

Promotion and impact assessment of tomatoes resistant to tomato leaf curl virus disease

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John Colvin
*Natural Resources Institute,
 University of Greenwich, UK*
 Venkataramappa Muniyappa
*University of Agricultural Sciences
 Bangalore (UASB), India*
 H. Ramaiah
National Seed Project, India
 P. Hanson
*South Asian Vegetable Research
 Network (managed by The World
 Vegetable Center, AVRDC) and
 CGIAR Tropical Whitefly IPM Project
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Whitefly (*Bemisia tabaci*) and tomato leaf curl virus disease (ToLCVD) currently cause huge economic losses in most tropical and subtropical regions of the world. Building on previous strategic work in India that developed three open-pollinated (true-breeding) ToLCVD-resistant tomato varieties, this applied project aimed to create a significant developmental impact by creating new mechanisms and partnerships for the sustainable delivery of research products to farmers. The team did this by first obtaining official authorisation to release these new resistant varieties, and then promoting and disseminating them through novel funding mechanisms or licence agreements. The three ToLCVD-resistant varieties were released successfully and notified in the *Gazette of India* for use throughout the country. Negotiations with commercial vegetable seed producers led to 16 taking up the rights, on a non-exclusive basis, to multiply and distribute the varieties and/or to use them as parental material to develop ToLCVD-resistant hybrids. Data have been collected and published on the performance of the varieties in different Indian states, and on the different ToLCV species and *B. tabaci* populations present in those locations. Impact assessment data showed that farmers could obtain up to 10 times the profits they used to achieve growing ToLCVD-susceptible open-pollinated varieties, and that they used the extra income to improve nutrition, children's education and health. To ensure sustainability, a revolving fund has been set up by the National Seed Project of UASB, where receipts from seed sales through various outlets are used to produce replacement seed that, in turn, will be sold.

ISSUES

After China, India is the world's second largest vegetable producer, with 5.5 million hectares of land under vegetable crops. Production in India is limited by losses caused by insect pests and diseases to the extent that the *per capita* consumption of vegetables is only 25–33% of the daily minimum requirement. Over the previous

two decades, whiteflies have been gaining worldwide prominence as important crop pests, causing direct and indirect losses through phloem feeding, excretion of honeydew and transmission of viruses. As part of a response to the problem in tomatoes, the UASB screened 1306 *Lycopersicon* genotypes for resistance to ToLCV, with the long-term objective of introducing ToLCV-resistance genes into edible



Vybhav (left) and a ToLCV-resistant hybrid developed from it (right) by the commercial company Namdhari Seeds



The tomato crop was severely infected with ToLCV in the 1999 epidemic season at Kaparasiddanahalli, Kolar taluk – this farmer is ploughing in the tomato crop without harvesting a single fruit

tomatoes through conventional plant-breeding techniques. AVRDC provided the project with tomato germplasm that could be screened to identify the best sources of resistance to ToLCVD in southern India.

Earlier farmer-participatory trials (R6627) identified the ToLCVD-resistant varieties TLB111, TLB130 and TLB182. The poorer farmers usually grow open-pollinated tomato varieties as they can keep their own seed, although they recognise that yields are lower than the relatively expensive hybrid varieties. In the past, the varieties available to them have had no ToLCV resistance, so tomato production involved particularly high financial risks in the ToLCV-epidemic season, often resulting in complete crop failure and loss of capital invested in the crop. The new varieties have the following benefits.

- Greater than 100% increase in yields compared with susceptible varieties in the presence of ToLCV disease, and on-farm trial benefit-to-cost ratios as high as 6.6 to 1.

- A 50–75% reduction in use of insecticides for control of whiteflies and geminiviruses, with consequent assumed environmental and consumer health benefits.
- Increased tomato production during ToLCVD-epidemic periods, leading to reduced seasonality of tomato supply and lower prices for consumers.
- Lower production costs and higher productivity, leading to higher income for farmers and other stakeholders involved in the supply chain.
- Reduced risk of crop losses from ToLCVD may encourage more poor farmers to grow tomatoes.
- Improved understanding of disease epidemiology, which has already led to the design of rational and environmentally friendly management techniques.
- Increased understanding and improved awareness of whiteflies and ToLCV among stakeholders and the general public.
- Facilitation of ToLCV-resistant hybrid development by the private sector.

These varieties have the potential to reach millions of tomato producers in India, including the poorer farmers, and to have a major impact. The current project aimed to fulfil that potential through making ToLCV-resistant hybrids available to farmers through both the public- and private-sector routes.

ACHIEVEMENTS

This project carried forward earlier assessment of whitefly and ToLCV diversity, identification of sources of resistance, and productive collaboration with AVRDC and Indian national agricultural research systems to develop productive, farmer-preferred, disease-resistant tomato varieties.

Three tomato varieties, Sankranthi, Nandi and Vybhav, have been released and assigned national identity numbers (IC 296388, IC 296389, IC 296390). Official notification of variety names was published in the *Gazette of India*, signifying that they can be used throughout India.

The UASB Technology Transfer Committee carried out negotiations with 10 vegetable seed companies, all of which have purchased breeder-quality seed from UASB. The varieties were grown by the companies in several additional states, including Himachal Pradesh (northern India) and Nagpur (central India), as part of their rigorous multi-locational trial procedure. Nine of the companies stated that the tomatoes did not show any ToLCVD symptoms. From molecular analysis of samples of ToLCV-infected tomato plants, weeds and *Bemisia tabaci* populations, the non-indigenous B biotype of *B. tabaci* was identified in Kolar and Nagamangala in Karnataka, and several locations in Gujarat. This supports previous predictions that its distribution within India would expand.

Analysis of the coat protein DNA sequence data for the viruses found in plants with leaf curl symptoms showed that there are five different ToLCV groups in India. ToLCVs were detected in alternative hosts including chilli,

cowpea, okra and tobacco, as well as the weeds *Croton* sp., *Parthenium* sp. and *Malvastrum* sp. Papaya leaf curl virus and pepper leaf curl Bangladesh virus were also detected in tomato for the first time. At least two completely new ToLCV species were identified. Colonies of three *B. tabaci* populations from eggplant, collected from Rannibenur, Coimbatore and Belgaum, and a population from the weed *Euphorbia geniculata*, collected from Bangalore, were established. The CO1 gene sequences of the Rannibenur, Coimbatore and Bangalore populations were obtained and fitted into previously identified population clusters. The reciprocal crosses were carried out.

Regions were identified in Karnataka and Andhra Pradesh where open-pollinated tomato varieties are widely grown. More than 90 farmers were visited and socio-economic data collected from them. As an additional activity, a small group of 20 farmers was given the ToLCV-resistant tomato seed. These seeds were monitored

closely and compared with another group in the same area, growing the traditional ToLCV-susceptible varieties. A comparison of the benefits/costs showed that those growing the project's tomatoes made up to 10 times more profit than those growing ToLCV-susceptible open-pollinated varieties.

Links were also maintained with the private seed companies that purchased the project's ToLCV-resistant lines, in order to collect impact data. Companies such as Namdhari, Cee Kay and Ankur Seeds are making rapid progress towards producing ToLCV-resistant hybrid varieties with a project variety as one of the parents.

A policy briefing paper, 'Countering the whitefly and plant-virus disease threat to sustainable livelihoods in India', will be handed out to the appropriate participants at the project workshop, which is to be held during the extension period in 2005. Project staff provided information on best cultivation practices and prepared a single-sheet pamphlet, written in Kannada, the local language



Open-pollinated tomato fruits at market at Kappalamadugu, Mulbagil taluk, Kolar District, Karnataka



Krishimela, an annual agricultural fair attended by 25,000–30,000 farmers from southern districts of Karnataka, is organised by the UASB to exhibit technologies developed by the university to farmers: here men and women farmers view a check-plot of ToLCV-susceptible tomato showing severe disease symptoms

of Karnataka. This described the resistant tomato varieties' characteristics, their high yield potential, low production costs, and the significant advantage that they can be grown without insecticides, which are normally sprayed intensively on susceptible tomato varieties to protect them from *B. tabaci* and ToLCVD. Press articles and radio and TV programmes have been released on the project's outputs, and a project website (www.tomatoleafcurlandwhitefly.org) has been established by UASB to disseminate the results, achievements and lessons learned.

The involvement of the private sector in producing ToLCV-resistant hybrids is likely to create enormous impact among better-off tomato growers, which will in turn benefit poorer urban consumers who need cheap sources of nutritious vegetables. To ensure that the poorest growers will be able to access resistant open-pollinated

varieties, a revolving fund has been set up by the National Seed Project of UASB. Fifty thousand seed pouches have been produced for the sale of ToLCV-resistant tomato varieties, and the UASB has conducted two field days and two training programmes at Mandya and Nagamangala taluks. Due to these promotional efforts, the total quantity of seeds sold so far is around 6 kg, and demand is increasing.

FURTHER APPLICATION

The project has the potential to generate enormous impact throughout India, as well as in Africa, the Caribbean and Asia. Links made with 10 private seed companies in India to develop ToLCV-resistant hybrids should have a significant impact in two to three years' time, even if only 30–50% of these companies succeed. Working with 10 companies rather than one will create competition

in the marketplace and stimulate farmer demand for quality seed – good for the seed industry as a whole, and for producers and consumers as it should result in lower seed and product prices. Sixty per cent of the area under tomato production in India involves open-pollinated varieties grown by the poorest farmers – responding to this demand has provided more scope for wider and facilitated dissemination to more farmers.

In order to maximise impact, a nine-month extension phase (R8425) took place in 2005 with activities aimed at promoting the uptake and sustainable adoption of the technologies and ToLCV-management practices with poorer growers. If successful, this will ensure that tomatoes can be grown successfully, even in the peak of the ToLCV-epidemic season, with greatly reduced insecticide use and associated benefits for farmers, consumers and the environment.