

Resistance to Yellow Vein Mosaic Virus and Okra Enation Leaf Curl Virus: challenges and future strategies*

Okra (*Abelmoschus esculentus* L.) or lady's finger is considered as an important vegetable crop of the tropical and subtropical regions of the world. It is popular in India, Nigeria, Pakistan, Cameroon, Iraq and Ghana. Though it is virtually not grown in Europe and North America, many people in these countries have now started eating this vegetable because of its nutritional composition with respect to vitamin A, folic acid, carbohydrates, phosphorus, magnesium and potassium.

India ranks first in the world with a production of 5.784 mt (72% of the total world production) of okra from over 0.498 mha land. Okra is available in India throughout the year and its production can be tailored according to the demand. After onion, okra has the major share in revenue generation through export of fresh vegetables. There are no separate data on export of okra, as its export figures are included in mixed vegetables. During 2012–13, the country had exported 0.768627 mt of fresh vegetables (other than onion) amounting to INR 15,160 million.

The crop is prone to damage by various insects, fungi, nematodes and viruses. Its cultivation in India is challenged by severe incidence of viral diseases, viz. Yellow Vein Mosaic Virus (YVMV) disease and Okra Enation Leaf Curl Virus (OELCV) disease, spread by an insect vector, namely whitefly (*Bemisia tabaci* Gen).

YVMV belongs to the genus *Begomovirus*, family Geminiviridae. Recently, it was found that at least 27 begomoviruses infect okra. Begomoviruses have high recombination rate and the emergence of 'B' biotype whiteflies is contributing to epidemics of begomoviruses in okra. The YVMV disease is characterized by a homogenous interwoven network of yellow vein enclosing islands of green tissues within the leaf. In extreme cases, infected leaves become completely yellowish or creamy. If plants are infected

within 20 days after germination, their growth is retarded with few leaves and malformed fruits resulting in loss ranging from 94% to 100%. The extent of damage declines with delay in infection of the plants. A loss of 49–84% has been reported when infection occurred after 50–65 days of germination.

Okra Enation Leaf Curl Virus (OELCV) disease is serious in North India. Initial symptoms of this disease include small, pin-headed enations on leaves, leaf curling, followed by warty and rough texture of the leaves. The undersurface of the leaves is characterized by mild, bold and prominent enations. There is twisting of main stem, lateral branches and leaf petiole. The leaves become thick and leathery. Leaf curling and enations are more prominent in middle-aged leaves. In severe cases, there are enations, leaf thickening and curling even in the young leaves. At times, the twisting and bending of the stem are so severe that the entire plant seems spreading on the soil surface. The infected plants either do not produce fruits or produce few deformed and small fruits unfit for marketing and consumption. The yield loss varies from 30% to 100% depending upon the age of the plant at the time of infection.

These viruses are neither sap-transmissible nor seed-transmitted. The natural transmission is through whitefly in a semi-persistent manner. The minimum number of whiteflies required to induce 100% infection is 10/plant, although a single whitefly can transmit the YVMV effectively. The female whiteflies are more efficient than the male whiteflies in transmitting the virus. Emergence of the polyphagous 'B' biotype of *B. tabaci* with its increased host range of more than 600 plant species, has resulted in Gemini viruses infecting previously unaffected crops. The 'B' biotype has the capacity to transfer the viruses at a fast rate.

A number of institutes of the Indian Council of Agricultural Research (ICAR), State Agricultural Universities (SAUs) and private seed companies are working on various aspects of genetic improve-

ment of okra in order to develop high-yielding and disease-resistant varieties. Through intensive research efforts more than 50 improved varieties and hybrids have been released. Some of these have already made significant impact/contribution in revolutionizing the production of okra in the country. However, 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 the above problems, a brainstorming on okra was recently organized. About 80 participants comprising researchers from different ICAR institutes, SAUs and representatives from the private sector participated in the deliberations.

The brainstorming on okra was inaugurated by N. K. Krishna Kumar (Deputy Director General (Horticulture), ICAR, New Delhi), who highlighted the importance of management of YVMV and OELCV in okra production in the country. He informed 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 the presence of early instar larvae of *Helicoverpa armigera*. Neonictinoid insecticides, viz. imidacloprid and thiomethoxam are causing colony collapse disorder in honey bees. So their uses are restricted in the European Union (EU). He stressed upon the detailed study on biotypes of *B. tabaci* and biotype-specific insecticide-resistance management (IRM). The blisters on okra fruits are caused due to jassid infestation. He requested the okra group to take stock of the national scenario and chalk out strategies to overcome these challenges.

The deliberations were under three themes, viz. (i) advances in virus-resistant breeding and wild species of okra; (ii) marker-assisted selection, and (iii) emerging viruses of okra. During the presentation, it was observed that the frequent breakdown of YVMV resistance may be due to pathogenic variability, or symptomless carriers and emergence of the

*A report on the brainstorming on okra held at Indian Institute of Vegetable Research, Varanasi on 28 September 2013.

polyphagous 'B' biotype of *B. tabaci* with its increased host range. Sequence analysis of the DNA-A component from YVMV isolates in India revealed that 80% of the isolates aligned into a common cluster. Virus isolates from Gujarat were highly distinct and aligned into two distinct clusters. The YVMV isolates collected from plants having enation like symptoms were nearly identical (95.5%) with Cotton Leaf Curl Gemini Virus and isolates with stem bending symptoms fell into distinct species. Rest of the isolates were identical to common Tomato Leaf Curl Virus. Host genetic resistance to viruses is one of the most practical, economical and environment-friendly strategies for reducing yield loss in okra. The occurrence of YVMV is severe in certain locations in certain seasons and accordingly screening of breeding populations is required to be done in these hotspot areas.

All the participating institutions both in public and private sector involved in breeding okra varieties/hybrids using existing known sources of resistance/tolerance to YVMV/OELCV should work in collaboration and prepare themselves for replenishing/replacing tolerant 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.

Simultaneously, attempts should also be made to incorporate broad spectrum resistance through gene pyramiding and develop okra varieties with durable resistance/tolerance to YVMV/OELCV followed by maintenance breeding. During the discussion, it was also felt that studies should be carried out on the reaction of resistant gene(s) in hosts to various strains of YVMV/OELCV resistance. This will help breeders identify major

genes controlling known physiological basis of resistance to YVMV/OELCV. It will also provide a tool to the breeders by which they can identify new strains as they appear and hence rapidly determine steps to be taken for their control.

There is no stable source of resistance to the above diseases in cultivated species. Some of the wild species of okra have stable and reliable sources of resistance to YVMV and OELCV. However, the transfer of resistance from wild relatives has been hampered by sterility problems and it is difficult to produce subsequent generations or even carry out backcrosses. So, systematic efforts should be made to collect and pool the okra germplasm available with the National Bureau of Plant Genetic Resources (NBPGR; New Delhi), SAUs, research institutions and private sector. It is all the more necessary to locate the sources of resistance/tolerance of YVMV/OELCV in these genetic resources, commercial varieties, land races and related species of *Abelmoschus* by screening them in natural hotspots as well as under artificial conditions in the laboratory. It is now being realized that cytology of the natural/induced amphidiploids being used in breeding programmes needs to be studied for their genetic and cytological stability. The ploidy level of okra material also needs to be considered while studying the breeding behaviour, inheritance and heritability of the character(s).

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 in okra due to the large number of chromosomes (varying from 56 to 196) and generally plant genome is polyploidy. The genome size of okra is 16,000 mb, having 65 linkage groups. Presence of 65 linkage groups makes okra a tough genetic system. Institutions

like the Indian Institute of Vegetable Research (IIVR), Varanasi; Indian Institute of Horticultural Research (IIHR), Bengaluru; NBPGR and Cooperating Agricultural Universities equipped with the needed infrastructure should 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 their utilization to develop breeding population.

In the plenary session an action plan was chalked out for detailed studies on these dreaded diseases of okra. It was decided that basic research will be carried out by IIVR and IIHR. The screening will be done in identified hotspot areas (Uttar Pradesh, Punjab, Haryana, Andhra Pradesh, West Bengal, Odisha, Gujarat, Madhya Pradesh and Tamil Nadu). Teams involving a cytogenetic/geneticist, breeder, biotechnologist, virologist and entomologist need to be assembled in IIHR, IIVR and Punjab Agricultural University for achieving the targetted goals. In addition to regular monitoring, report writing and holding workshops, it is important that the okra group involved in the above programme should meet during alternate years to take stock of the progress made and chalk out a road map for the next two years.

The outcome of this four-year study is expected to provide superior pre-breeding lines/hybrids resistant to YVMV and OELCV, identification of new sources of resistance, elucidation of genetic relationships within and among species, molecular markers linked to resistance genes, characterization of viruses infecting wild species and virus-vector relationship.

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