be maintained for 24 hr. Thereafter, the temperature will be reduced to room temperature for 3 days. Hence, the total duration of this treatment is five days at the cost of 1-2 per cent germination loss. The treated seeds are recommended for immediate sowing.
- Defuzzing of tomato seeds can be done by using physical methods (Cement mixer, washing machine rotation, Centrifuging at low rpm). It may be completed prior the treatment of Tri-sodium phosphate.
- TMV infection in tomato seeds can be reduced by treatment of the pulp with one quarter of its volume of concentrated HCL for 30 minutes, followed by washing and drying of the seeds.
- Even soaking the seed in 10% solution of teepol for 2 hrs or soaking in a 10% solution of trisodium orthophosphate or 10% sodium carbonate solution helps in freeing the seed from TMV contamination.
- Seed treatment with *Trichoderma*+/*Pseudomonas* reduces the infection/infectivity in the seed transmitted virus incidence, especially with *Pythium*&*Phytophthora*.

**2. Seed/seedling certification/tolerance levels** – Following deliberations were noted during the round table discussion on seed/seedling certification/tolerance levels -

- Zero per cent tolerance is advised in case of viruses.
- Seed sanitation should start from production field itself.
- Isolation of seed production areas from commercially grown areas.
- Accredited agencies are recommended in seed health testing.
- Recommended POPs should be followed in production.
- Regulatory bodies should be established to monitor the seed health.
- Uniform standards should be established for seed health testing.

**3. Effectiveness of quarantine systems** – In the round table discussion, participants raised questions regarding the effectiveness of quarantine system in India. During the deliberations, it was suggested

- to open more diagnostic centers/laboratories for quick and accurate detection and identification of pathogens
- to create more awareness and clarity on PSC and
- to build one window for PSC and additional declarations

**4. Seed transmitted pathogens of high value vegetable crops -**

*Viruses infecting Solanaceous Crops*

Dr. Robert L. Gilbertson deliberated on viruses infecting solanaceous crops and stated that, understanding the biology of the virus is necessary for effective disease management. He also gave a list of key viruses that infect tomato and pepper. He enlisted the major viruses of tomato and chili and described vectors of transmission, host range and biology. He also emphasized on various modes of transmission of viruses.

*Seed-borne Cucurbit Viruses*

Dr. Sue Tolin elaborated the seed borne viruses infecting cucurbitaceae e.g. Cucumber mosaic virus, Watermelon mosaic virus, Papaya ringspot virus (strain W), Zucchini yellow mosaic virus, Squash mosaic virus, Melon necrotic spot virus and Cucumber green mottle mosaic virus. She explained structure, genome constitution,

host range, transmission factors, treatment of infected seeds and their management practices. She elaborated that for most of the cucurbit viruses, immuno-strips can be used for accurate detection.

The session ended with discussion on a number of issues ensuing the following deliberations-

- Sterilization of media is necessary for raising the seedlings
- Treatment of media with bio-pesticide/fungicide
- Cross protection, i.e., inoculation of host crops with mild strain of the virus to avoid devastating effect. But the disadvantage is that the virus may mutate.
- Management of tospovirus requires control of vectors in primary nursery, media sterilization, yellow sticky traps for monitoring, concrete floor in nursery, weed control, spraying floor, media & soil with bio-control agents like *Metarrhizium* etc..
- Symptoms of Tospovirus may be confused with Tobacco etch virus. Hence, usage of tospovirus immune strips is recommended for the precise identification of tospovirus
- Raising continuous seedlings in the net house might be the source of constant availability of inoculum. Hence, staggered seedlings may be isolated.
- Multiple strategies require Integrated approach
- Implementation of USDA Pest database model, which entrusts compilation of pest data to State Department of Agriculture. All the state Departments in turn aid in creating the National Pest database.

**Day 3: 4 June, 2014**

#### **Session - IV**

Chair Person : Dr. N. Sathyanarayana

#### ***National Germplasm Programs***

**Dr. SarathBabu**, Principal Scientist, NBPGR, Hyderabad gave a brief description on National Germplasm Programmes in India. He gave a brief account on importance of Plant Genetic Resources (PGR). In any country, species diversity and ecological

stability are maintained due to abundance of PGR's. They serve as raw materials in crop improvement programmes, act as store-house for genetic variability, helps the farming community to have diversification of cropping and farming systems, adaptability to climate change and serve important role in food, nutritional and environmental security. India is rich in biodiversity with 7.36% of species abundance. India is native to many crop plants and rich in gene diversity. The national plant genetic resources are managed under the umbrella of DARE/ ICAR by National Bureau of Plant Genetic Resources (NBPGR), which has two important roles to play *viz.* networking of 10 Regional Stations and 59 National Active Germplasm Sites (ICAR Crop-specific Institutes) and collaborates between National Stakeholders and International Collaborators. Management of national germplasm resources is done by carrying out germplasm explorations, characterization and evaluation of germplasm, exchange of germplasm, plant quarantine, germplasm conservation and documentation.

### ***Capacity Building and Other Needs***

*Dr. Sue Tolin*, Plant Pathologist, VirginiaTech, IPM-IL elaborated on Capacity building programmes being organized by IPM-IL in various countries. IPM-CRSP/IL organizes long-term training programmes at US or at 17 host country universities. The long-term training programmes are in the form of under-graduation or post-graduation or doctorate degrees. The short-term capacity building training programmes are organized at regional level with emphasis of problems faced by the countries within the region or on the global theme projects such as (i) Invasive Weeds (*Parthenium*) (ii) International Plant Disease Laboratory, (iii) Plant Virus Disease, (iv) Impact Assessment & (v) Gender Knowledge. Apart from these long-term and short-term capacity building programmes, IPM-CRSP-IL also organizes workshops on various themes such as bio-control agent production and use, fungal bio-pesticides, biological control and management of *Parthenium* weed and also organizes Farmers field schools in various developing countries.

***International and National capacity building programmes (NIPHM)***

*Dr. N. Sathyanarayana*, Director, Plant Biosecurity, NIPHM, Hyderabad gave a presentation on various International and National capacity building programmes being organized at NIPHM. The training programmes are organized under 3 categories i.e. Plant Health Management, Pesticide Management and Plant Biosecurity. The long-term training programme in Plant Health Management includes season-long training programme on Agro-Ecosystem Analysis & Ecological engineering in pest management. Short-term training programmes include Agro-Ecosystem Analysis, Ecological engineering in pest management for extension officials/researchers, Production protocol for bio-control agents and bio-pesticides, Good Agricultural Practices, Quality analysis and Quality Management of bio-pesticides and Vertebrate pest management. The training programmes in Pesticide Management includes Pesticide Residue Analysis, Pesticide Formulation Analysis, Sampling and testing pesticide residue in fruits and vegetables, International code of conduct on pesticide management and safety, Aflatoxin Analysis and Advances in Pesticide Residue Analysis. The training programmes in Plant Biosecurity includes Plant Biosecurity and Incursion Management, Pest Surveillance, Pest Risk Analysis, Quarantine pest detection and diagnosis, Stored Grain pests detection and diagnosis, Timber log pests detection & diagnosis, Phytosanitary Treatments (MBr & ALP fumigations) and Harmonization of Phytosanitary procedures for SAARC countries.

**Day 4: 5<sup>th</sup> June, 2014**

Delegates were shown the laboratory facilities of Entomology, Pathology, Pesticides and Bio-control at NIPHM. An Institutional visit to ICRISAT was also organized where in the participants were exposed to various activities undertaken by ICRISAT. The AVRDC which is housed in the ICRISAT Campus was also visited to know its activities in Vegetable Research and Development.



### **Closing Remarks**

Dr. K. Satyagopal, IAS, Director General, NIPHM, Hyderabad chaired the plenary session and concluded the workshop by appealing all the stakeholders to bestow their attention in using the recommendations made by the panellists as a follow up in management of seed borne and seedling borne diseases of vegetable crops. A vote of thanks was proposed by Dr. K. Susheela, SO-PRA, NIPHM.

### **Conclusion and Way forward**

The variety and richness of discussion at the Workshop made it possible to draw together all the insights, observations and proposals for action that had emerged during the course of the Workshop. The workshop participants identified a number of general issues such as seed treatment, seed health regulations, effectiveness of quarantine systems, challenges in domestic trade etc. Specific issues discussed included infrastructure and facilities for seed testing and seed health, challenges in international trade and timely certification. The individuals and organisations are expected to have been motivated by these discussions to take up the appropriate IPM strategies and find solutions by simplified and timely seed certification for both domestic and global market.

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