CROP PROTECTION PROGRAMME

Project Title: Sustainable impact generation and technology promotion to manage *B. tabaci* and tomato leaf curl virus disease amongst the poorest South Indian tomato growers

R No 8425 (ZA 0546)

FINAL TECHNICAL REPORT

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Executive Summary

The whitefly, *Bemisia tabaci* (Gennadius), and tomato leaf curl virus disease (ToLCVD) currently cause huge economic losses in most tropical and sub-tropical regions of the world. In response to the demand for a solution to this "burning problem" in India, previous phases of this project developed three open-pollinated (OP = true breeding) ToLCVD-resistant tomato varieties, as well as alternative management practices to the intensive use of pesticides. These new technologies and practices were designed to enable tomatoes to be grown with greatly reduced input costs and without the use of insecticides and, therefore, they directly benefit the poorest farmers, consumers and the environment. A conservative estimate suggests that within the next year in South India alone, the project's varieties or hybrids developed from them will be grown by more than 55,000 farmers.

For the period covered in this report, the pathways and mechanisms that generate significant impact amongst the different categories of tomato growers were established and nurtured and the activities were designed to create substantial 'added value' for all of the stakeholders by promoting the uptake and adoption in a sustainable manner of the project's proven research technologies.

The University of Agricultural Sciences' (UASB) Directorate of Extension (DoE) and the National Seed Project (NSP) promoted and disseminated the project's management practices and technologies to the poorest OP tomato growers. The 'revolving fund' for seed sale and production began to operate and links were established with Krishi Vigna Kendras (KVKs = Agricultural Science & Information Centres), to market and promote the ToLCV-resistant tomato varieties amongst the poorest farmers.

Three peer-reviewed scientific publications were produced and *Lycopersicon hirsutum* LA1777 introgression lines were screened to assess their resistance to the B-biotype of *B. tabaci*.

At the project workshop, held on 16-17 January 2006 and attended by the Minister for Horticulture, the project website was launched. The following project outputs were also released officially and disseminated to the workshop participants: a farmer training multimedia CD, an IPM leaflet, a leaflet on growing the ToLCV-resistant varieties, a leaflet on value addition and a policy document.

Background

Tomato leaf curl virus (ToLCV) and its whitefly vector, *Bemisia tabaci* (Genn.), are two of the most serious constraints to tomato production in India. Farmers consider these problems to be of "burning" importance and they have attempted previously to manage them with the only tool available to them - intensive and widespread use of insecticides (Nagaraju *et al*., 2002).

In August 2000, the situation in South India deteriorated significantly with the arrival of the highly destructive B-biotype of *B. tabaci* (Banks *et al*., 2001). This whitefly is highly resistant to a wide range of insecticides and includes tomato as one of its most preferred host-plant species. The high populations of the B-biotype resulted in the rapid spread of ToLCV disease into tomato nurseries and the subsequent failure of the tomato crop in a major vegetable growing area of South India (Banks *et al*., 2001; Colvin *et al*., 2002). The B-biotype is currently continuing to spread throughout India and has been associated with the emergence of new plant-viral disease epidemics in okra, pumpkin, potato and beans.

In response to the pressing demand for a solution to this problem, earlier phases of this project developed and tested various new technologies and alternative management practices to insecticides (Colvin *et al*., 2003), focussing eventually on the development, through farmer-participatory breeding, of three ToLCV-resistant open pollinated (OP) tomato varieties, Sankranthi, Nandi and Vybhav (Muniyappa *et*

al., 2002). These are high yielding and highly resistant to ToLCV. They performed extremely well, therefore, even under the ToLCV-epidemic conditions caused by the arrival of the B-biotype. These varieties were released officially in the third phase of the project and breeder seed has been purchased by sixteen private seed companies, who are currently using it in their breeding programmes to produce ToLCV-resistant tomato hybrids. A conservative estimate suggests that within the next two years, hybrids developed from our varieties will be grown by more than 55,000 South Indian farmers (Dr Anand, Namdhari Seeds, pers. comm.). A recent survey of 75 tomato farmers, carried out by the project staff, showed that the increased income from growing ToLCV-resistant tomatoes is spent on an improved diet, children's education and health. The current phase of the project has activities aimed at monitoring and assessing the impact on these and other aspects of the lives of farming families.

The creation of a positive impact in the family lives of the poorest tomato growers, however, will not be possible through the production of ToLCV-resistant hybrid tomatoes alone, as this category of grower prefers OP varieties, which have lower input costs and thus reduced financial risk. The third phase of the project, therefore, initiated activities aimed at promoting the uptake and sustainable adoption of our technologies and ToLCV-management practices, with these poorer growers. The widespread adoption of the project's outputs 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 to the poorest farmers, consumers and the environment. The activities reported here aimed to facilitate that process and provide added, sustainable value, which would build directly on previous research and promotional achievements.

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Project Purpose

Promotion of pro-poor strategies to reduce the impact of key pests, improve yield and quality of crops, and reduce pesticide hazards in peri-urban systems.

Improved methods for the management of insect pests of fruit and vegetables, particularly whitefly and spider mites, developed and promoted

Research Activities & Outputs

1. ***Output:*** *Impact monitoring and assessment data available, which will be collected from tomato growers, extension workers, the National Seed Project, NGOs, KVKs, private seed companies and the AVRDC.* **Activity:** The impact on the poorest farmers' families, of growing the ToLCV-resistant varieties, will be monitored using the previously approved protocols and survey format. In addition, links will be established and our technology promoted with NGOs and KVKs, who work with the poorest tomato growers. Promotion activities will be organised using exhibition materials and data will be collected on the increasing demand for seed. Visits by project staff will continue to be made to the seed companies that purchased the project's varieties in order to obtain impact-data on hybrid production and marketing.

Outcome: Impact monitoring activities were carried out as planned and the data are included in the draft socio-economic publication detailed in Output 3. Seed of these varieties has now been distributed to 14 institutes in thirteen different countries. Within India, breeder seed has now been purchased by 16 commercial seed companies. Seed has also been distributed through the NGO, Gram Vikas Samstha (GVS), Madanapalli, as well as the Agricultural Technology Information Center (ATIC), Hebbal, the National Seed Project (NSP), GKVK, and Krishi Vigyan Kendra (KVK), Kandli. Visits by project staff were made to the following seed companies: Namdhari Seeds Pvt. Ltd., Cee Kay Seeds and Seedlings, Zuari Seeds and ECL Agrotech to monitor the performance of the project's varieties. As part of the World Food Day, over 500 farmwomen, farmers and panchayat members took part in a programme where the ToLCV-resistant tomato varieties were displayed along with 'value-added' products that can be made from them.

2. ***Output:*** *Multimedia CD in Kannada and English available describing the project's innovative approach, research achievements and impact.* **Activity:** The project has historical video footage, which will be used with new material of private company managers and breeders as well as policy makers endorsing the achievements and innovations of the project and documenting the successful commercialisation of ToLCV-resistant hybrids. A version will be made in Kannada, aimed at farmers and a second one in English will have research scientists involved in development, policy makers and donors as the target audience.

Outcome: A multimedia video CD has been produced in Kannada, which was released officially at the project's workshop (CD enclosed).

A video documentary, "Sustainable Management of Tomato Leaf Curl Virus and Whitefly on Tomato in India" (V. Muniyappa, K.T. Rangaswamy, N. Nagaraju and J. Colvin, eds). Produced by Utham Infotech, Bangalore.

Video footage shot at the workshop will be included in a shorter English version (5 min duration). It is intended that this will be available by the end of February 2006.

3. ***Output:*** *Socio-economic publication containing survey data and detailing the impact created by the project's technologies.* **Activity:** In the current phase and the extension period, the project will have collected sufficient data to produce a peer-reviewed scientific publication documenting the project's current and potential impact, as well as the lessons learnt. This will include data particularly on the impact in the livelihoods of the lowest income farmers, in relation to the Millennium Development Goals.

Outcome: A draft paper called, "Lessons learnt from the Socio-economic Impact Monitoring of a Scientific Project Oriented towards Poverty Lessening through the Development of Three Open-pollinated Seed Varieties Resistant to Tomato Leaf Curl Virus (ToLCV) in South India", has been written and will be submitted to an appropriate journal by mid March 2006 (Annex I).

Some of the socio-economic data will also be published in the following PhD thesis:

MANJUNATHA REDDY, T.B. (2006). Impact assessment of ToLCV resistant varieties and distribution pattern of B biotype *Bemisia tabaci* and tomato leaf curl virus in different agro climatic regions. PhD Thesis, University of Agricultural Sciences, Bangalore, India.

4. ***Output:*** *Vector entomology publication describing the spread of the B-biotype, its association with severe ToLCV disease and other emerging vegetable-virus epidemics.* **Activity:** In the previous and the current phase of the project, we have collected molecular evidence documenting the spread of the B-biotype and the associated increased severity of the ToLCV disease epidemics. There are also increasingly numerous reports of higher *B. tabaci* populations and associated plant-virus epidemics in other vegetable crops. Molecular data will be collected to characterise the whitefly biotypes and viruses responsible for these epidemics. These data will be combined with data collected in the previous phase and a scientific paper will be written on the spread of the B-biotype and associated vegetable-virus epidemics in South India.

Outcome: This output was produced successfully (Annex II).

REKHA, A.R., MARUTHI, M.N., MUNIYAPPA, V. & COLVIN, J. (2005) Occurrence of three genotypic clusters of *Bemisia tabaci* (Gennadius) and the rapid spread of the B-biotype in South India. *Entomologia Experimentalis et Applicata*, **117**, 221-233.

5. ***Output:*** *Resistance screening data for the response of Lycopersicon hirsutum LA1777 introgression lines to the B-biotype of B. tabaci.* **Activity:** Tomato is a highly preferred host plant of the B-biotype. Even low populations cause irregular ripening of the fruit and rapid ToLCV spread. There is therefore an immediate need to address this problem and also a longer-term strategic reason, which is that the incorporation of resistance to the B biotype in tomatoes should help to conserve ToLCV-resistance, which is a non-renewable and valuable resource. Preliminary screening work has shown that certain *L. hirsutum* lines have very high levels of

resistance to the indigenous population of *B. tabaci*. The UASB has a proven methodology for rigorously screening tomato genotypes both in the laboratory and field (Muniyappa *et al*., 2002; see also activities in phases I & II) and at least 15 new lines will be assessed in this extension period. The private seed companies and the UASB Dept. of Plant Breeding & Genetics will be involved in this activity from the beginning, which will ensure that lines identified with resistance will be incorporated into breeding programmes and will reach farmers quickly.

Outcome: Recombinant inbred tomato lines (RILs) were screened for whitefly resistance. The RILs LA3914, LA3920, LA 3921, LA 3923 and LA 3927 were identified as particularly promising with respect to resistance against the B biotype of *Bemisia tabaci* (Annex III). At the project workshop, the seed company representatives were unanimous in their support for this type of basic research, because they realise the need to make the existing resistance more sustainable and pyramiding whitefly resistance genes into the project's varieties may help achieve this.

6. ***Output:*** *Proceedings of the workshop held to promote the project's achievements with senior policy makers concerned with agriculture.* **Activity:** All stakeholders will be invited to attend a final promotional workshop, which will provide an important opportunity to highlight the project's achievements with senior policy makers concerned with agriculture. The policy document, multimedia CDs, ToLCV-management leaflet and other promotional material will be distributed during the workshop.

Outcome: The project's workshop was held on the 16th and 17th of January 2006 and was inaugurated by the Minister for Horticulture, Sri R. Srinivas (Annex IV). The workshop was reported in five Indian papers; The Deccan Herald, Eesanje, Prajavani, Vijaya Karnataka and Vijay Times (Annex V).

Breeders and senior management from 23 seed companies, Scientists from IIHR and UASB, NGOs and KVK representatives, and more than 350 tomato growers attended the workshop. The following promotional material was released: multimedia CD, leaflet on IPM, leaflet on the ToLCV-resistant tomato varieties, leaflet on creating 'value addition' to the ToLCV-resistant tomatoes and the project's policy document. In addition, the project's web site (CD enclosed) was launched officially at the address: http://www.tomatoleafcurlandwhitefly.org/

Add-on. ***Output:*** *Data analysis and publishing two scientific papers.*

Outcome: These outputs were successfully produced. One paper is in press (Annex VI) and the other has been published (Annex VII).

1. COLVIN, J., OMONGO, C.A., GOVINDAPPA, M.R., STEVENSON, P.C., MARUTHI, M.N., GIBSON, G., SEAL, S.E. & MUNIYAPPA, V. (2006) ~~Mechanisms driving the spread of some vector-borne plant virus disease epidemics: eH~~ffects ~~of h~~ost-plant viral infection effects on arthropod-vector population growth, development and behaviour: management and epidemiological implications. *Advances in Virus Research*, in press.

2. RAJESHWARI, R., CHOWDA REDDY, R.V., MARUTHI, M.N., COLVIN, J., SEAL, S.E. & MUNIYAPPA, V. (2005) Host range, vector relationships and

sequence comparison of a begomovirus infecting hibiscus in India. *Annals of Applied Biology*, **147**, 15-25.

An article also appeared on the ToLCV-resistant varieties in the University of Agricultural Sciences "Profile" magazine.

Contribution of Outputs to developmental impact

How is the knowledge promoted benefiting the poor? The knowledge, technology and outputs are being promoted through the variety of channels detailed above.

What coverage has been achieved (numbers of farmers, institutions and production areas adopting the technology). Seed of these varieties has now been distributed to 14 institutes in thirteen different countries. Within India, breeder seed has now been purchased by 16 commercial seed companies and is being used in their hybrid breeding programmes. Several companies are in the process of releasing the first ToLCV-resistant hybrids to the market. Seed has also been distributed to the poorer farmers through the NGO Gram Vikas Samstha (GVS), Madanapalli, as well as the Agricultural Technology Information Center (ATIC), Hebbal, National Seed Project (NSP), GKVK and Krishi Vigyan Kendra (KVK), Kandli. A conservative estimate suggests that within the next year in South India alone, hybrids developed from our varieties will be grown by more than 55,000 farmers.

What is the potential for wider scale impact. There is considerable scope for wider scale and more diversified impact, particularly amongst the poorer farmers and the women of farming families in India. This could be achieved through a "Research into Use" project aimed at helping the poorer farmers achieve added value to the tomato crop. Tomatoes naturally have a short shelf life and in order to reduce the risk of growing them even more, products such as sun-dried tomatoes, tomato juice and pastes could be produced through micro-financed women's groups. Farmers can already increase their income from tomatoes by approximately 10-fold, when growing the project's varieties and 'value addition' activities would increase this still further.

What follow up action/research is necessary to promote the findings of the work to achieve their development benefit? There remain a significant number of activities that could be carried out to achieve greater developmental benefit. These are:

- Contribute to the global demand for research in this area by establishing an All India Coordinated Research Project on the B biotype of *Bemisia tabaci* and associated plant-virus disease epidemics.
- Focus research on integrated pest management technologies developed to protect ToLCV resistance, which is a non-renewable resource.
- Target research and development funds at low cost 'embedded' technologies that reduce both input costs and the financial risks posed by extreme price fluctuations.
- Greater emphasis on the provision of nutritional security, which can be provided by improved tomato and other 'thrust' vegetable production.
- Increase farmer awareness of the advantages of growing disease-resistant tomatoes and other vegetable crops.
- Vegetable grower skill empowerment through training in the latest integrated pest and disease management practices and technologies.
- Encourage the setting up of intermediate-technology tomato and vegetable seedling production nurseries.
- Promote judicious insecticide use, with associated benefits to the environment and human health.

- Stimulate processing and value addition activities to cope with the enhanced productivity.

Biometricians Signature

The projects named biometrician must sign off the Final Technical Report before it is submitted to CPP. This can either be done by the projects named biometrician signing in the space provided below, or by a letter or email from the named biometrician accompanying the Final Technical Report submitted to CPP. (Please note that NR International reserves the right to retain the final quarter's payment pending NR International's receipt and approval of the Final Technical Report, duly signed by the project's biometrician).

This FTR does not contain any statistical analyses that have not already been through the peer-review process required prior to the publication of scientific papers. I have therefore submitted this FTR in order to meet the deadline and will forward a covering letter from the project's named biometrician (Mrs F. Jolliffe) within the next week.

I confirm that the biometric issues have been adequately addressed in the Final Technical Report:

Signature:
Name (typed):
Position:
Date:

ANNEX I

ANNEX II

ANNEX III

ANNEX IV

ANNEX V

ANNEX VI

ANNEX VII