

PROCEEDINGS OF THE BRAINSTORMING ON OKRA

DATE: SEPTEMBER 28, 2013



Organized by



**Indian Institute of Vegetable Research
(Indian Council of Agricultural Research)
Varanasi- 221 305**



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Date: September 28, 2013

Venue: Indian Institute of Vegetable Research, Varanasi

India ranks first in the world with a production of 5784.0 thousand tons (72% of the total world production) of okra from over 498.00 thousand ha land (FAOSTAT, 2012). It is also cultivated in Nigeria, Sudan, Pakistan, Ghana, Egypt, Benin, Saudi Arabia, Mexico and Cameroon. Andhra Pradesh is the leading okra producing state which has production of around 1184.2 thousand tons from an area of 78.90 thousand ha with a productivity of 15 tons/ha followed by West Bengal (862.1 thousand tons from 74.00 thousand ha with 11.70 tons/ha productivity).

Okra is an important source of vitamins, calcium, potassium and other minerals which are often lacking in the diet in developing countries. The crop is prone to damage by various insects, fungi, nematodes and viruses, although there is wide variability in their degree of infestation. Some of the important insect pests are shoot and fruit borer, jassid, aphid, whiteflies and mites etc. The okra is also subjected to the attack of many diseases affecting leaves, flowers and fruits. Its cultivation in India is challenged due to severe incidence of Yellow Vein Mosaic Virus (YVMV) and Enation Leaf Curl Virus (ELCV) diseases, spread by an insect vector namely white fly (*Bemisia tabaci*). The loss in marketable yield has been estimated at 50-94 % depending upon the stage of crop growth at which the infection occurs. Lack of sources of resistance to these viruses in cultivated species has forced breeders to look into the wild species for resistance sources. The transfer of resistance from wild relatives has also been hampered by sterility problems. Hence continuous search for new sources of resistance and development of better varieties/hybrids with higher level of resistance should be prime objective.

In India, a number of ICAR Institutes, State Agricultural Universities and private seed companies are working on various aspects of genetic improvement of okra in order to develop high yielding and disease resistant varieties. Through intensive research efforts > 50 improved varieties and hybrids have been released. Some of these varieties and hybrids have already made significant impact/contribution in revolutionizing the production of okra in the country. However, still a vast gap exists in the research efforts and the expected outcome. Emerging biotypes of whitefly, new virus strains and breakdown of resistance in okra varieties/hybrids are the major challenges which need to be addressed.

Keeping in mind above problems, brainstorming on okra was organized on September 28, 2013 at Indian Institute of Vegetable Research (IIVR), Varanasi. About 80 participants comprising researchers from different ICAR institutes, State Agricultural Universities and representatives from private sector participated in the deliberations.

Dr. N.K. Krishna Kumar, Deputy Director General (Horticulture), ICAR, New Delhi inaugurated "Brainstorming on Okra". In his address, DDG (Horticulture) appreciated the role of IIVR in the development of okra varieties/technologies. He informed the house that due to heavy loads of pesticides, curry leaf and drumstick exports from India are under scanner. Similarly, okra fruit consignments are under threat due to presence of early instars larvae of *Helicoverpa armigera*. Neonictinoid insecticides viz., imidacloprid and thiomethoxam are causing colony collapse disorder in honeybees. So their uses are restricted in EU. He stressed upon the detailed study on biotypes of *B. tabaci* and biotypes specific insecticide resistance management (IRM). The blisters on okra fruits are caused due to jassid infestation. He further added that the studies should be carried out on honeydew

and their possible role in okra ecosystem. He emphasized the leading role of India in Okra research and technology development in the world and particularly for African countries. He mentioned that emerging biotypes of whitefly, new virus strains and breakdown of resistance in okra varieties/hybrids were the major challenges which need to be addressed and requested the okra group to take stock of the national scenario and chalk out strategies to overcome these challenges.

SESSION -I

Chairman: Dr. N. K. Krishna Kumar, Deputy Director General (Horticulture), ICAR, New Delhi

Rapporteurs: Dr. Ranjeet Gujar and Dr. Suresh Reddy

Dr. O.P. Dutta gave a brief presentation on “Advances in okra breeding with special reference to virus resistance”. He presented the history, yield losses, virus transmission and common hosts of BYVMV, OELCV and petiole bending virus. Sequencing analysis of the DNA-A component from various isolates collected from India revealed that 80% of the isolates aligned into a common cluster and virus isolates from Gujarat were highly distinct and aligned to two distinct clusters. The isolates with Enation like symptoms were nearly identical (95.5%) with Cotton Leaf Curl Gemini Virus and isolates with stem bending symptoms fall into distinct species. Rest of the isolates were identical to common Tomato Leaf Curl Virus. He reported that under favorable environment (High temperature & low humidity), the vector (*Bemisia tabaci*) can carry 3 different viruses for 6 days simultaneously. He also explained the concepts and practical utility of multiple virus susceptibility, pathogenic variability and elements of epidemics. Dr. Dutta informed the house about the sources of resistance against YVMV along with their hotspots and elaborated their importance in okra breeding programme with special reference to Shuttle Breeding. He schematically described the field design for screening of okra in hotspots and under artificially induced epiphytotic conditions and mentioned about genetics of YVMV resistance and stressed the need for development of stable virus resistant varieties. Dr. Dutta also explained different breeding methods for creating YVMV resistance in okra i.e. Interspecific hybridization/back cross, pedigree breeding method and heterosis breeding. At the end, he stressed the need for cytological studies, understanding biochemical mechanism of disease resistance, maintenance breeding, marker assisted breeding and gene pyramiding.

There was enthusiastic discussion after Dr. Dutta’s presentation and following are some of queries raised by delegates:

Dr. A.A. Deshpande enquired about the importance of high humidity in screening for YVMV resistance and he stressed the importance of multi-location trials and team work to tackle the problem.

Dr. O.P. Dutta replied that high humidity helps in whitefly multiplication and high temperature helps in virus multiplication. More plant to plant spacing helps in faster spread of whitefly.

Dr. S.K. Sanwal informed the house that under flagship programme, IIVR scientists have selected five locations (BCKV, Kalyani; PAU, Ludhiana; TNAU, Coimbatore; MAU, Parbhani and IIHR, Bangluru) in hot spot areas for screening of all the released varieties and advance lines from IIVR & IIHR. We are going to get result by next January or February.

Dr. Mamta Pathak enquired whether 40-50 days after sowing is optimal time for YVMV scoring.

Dr. O.P. Dutta replied that symptoms may appear after 40-50 days of sowing but 75-80 days after sowing is good for YVMV scoring. Same thing was recommended by Dr. B. Singh.

Dr. VK Tripathi asked to go for combined resistance to YVMV, OELCV and petiole bending.

Dr. O.P. Dutta said that combined resistance can be achieved through proper screening of germplasm lines in respective hotspots of diseases and mentioned the approach of gene pyramiding with the help of molecular markers.

Dr. S.K. Pandey enquired about the useful sources for resistance.

Dr. O.P. Dutta said land races, specifically belonging to West Bengal, are good sources of horizontal resistance.

Dr. N.K. Krishna Kumar suggested to identify critical areas for resistance against multiple races/biotypes of YVMV virus. He asked the opinion of the house whether a tolerant variety (a symptom less carrier) should be released or not?

Dr. H.C. Prasanna suggested that if it gives yield advantage to the farmer over susceptible line, it can be considered for release. Dr. Krishna Reddy also favoured this opinion particularly in case of Begomoviruses like YVMV, OELCV etc.

Dr. K.V. Bhat stressed the need for a research programme including development of molecular markers, their validation and map construction. He also briefed the importance of cytological studies.

The second presentation in the session was by Dr. K. V. Bhat.

Dr. K.V. Bhat made presentation on “Wild species of okra: Diversity, distribution and utilization”. He discussed about the *Abelmoschus* species variability and morphological key to distinguish various taxa occurring in India and mentioned about “Collector’s Guide” for species identification. He proposed current classification of Indian material based on findings of NAIP on Biosystematics at NBPGR (2012) and discussed on new species *Abelmoschus enbeepeegearensis* reported by NBPGR scientist. He informed the house about the ex-situ conservation of *Abelmoschus spp.* at NBPGR, New Delhi and NBPGR regional station, Trichur. He also explained the phytogeographical distribution and diversity of wild species in the world and India and summarized the crossability behavior of different okra spp., pre-fertilization and post-fertilization barriers and embryo rescue studies conducted on okra. He listed the Okra germplasms which may be used as potential sources for resistance to biotic and abiotic stresses, high pod number, tender pod, different pod colours, etc. He also stressed the need for proper evaluation of germplasm lines and their utilization through large scale interspecific hybridization programmes, to develop a network to exploit the potential and a repository to maintain the derivatives.

Some of the points raised after the presentation were:

Dr. A.A. Deshpandey requested to provide accession numbers of interspecific hybrids.

Dr. Bhat agreed to provide the accession numbers of interspecific hybrids.

Dr. VK Tripathi complained for poor germination of seeds of different accessions and also asked for germplasm exchange with private companies.

Dr. Bhat informed that with respect to *A. esculentus*, the germination may be a sporadic incidence. In case of wild spp., Dr. Bhat advised for acid treatment to improve germination.

Dr. N.K. Krishna Kumar asked in reply whether private companies are ready to reciprocate the transfer of genetic material and also suggested the involvement of Biodiversity Authority of India on the issues of germplasm exchange. He further enquired about conservation of wild accessions in pollen form and asked whether the information on time of anthesis and flowering is recorded for all the accessions of okra.

Dr. Bhat informed that few accessions of okra are already conserved in pollen form and the same will be adopted for remaining accessions in future and the time of anthesis and flowering are recorded for all the germplasm lines.

Dr. B. Singh asked to provide interspecific populations to IIVR and IIHR and stressed the importance of cytological studies in okra. He suggested for collection of the okra germplasm from all parts of India and keep proper records of seed germination percentage for all the accessions.

Dr. Radha Anandalakshmi asked about the availability of controlled conditions and whether work on bridging spp. has been done or not?

Dr. Bhat in his reply said that there is National Phytotron Facility at IARI, New Delhi for this purpose. He also mentioned about their work at Thrissur, Kerala. He explained that the main target of this work was taxonomy and identification.

At the end of the session Dr. N.K. Krishna Kumar suggested for trichome profiling in okra accessions.

Session II

Chairman: Dr. S.K. Pandey, EX Director, CPRI, Shimla

Rapporteurs: Dr. Venketravanappa and Dr. Pradeep Karmakar

Dr. Elangovan Mani from Advanta made 1st presentation on “Breeding for okra hybrids with next generation molecular breeding tools: lesson we can learn from its distant relatives”. He stated that present annual turnover of hybrid okra seed is around 1500 t, which is valued ~ INR 150 crore (growing at 30% CAGR). The cultivation of okra is threatened by viral diseases such as Yellow Vein Mosaic Virus (YVMV), Enation Leaf Curl virus (OLCV) and conventional breeding approaches has limited success in delivering high level of tolerance in hybrids which is stable across the country. The exploitation of germplasm in okra breeding is often limited due to few molecular markers or absence of molecular genetic map or other molecular tools. Chromosome linkage groups cannot be constructed due to large number of chromosomes and generally plant genome is polyploidy. He mentioned that the genome size of okra is 16000 mb having 65 linkage groups. Thirty six chromosome of cultivated *A. esculentus* show homology with *A. ficulneus*. Twenty nine chromosomes of *A. esculentus* (genome TC) had complete homology with 29 chromosomes of *A. tuberculatus*. These studies established that cultivated okra is an amphidiploid (29 TC +36 Y). Presence of 65 linkage groups makes okra tough genetic system after wheat -an hexaploid with 21 linkage groups. For development of cheap and robust markers (SNPs), he stressed upon

- Constitution of consortium for okra SNP development just like other major field crop consortia. Consortium decreases cost of investment for participating members and will brings diverse pool of germplasm into panel, making the SNP markers widely applicable for the member breeding programmes.
- Identification of SNP markers using RAD sequencing. Initially SNPs should be identified in 25K to 50K with identification with long read sequence best fit for de novo construction.
- Wet lab validation of SNPs: The percentage of SNP conversion success from dry lab to wet lab can be as low as 40% in polyploidys. Screen large set of okra genotypes from consortium members or public and reduce the core set of SNPs from 50K to 1536 SNPs and try to map these core set of SNPs in RIL population of consortium members.

He also discussed on male sterility system and stressed development of CGMS lines with Rf markers for F₁ hybrid seed production in okra.

Following clarifications were sought after presentation.

Dr. S. K. Pandey enquired whether marker developed for YVMV will also work for other viruses or not and is it possible to develop tomato like system in okra to develop YVMV resistant variety?

Dr. Elangovan Mani replied that okra has very complex genome and first it is essential to resolve the genome complexity in okra

Dr. H.C. Prassana enquired about copy number and how it is associated with okra?

Dr. Elangovan Mani replied that though the copy number is frequently used in the case of transgene, but it is also used in okra as it is a polyploid and it may contain same gene in multiple copies as per the ploidy level.

George Thomos was surprised as to why breeders should jump to SNPs without validating SSR markers?

Dr. Elangovan Mani informed that SSR markers are more useful to develop saturated maps. Therefore, it is essential to take up the development of SSR markers and validation of these markers in okra.

The 2nd presentation was made by **Dr. Kiran V Hegde** of Chromous Seeds on “Marker Assisted Selection in okra Breeding -Complications and Solutions”. He stated that Marker-assisted selection (MAS) is a method of selecting desirable offspring in a breeding program based on DNA molecular markers apart from their phenotypes. When used appropriately it helps plant breeders to select offspring more efficiently for desirable agronomic traits. In MAS, breeder can select the desirable plants in early generations, therefore, it scales down the breeding program to focus on fewer offspring as compared to conventional breeding and exceeds the limits of classical breeding in terms of removal of linkage drag, pyramiding resistance genes, polygenic traits and possibilities of detecting an offspring equivalent (genetically) to F4 in F2 generation etc. In his presentation the speaker also ascertained that the phenotype is an imperfect predictor of the genotype. The phenotype is not effective in resolving negative associations between genes (linkage, epistasis). Therefore, breeder should consider MAS in their breeding programme. He also described that okra had complex genome with less stability. Amphidiploidy, marker linkage and stability, and complexity in copy number were the main drawbacks in using MAS in okra breeding. A genic maker was developed in collaboration with UGI and patent filed by Chromous Seeds. 80 commercial germplasm from different companies screened with this marker. The marker data gave correct interpretation in > 95% samples. There was a complication in interpretation of phenotype data towards resistance / tolerance. He also described the way out for using marker in complex genome like okra. He recommended to perform one round of field screening or *in-vitro* testing to correlate the marker data, once correlated the marker data can be used to purify the line and as primary screening tool and screening of foundation / breeder seed for homogeneity. He also emphasized that the genetic distance between the donor and recurrent parent determined using FAB technology. Assume the polymorphism within 1,000 loci analyzed is 30% or identity is 70%. A chart is made to understand the BC population genetic similarity with recurrent parent at each backcross cycle. Since the distribution of alleles is random there will be some population of plants with genome more similar to recurrent parent i.e genetic similarity > 92.5 %. Statistically we can get plants similar to BC2 in BC1 itself. Such plants with more genetic similarity can be taken for next cycle of backcrossing. The cycle of screening is continued and a breeding program can be completed within 3 – 4 cycles of back cross instead of traditional 7 – 8 cycles. In his conclusion, Dr. Hedge said that “for complex genomes like okra- a successful breeding program can be effectively completed faster by combined approach of MAS and Genotypic screening.”

Dr. H. C. Prasanna sought details on marker and copy numbers identified by Chromous seeds Pvt. Ltd.

Dr. Kiran V Hegde replied that the marker has been identified using the sequence information of gene that plays role in supporting the virus in the host. The Chromous is using this for MAS and has provided

services to as many as 12 companies. On the issue of the copy numbers, the speaker replied that numbers are detected using florescent peaks.

Dr. K.V. Bhat asked whether we can determine the variety/genotype resistance based on copy number of the gene?

Dr. Kiran V Hegde was affirmative if the resistance is recessive like in the case of YVMV, having all resistant loci will lead to resistance. In case of dominant gene based resistance, copy number might not be that important.

Dr. Radha was concerned due to differences in chromosomal number, whether marker can be used in complex genome

Dr. Kiran V Hegde replied that if one round of phenotype to genotype correlation is done, it can be used.

The last technical presentation was presented by **Dr. M. Krishna Reddy** on “Emerging viruses of okra”. In his introductory remarks Dr. Reddy said that begomoviruses are most prevalent (25%) plant virus followed by potyvirus (21%), tospovirus (12%), crinivirus (9%) and potexvirus (8%). In Asia 21 plant viruses are reported and among these 19 viruses are reported in India. Twenty seven begomoviruses and one each of ilarvirus, nepovirus, potyvirus, tospovirus and tymovirus infect okra and cause several viral diseases. In tobacco streak virus infected plant, fruits become distorted and this disease is transmitted by thrips and seeds. Yellow vein mosaic is most devastating disease of okra causing > 60% yield loss. okra enation Leaf curl virus is serious in North. TSV an ilarvirus is an emerging problem for okra production. Begomoviruses have high recombination rate and the presence of B-biotype whiteflies are contributing to epidemics of begomoviruses in okra. Host genetic resistance to viruses is one of the most practical, economical and environmentally secure strategies for reducing yield losses in okra. He stated that Begomoviruses possess a genome comprised of one or two circular ss-DNA molecules, genome is monopartite (2.5–3.0 kb) or bipartite (2.5–5.0 kb), having smallest known genome for an independently replicating twinned icosahedral virions [18X30nm] and transmitted primarily by whitefly *Bemisia tabaci* and few are also transmitted mechanically. Natural resistance is available in wild species and land races of bhindi which has to be identified for each virus and ecological region. He presented the symptoms of different viral diseases in okra, distribution of wild species of okra along with the begomoviruses in Indian sub-continent. In this presentation Dr. Reddy also demonstrated the phylogenetic grouping of okra begomoviruses. In India okra crop is infected by seventeen types of begomoviruses. He described the PCR based diagnostic techniques of OYVMV, OELCV and TSV; Detection of BYVMV in whiteflies using PCR and techniques of Identification of vector biotypes. Resistance to yellow vein mosaic in okra is governed by recessive alleles, two complementary dominant genes and a single dominant gene in different resistant sources. On this account he also presented the different techniques of resistance breeding in okra. Efficient Screening of genetic materials may be done through screening in hot spots/regions, artificial screening through whitefly and screening through grafting/agroinoculation. Resistance evaluation can be performed through sensitive assay like visual symptoms, ELISA/nucleic acid probe and PCR assay. Punjab, Haryana, Andhra Pradesh, Jharkhand, West Bengal and Odisha were identified as hot spots for yellow mosaic disease screening. Dr. Reddy also provided information on artificial screening techniques for YVMV resistance and virus disease indexing scale. Zero per cent disease incidence along with negative probe/PCR gives immune reaction, while 1-10% and 11-25% disease incidence with positive/negative and positives probe/PCR provide highly resistant and resistant, respectively. In concluding remarks he outlined the future plans viz., identification of stable sources of resistance, identification of virus specific resistance, introgression of resistance genes from wild species, virus specific and source specific genetics of inheritance and identification of resistance to whitefly.

There was a discussion after Dr. Reddy's presentation and following are some of the queries raised by the delegates.

Dr. A.A. Deshpandey wanted to know whether petiole bending in okra leaf is a new begomovirus or existing once.

Dr. Reddy replied that it is not clear that petiole bending is a new virus or it is a part of okra enation leaf curl virus as yet.

Dr. VK Tripathi was curious to know as to why the genotypes resistant to YVMV are mostly susceptible to enation leaf curl virus?

Dr. Reddy informed that it is not always true. Some of the genotypes have enation leaf curl virus but they do not express the symptoms.

PLENARY SESSION

The summary of presentations of all the technical sessions was presented in the plenary session followed by a discussion. Important recommendation and action point are briefly mentioned below.

Recommendation	Action Point
(1). A two pronged breeding programme with short term and long term objectives may be followed to breed okra varieties preferably with multiple resistance/tolerance to BYVMV, ELCV and possibly petiole bending virus.	All the participating institutions both in public and private sectors involved in breeding okra varieties/hybrids using existing known sources of resistance/tolerance to BYVMV/ELCV/petiole bending virus should work in collaboration and prepare themselves for replenishing/replacing these varieties at appropriate intervals before they succumb to new strains of viruses and become uneconomical. Work plan, time bound activities, allotment of duties, responsibilities and funds should be chalked out to achieve the said objectives.
(2). Simultaneously the long term breeding programmes against these viruses should aim at developing stable resistant hybrids/varieties through gene pyramiding.	Incorporate broad spectrum resistance through gene pyramiding and develop okra varieties with durable resistance/tolerance to BYVMV/ELCV/petiole bending virus followed by maintenance breeding. Counteract the new variability in the virus strains through sustainable breeding programmes by the collaborative partners.
(3). Systematic efforts should be made to collect and pool the available okra germplasm and identify the sources of stable resistance against YVMV, OELCV and petiole bending.	Pool okra germplasm available with NBPGR, SAUs, research institutions and private sector. Locate the sources of resistance/ tolerance of OKYVMV/OELCV and petiole bending virus/strains in commercial varieties, land races and related species of <i>Abelmoschus</i> by screening them at natural hot spots as well as under artificial condition in lab.
(4). Breeding efforts should be strengthened with the aid of robust molecular markers (SSRs, SNPs etc) in screening breeding populations.	IIHR , IIVR, NBPGR and Cooperating Agricultural Universities equipped with needed infrastructure will work on identification and validation of robust

	markers, gradual development of denser linkage maps and exploitation of these markers as an aid in screening sources of resistance and later breeding population
(5). Stable resistance in the identified sources may be used in interspecific hybridization, development of backcross population etc deploying molecular markers for ease and saving on time.	Develop pre-breeding lines resistant/tolerant to BYVMV/ELCV/Petiole bending virus individually or in combination using appropriate breeding programme with the aid of molecular markers.
(6). Resultant pre-breeding lines need to be shared among co-operating partners.	Share pre-breeding lines with single or multiple virus resistance to YVMV, OELCV/petiole bending virus among the collaborators for further breeding efforts.
(7). Study genetic basis of resistance/tolerance BYVMV/ELCV/Petiole bending strains and classify the genotype having strain specific and strain-non-specific resistance/tolerance	Study the cytology of the natural/induced amphidiploids being used in breeding programmes for their genetical and cytological stability. Keep in mind the ploidy level of okra material while studying the breeding behaviour, inheritance and heritability of the character(s).
(8). Study variation in strains of YVMV/OELCV/petiole bending virus, their pathogenicity in differential hosts of known genetic base. Similarly variation in the white fly biotypes needs to be studied for their efficiency in virus transmission.	Study the reaction of resistant gene(s) in hosts to various strains of YVMV/OELCV/Petiole bending virus. This will help breeders to identify major genes controlling known physiological basis of YVMV/OELCV/Petiole bending virus. This will also provide of tool to breeder by which they can identify new strains as they appear and hence rapidly determine steps to be taken in their control. It is imperative that a virologists and entomologists are closely involved in development of resistant varieties
(9). Develop strong teams for breeding stable resistant population to YVMV, OELCV and petiole bending under long term programme	It is essential that teams involving a cytogenetics/genetists, breeder, biotechnologist, virologist and entomologist need to be assembled in IIHR, IIVR and PAU for achieving the targeted goals.
(10). The breeding programme should be regularly monitored and progress assessed by backstopping team for mid-course corrections.	Besides regular monitoring, report writing and holding workshops etc, it is important that the okra group involved in the above programme may meet in alternate years to take stock of progress made and chalk out road map for next two years.

List of participants and involvement of different organizations in various activities are given in Annexures-I to VI.

ANNEXURE-I: LIST OF PARTICIPANTS

Public funded organizations

1. Dr. K.V. Bhat, NBPGR, New Delhi
2. Dr. M. Krishna Reddy, IIHR, Bangalore Hessarghatta
3. Dr. Randhir Kumar, Bihar Agril. University, Sabour, Bhagalpur
4. Dr. M. Pitchaimuthu, IIHR, Bangalore Hessarghatta
5. Dr. V Celia Chalam, NBPGR, New Delhi
6. Dr. K.V. Ravishankar, IIHR, Bangalore
7. Dr. V. Lakshmanan, TNAU, Coimbatore
8. Dr. D.P. Gohil, Anand Agril. University
9. Dr. Mamta Pathak, Asstt. Veg. Breeder, PAU, Ludhiana
10. Dr. K.K. Gangopadhyay, NBPGR, New Delhi
11. Dr. S.S. Solanki, Bihar Agril. University, Sabour, Bhagalpur
12. Dr. B.T. Patil, MPKV, Rahuri (M.S.)
13. Dr. M.N. Bhalaker, MPKV, Rahuri (M.S.)
14. Dr. A.T. Daunde, VNMKV, Parabhani (M.S.)
15. Dr. S. Harish, TNAU, Coimbatore
16. Dr. M. Thirupathi Reddy, Rajendra Nagar, Hyderabad
17. Dr. Joseph John K., NBPGR, R.S. Thrissur, Kerala
18. Dr. A.K. Naidu, JNKVV, Jabalpur (M.P.)
19. Dr. S.K. Mitra, Sr. Scientist, JNKVV, Jabalpur (M.P.)
20. Dr. Niranjan Senapati, OUAT, Bhubaneswar
21. Dr. L.L. Jivani, Junagadh Agril. University, Junagadh, Gujrat
22. Dr. R.R. Acharya, MVRS, AAU, Anand
23. Dr. P.K. Tiwari, C.S.A.U. Kanpur
24. Dr. R.K. Yadav, IARI, New Delhi
25. Dr. Dharendra Kumar Singh, G.B.P.U.A.T., Pantnagar
26. Dr. B. Singh, IIVR, Varanasi
27. Dr. Major Singh, IIVR, Varanasi
28. Dr. A.B. Rai, IIVR, Varanasi
29. Dr. SNS Chaurasia, IIVR, Varanasi
30. Dr. Hira Lal, IIVR, Varanasi
31. Dr. P.M. Singh, IIVR, Varanasi
32. Dr. N. Rai, IIVR, Varanasi
33. Dr. D. Ram, IIVR, Varanasi
34. Dr. S.K. Sanwal, IIVR, Varanasi
35. Dr. Rajesh Kumar, IIVR, Varanasi
36. Dr. H.C. Prassana, IIVR, Varanasi
37. Dr. Sudhakar Pandey, IIVR, Varanasi
38. Dr. B.K. Singh, IIVR, Varanasi
39. Dr. Shalaish Tiwari, IIVR, Varanasi
40. Dr. Pradeep Karmakar, IIVR, Varanasi
41. Dr. Ranjeet Gujjar, IIVR, Varanasi
42. Dr. Suresh Reddy, IIVR, Varanasi
43. Dr. Venket Ravanappa, IIVR, Varanasi
44. Dr. Jaydeep Halder, IIVR, Varanasi

Private sector

45. Dr. O.P. Dutta, Namdhari Seeds Pvt. Ltd., Bidadi Bangalore
46. Dr. C.S. Pathak, Nath Bio-Genes (L), Aurangabad
47. Dr. A.A. Deshpande, J.K. seeds, Bangalore
48. Dr. B.K. Tripathi, Nuziveedu seeds, Bangalore
49. Dr. Kiran Hegde, Chromos Seeds, Bangalore
50. Dr. Elangovam M, Advanta, Hyderabad
51. Dr. Mukesh Kumar Varshney, Metahelix Life Sciences Bangalore
52. Dr. Radha Anandlakshmi, MAHYCO, Jalna Maharashtra
53. Dr. C.S. Rao, Rasi Seeds, Bangalore
54. Dr. Vijay Bhan Singh, Nunhems India, Bangalore
55. Dr. Manoj S. Phalak, Ankur Seeds., Nagpur
56. Suresh Jadhav, Nath Bio-Genes (L), Aurangabad
57. Parag Agarwal, VNR Seeds., Raipur
58. Satish, Bioseed Research India, Hyderabad
59. Dr. George Thomas, MAHYCO, Jalana
60. B. Venkatalau, J.K. Seeds, Hyderabad
61. Rakesh Kumar, JK Seeds, Hyderabad
62. Asheesh Kumar Singh, Nuziveedu Seeds, New Delhi
63. Dr. K.V. Rao, Kaveri Seeds, Secunderabad
64. Dr. S.K. Sharma, Kaveri Seeds, Secunderabad
65. Sanjay Kumar, Nuziveedu Seeds, New Delhi
66. K. Tripathi, NSL, Lucknow
67. B.K. Sharma. NSL, Lucknow
68. Rajesh Mishra, Nath Seeds, Varanasi
69. Sarwade D.B. Bejo Sheetal Seeds, Jalna
70. Brijesh Singh, Bejo Sheetal Seeds, Varanasi
71. Pratikshit Rai, Bejo Sheetal Seeds, Varanasi

ANNEXURE-II: LIST OF PARTICIPATING AGENCIES WILLING TO POOL OKRA GERMPLASM FOR SCREENING TO BYVMV/ ELCV/ PETIOLE BENDING.

1. Indian Institute of Vegetable Research (IIVR), Varanasi
2. Indian Institute of Horticultural Research (IIHR), Bangluru
3. BCKV, Kalyani
4. PAU, Ludhiana
5. TNAU, Coimbatore
6. MAU, Parbhani
7. JK seeds,
8. Ankur Seeds,
9. Bio-Seeds,
10. MAHYCO,
11. Nath Royal Seeds,
12. Namdhari Seeds

ANNEXURE-III: LIST OF HOT SPOTS AND PARTICIPATING AGENCIES FOR SCREENING OKRA GERMPASM AGAINST DIFFERENT VIRUSES

1. Indian Institute of Vegetable Research (IIVR), Varanasi
2. Indian Institute of Horticultural Research (IIHR), Bangluru will screen at Guntur
3. BCKV, Kalyani
4. PAU, Ludhiana
5. TNAU, Coimbatore
6. MAU, Parbhani
7. GAU, Anand

ANNEXURE-IV: LIST OF PARTICIPATING AGENCIES INVOLVED IN VIRUS SCREENING WORK IN OKRA UNDER ARTIFICIAL DISEASE EPIPHYTOTIC CONDITIONS IN A LABORATORY.

1. Indian Institute of Vegetable Research (IIVR), Varanasi
2. Indian Institute of Horticultural Research (IIHR), Bangluru BCKV, Kalyani
3. PAU, Ludhiana
4. BCKV, Kalyani

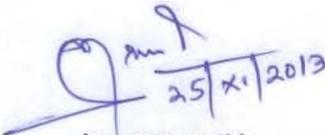
ANNEXURE-V: LIST OF PARTICIPATING AGENCIES INVOLVED IN DIFFERENT ACTIVITIES.

1. Breeding work (IIVR, IIHR, PAU Ludhiana)
2. Cytogenetical studies (IIVR, IIHR, PAU Ludhiana)
3. Molecular marker development (IIVR, IIHR)
4. Study of strainal variation (IIVR, IIHR)
5. Pathogenicity & development of differential hosts (IIVR, IIHR)
6. Identification of biotypes in whitefly population (IIVR, IIHR)

ANNEXURE-VI: PROGRESS ASSESSMENT AND BACK STOP MONITORING TEAM

1. Dr. N.K. Krishan Kumar, DDG (Horticulture), ICAR, New Delhi: Chairman
2. Dr. Suresh Malhotra, ADG (Horticulture-II), ICAR, New Delhi
3. Director IIHR, Bangluru
4. Director IIVR, Varanasi
5. Dr. S.K. Sanwal, Sr. Scientist, IIVR, Varanasi (Member Secretary)

This issue with the approval of Deputy Director General (Horticulture), ICAR, New Delhi.


25/11/2013

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