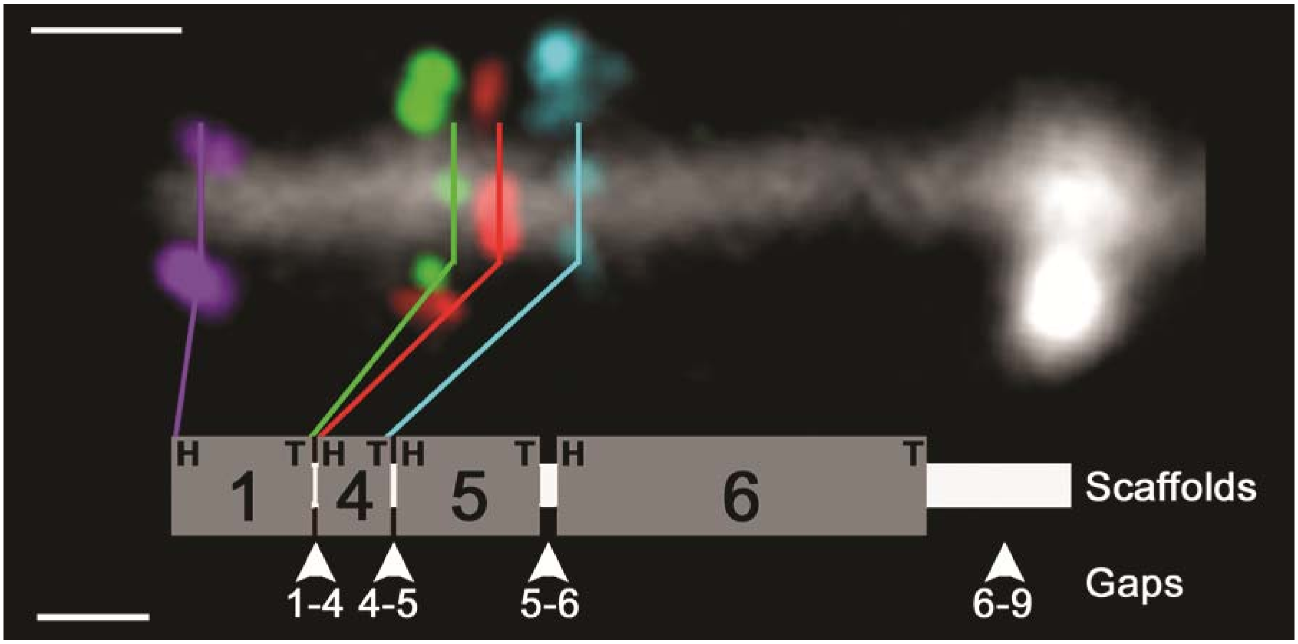
Report of the Tomato Genetics Cooperative



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Report

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Tomato Genetics Cooperative

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University of Florida

Gulf Coast Research and Education Center

14625 County Road 672

Wimauma, FL 33598 USA

Foreword

The Tomato Genetics Cooperative, initiated in 1951, is a group of researchers who share and interest in tomato genetics, and who have organized informally for the purpose of exchanging information, germplasm, and genetic stocks. The Report of the Tomato Genetics Cooperative is published annually and contains reports of work in progress by members, announcements and updates on linkage maps and materials available. The research reports include work on diverse topics such as new traits or mutants isolated, new cultivars or germplasm developed, interspecific transfer of traits, studies of gene function or control or tissue culture. Relevant work on other Solanaceous species is encouraged as well.

Paid memberships currently stand at approximately 50 from 16 countries. Requests for membership (per year) at US$10 for the online edition should be sent to Dr. J.W. Scott, jwsc@ufl.edu. Please send only checks or money orders. Make checks payable to the **University of Florida**. We are sorry but we are **NOT** able to accept cash, wire transfers or credit cards.

Cover: This is a figure from the 2013 feature article entitled “Using fluorescence *in situ* hybridization (FISH) to improve the assembly of the tomato genome” by Shearer et al. describing work that involved six laboratories at several institutions. A more detailed refereed paper will be published later, but you can get a glimpse of this exciting work right here in the Tomato Genetics Cooperative so be sure to check it out.

From the editor:

Happy Halloween 2013 to all TGC members! Belated Happy Halloween to all you non-members. Volume 63 will be online in October this year which makes two TGC volumes in one year since the 2012 TGC did not get published until March 2013. Pretty spooky!! Thanks to those who sent in papers this year. This year's feature article by Steve Stack et al., on the use of FISH to improve the tomato genome assembly will be published in greater detail later in a high impact journal, but you got a sneak peek first right here at TGC. Perhaps this will stimulate some of you to do the same type of thing in future years.

Big News on the keyword search function: All Volumes except the most recent one each year of the Tomato Genetics Cooperative are now all searchable by keyword and this will allow you to efficiently find articles about topics of interest. We have been striving for this for years and it is finally a reality! Follow instructions at the top of the Online Volumes section on the TGC website. When you get the list of articles the ones with the .html (or .htm) extension will be individual articles. Those with .pdf extensions will pull up the whole volume. The browser will give you the volume so citations can be easily tracked down. If anyone has any suggestions for improvement of this feature or anything else about TGC please contact me. Thanks to Dolly Cummings for her expert help with TGC operations and to Christine Cooley for her help with the website. Dolly and Christine are also responsible for getting the keyword search functioning. The value of great employees cannot be overstated!

I hope you have a good year ahead, maybe the US government will be open again by next year, but given the present political scene that is not something to be counted on (it may open again but I'm sure Congress will find a way to shut it down again). Now that <u>is</u> spooky!

My contact information:

Jay W. Scott, Ph.D.
Gulf Coast Research & Education Center
14625 CR 672
Wimauma, FL 33598
USA
Phone; 813-633-4135
Fax: 813-634-0001
Email: jwsc@ufl.edu

Jay W. Scott
Managing Editor

Upcoming Meetings

XVIIIth EUCARPIA Meeting of the Tomato Working Group, April 22- 25, 2014
https://colloque.inra.fr/eucarpia2014-tomato-avignon

Tomato Breeders' Round Table September 14 - 17, 2014 Asheville, NC.
Check Tomato Genetics Cooperative website http://tgc.ifas.ufl.edu/index.htm for further details.

Using fluorescence *in situ* hybridization (FISH) to improve the assembly of the tomato genome

Lindsay A. Shearer[1], Lorinda K. Anderson[1], Hans. de Jong[2], Sandra Smit[3], José Luis Goicoechea[4], Bruce A. Roe[5], Axin Hua[5], James J. Giovannoni[6], and Stephen M. Stack[1]

[1]Department of Biology, Colorado State University, Fort Collins, CO 80525, USA
[2]Laboratory of Genetics, Wageningen University, Radix-West, W1.Cc.054, Droevendaalsesteeg 1,6708 PB Wageningen, The Netherlands
[3]Laboratory of Bioinformatics, Wageningen University, Droevendaalsesteeg1, 6708 PB Wageningen, The Netherlands
[4]Arizona Genomics Institute, University of Arizona, Tucson, AZ 85721
[5]Department of Chemistry and Biochemistry, Stephenson Research and Technology Center, University of Oklahoma, Norman, OK, USA73019
[6]Department of Plant Biology, Cornell University, Ithaca, NY 14853, USA

INTRODUCTION

The genome of tomato (*Solanum lycopersicum*, 2*n* = 2*x* = 24, cultivar Heinz 1706) recently was described in Nature (The Tomato Genome Consortium 2012) as twelve DNA pseudomolecules that correspond to the twelve tomato chromosomes. Ideally the DNA sequence of a pseudomolecule is the same DNA sequence that runs from the head (end of the short arm) to the tail (end of the long arm) of the chromosome. In reality, most pseudomolecules are not complete but consist of a series of more or less long DNA sequences called scaffolds that are assemblies obtained from matching overlapped segments of sequenced DNA. A pseudomolecule is assembled by lining up its scaffolds in the same order and orientation they would have in the corresponding chromosome.

Two methods were used to order and orient (arrange) DNA scaffolds in tomato pseudomolecules. One relies on the tomato Kazusa EXPEN 2000 linkage map (Shirasawa et al. 2010; http://solgenomics.net/cview/map.pl?map_version_id=103), which is a high-resolution linkage map based on an F2 mapping population derived from an interspecific cross between the *Solanum lycopersicum* cultivar LA925 and the wild species *S. pennellii* line LA716 (Fulton et al. 2002). Mapped DNA sequences were identified in scaffolds, and then scaffolds were ordered and oriented according to the locations of these sequences in the linkage map. This method should be relatively accurate in parts of the genome where crossing over is frequent, *i.e.*, distal euchromatin, but it is expected to be less accurate in regions of the genome where crossing over is infrequent, *e.g.*, pericentric heterochromatin. The other method uses fluorescence *in situ* hybridization (FISH) of bacterial artificial chromosomes (BACs) to locate mostly single copy DNA sequences on spreads of synaptonemal complexes (SCs = pachytene chromosomes; Figure 1). Each BAC contains an insert of about 100 kb of tomato genomic DNA. While the two methods usually yield the same arrangement of scaffolds in distal euchromatin, they often do not agree in pericentric heterochromatin that includes 77% of the tomato genome (Peterson et al. 1996) and about 10% of tomato's ~35,000 nuclear genes (Van der Hoeven et al. 2002; Wang et al. 2006; The Tomato Genome Consortium 2012; Peters et al. 2009). In cases of disagreement, the published paper on the tomato genome described scaffold order and orientation according to the linkage map (The Tomato Genome Consortium 2012). At the time of publication, this was appropriate because most of the needed FISH localizations at scaffold borders were not yet available. However, these FISH localizations have now been completed for all tomato scaffolds, and numerous differences were noted between the linkage map-based scaffold arrangements compared to the FISH-based scaffold arrangements. We present evidence that FISH results are preferable for arranging scaffolds, especially in portions of the genome where the linkage map is inaccurate due to low rates of crossing over, *e.g.*, pericentric heterochromatin.

MATERIALS AND METHODS

Two lines of tomatoes *Solanum lycopersicum*, var. *Cherry*, accession LA4444 and *Solanum lycopersicum*, var. Heinz 1706 were grown from seeds to flowering in a greenhouse with controlled temperature and supplemental lighting.

While the genome of tomato variety Heinz 1706 was sequenced (The Tomato Genome Consortium 2012), we used tomato variety *Cherry*, accession LA4444 for spreading SCs because it flowers abundantly and has indeterminate growth, unlike Heinz 1706. Based on FISH, the two genomes seem to be structurally almost identical.

Tomato SC spreads. Spreads were prepared for FISH as described (Stack et al. 2009; Stack and Anderson 2009). Cot 100 nuclear DNA was used for chromosomal *in situ* suppression (CISS) hybridization because it includes most of the repetitive sequences in the tomato genome (Peterson et al. 1997; Zwick et al. 1997; Chang 2004; Peterson et al. 1998). Probes for fluorescence *in situ* hybridization (FISH) were prepared from tomato *Hind*III, *Mbo*I, *Eco*RI, and sheared BAC libraries and from a tomato fosmid library all located at Cornell University (http://www.sgn.cornell.edu). The DNAs were labeled with digoxygenin, biotin, or dinitrophenol (DNP) using a nick translation kit (Roche Applied Science).

FISH. FISH was performed as described (Zhong et al. 1996; Chang 2004). Briefly, SC spreads on glass slides were fixed briefly in 45% acetic acid followed by 1:3 acetic ethanol and then digested with RNase followed by pepsin. After additional fixation in 1% paraformaldehyde, labeled probes with Cot 100 tomato DNA in standard hybridization medium was placed on each slide. Slides were incubated at 80° to denature the DNA and then incubated at 37° to hybridize the DNA. Slides were washed in conditions for 80% stringency, *i.e.*, hybridization of DNAs with at least 80% complementarity (Schwarzacher et al. 2003). After blocking, slides were incubated with appropriate antibodies for the probes (mouse anti-biotin, biotinylated donkey anti-mouse, rat anti-DNP, and/or sheep anti-digoxigenin) followed by incubation with appropriate secondary antibodies labeled with fluorescent dyes (TRITC, Dylight 649, and FITC). After immunolabeling, cover glasses were mounted with Vectashield (Vector laboratories) containing 5 µg/ml 4',6-diamidino-2-phenylindole (DAPI). Microscopy and photography were performed with Leica DM 5000B and DM 5500B microscopes, both equipped for phase contrast and fluorescence microscopy with DAPI, FITC, TRITC, and Cy5 filter cubes and zero pixel shift. Images were captured with cooled Hamamatsu monochrome 1344X1044 pixel cameras using IP Lab software.

Measuring positions of BACs on SCs. See Chang et al. (2007) and Stack et al. (2009) for details. The position of a BAC was measured on ten or more different SC spreads (with a few rare exceptions) to yield an average position expressed as a percent of the arm length from the kinetochore. This decimal fraction was multiplied by the average length of the arm in micrometers to describe the position of the BAC in micrometers from the kinetochore (Chang et al. 2007; http://solgenomics.net/cview/map.pl?map_version_id=25).

Optical mapping. Optical mapping of tomato nuclear DNA was performed by OpGen, Inc. using the protocol previously described for other plant genomes (Zhou et al. 2009; Dong et al. 2013; Young et al. 2011). Optically mapped scaffolds were aligned with sequenced scaffolds by comparing patterns of digestion by BamH I of the former with expected *in silico* cutting patterns of the latter using OpGen-supplied Genome-Builder™ software. When optical mapping spanned gaps between sequenced scaffolds, superscaffolds were created and the size of their included gaps were estimated.

RESULTS AND DISCUSSION

For most BACs, FISH on SC spreads resulted in a single, discrete site of hybridization (Figure 1). Because there is little or no distortion of SCs in spreads, BAC positions can be mapped with a high degree of accuracy. In addition, with inclusion of Cot 100 DNA for CISS hybridization to block repeated sequences, BAC localizations in heterochromatin often were as informative as those in euchromatin. We have localized 627 BACs to unique sites on tomato SCs, including sites in euchromatin, heterochromatin, chromomeres, and kinetochores (see http://solgenomics.net/cview/map.pl?map_version_id=25 for localization and identification of most of these BACs on a pachytene idiogram with supporting FISH images.

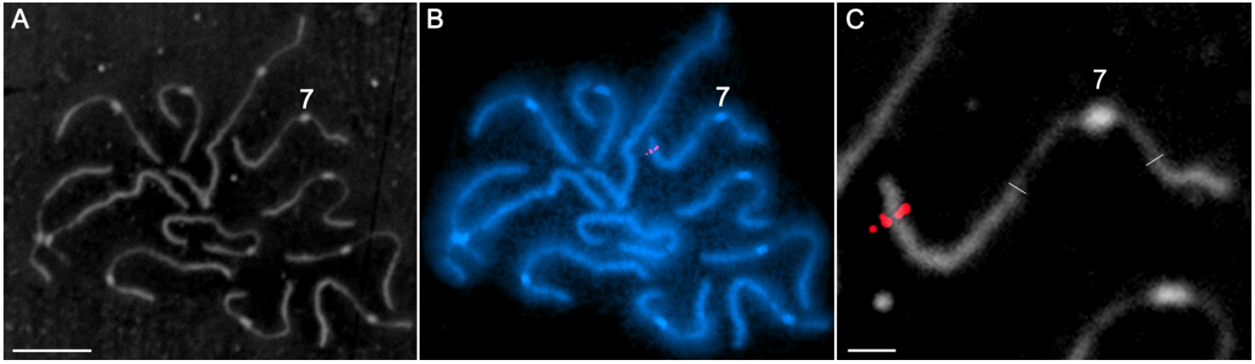

Figure 1. Example of a complete set of spread tomato SCs used for FISH. A. Digitally reversed phase contrast image of a complete set of 12 SCs before FISH. SCs are thicker in distal euchromatin and thinner in proximal pericentric heterochromatin. Kinetochores are white ellipsoids about 1 micrometer in diameter near the center of pericentromeric heterochromatin of each SC. The kinetochore of SC *7* is marked "7." B. Fluorescent image of the same SC set shown in A after DAPI staining and FISH. Pachytene chromosomes are fuzzy blue structures due to chromatin loops extending laterally from the SC axes. Kinetochores are visible as intense blue ellipsoids, one of which is marked "7" on chromosome *7.* Note the red foci in the distal euchromatin of the long arm of chromosome *7*, which mark the location of BAC LE_HBa0227C07. C. Enlarged digitally reversed phase image of the same SC *7* shown in A and B. The borders of distal euchromatin and pericentric heterochromatin in both arms are marked with thin transverse white lines. Red fluorescent foci in the distal euchromatin of the long arm of chromosome *7* mark the location of BAC LE_HBa0227C07. The bar in A represents 10 µm for A and B. The bar in C represents 2 µm.

Comparing linkage map-based and FISH-based pseudomolecules. Scaffolds in each pseudomolecule originally were numbered (1, 2, 3, …) based on the order determined from the Kazusa EXPEN 2000 linkage map starting from the head (= end of the short arm) of the chromosome (The Tomato Genome Consortium 2012). To determine the order and orientation of scaffolds by FISH, BACs at or near each end of most scaffolds were localized by FISH to SC spreads, although only one BAC was localized for very short scaffolds. This allowed us to determine the order and orientation of scaffolds independently from the linkage map and to estimate gap sizes between scaffolds. For example, Figure 2 shows FISH localization of four BACs that mark each end of two adjacent scaffolds on the short arm of chromosome *3*. Because scaffold numbering is based on the linkage map, the two adjacent scaffolds are numbered 1 and 4. Scaffolds 2 and 3 were localized by FISH to separated positions on the long arm of chromosome 3. The SC lengths corresponding to each scaffold (*e.g.*, the distance between the purple and green signals for scaffold 1 and between the red and turquoise signals for scaffold 4) and the SC lengths corresponding to the gaps between scaffolds (*e.g.*, the distance between the green and red signals for gap 1-4) were measured for all 91 scaffolds and all 79 gaps distributed along the twelve tomato SCs.

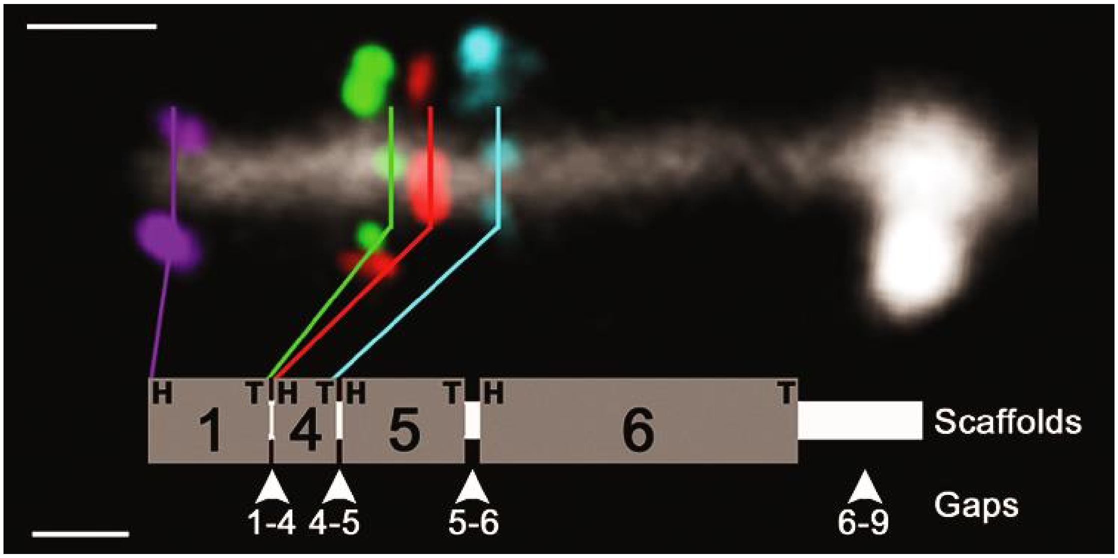

Figure 2. Reversed phase image of the short arm of SC3 overlaid with fluorescent signals from four BACs that were localized simultaneously by FISH. The four BACs define the edges of two scaffolds and the gap between them. The upper lobe of the white, dumbbell-shaped structure to the right is the kinetochore, while the lower lobe is debris (visible by phase microscopy but not by fluorescence). BAC SL_s0009C01 (purple) is at the head (H = toward the end of the short arm) and BAC SL_s0086D22 (green) is at the tail (T = toward the end of the long arm) of scaffold 1 (= SL2.40sc04439). BAC SL_s0018K15 (red) is at the head and BAC SL_s0002G24 (turquoise) is at the tail of the adjacent scaffold 4 (= SL2.40sc4696). Scaffolds 1 and 4 are in distal euchromatin. The space between the green signals and the red signals is the gap between scaffolds 1 and 4. The purple and turquoise foci mark the location of DNP-labeled BAC probes that were the same color in the original image but which have been given different colors here. In the diagram the thick grey segments labeled 1, 4, 5, and 6 represent scaffolds SL2.40sc04439, SL2.40sc4696, SL2.40sc05330, and SL2.40sc4126, respectively; with their lengths proportional to the amounts of DNA they represent. BAC-FISH localizations used to order and orient scaffolds 5 and 6 are not illustrated. Scaffold numbering is based on the order of scaffolds determined from the Kazusa EXPEN 2000 linkage map. Based on FISH, these scaffolds have the same head-tail orientation, but a different order from that derived from the linkage map (Figures 3, 4). Gaps between scaffolds are named according to the scaffolds on either side, *e.g.*, 1-4, 4-5, *etc*, and their lengths (white lines between the scaffolds) are proportional to the amount of DNA they are estimated to represent based on measurements of the relative positions of the four foci on 10 or more SCs. The upper bar represents 1 µm in reference to the SC segment, while the lower bar represents 2 Mb in reference to the pseudomolecule.

For 46 of the scaffolds, FISH-based arrangements were the same as linkage map-based arrangements (Figure 3; thick black bars). However, for the remaining 45 scaffolds representing 34% (259.8 Mb) of the sequenced DNA (760.0 Mb), the FISH-based arrangement differs from the linkage-based arrangement (Figure 2; thick colored bars). Twenty-eight of the differences involved only order (red bars), three differences involved only orientation (blue bars), and fourteen differences involved both order and orientation (purple bars). In general, scaffolds located in euchromatic regions of the chromosomes were more likely to be in the same arrangement in both linkage map-based and FISH-based pseudomolecules, while scaffolds located in pericentric heterochromatin were more likely to differ.

Figure 3. Diagrammatic representations of the twelve tomato pseudomolecules containing 91 scaffolds showing the order and orientation of scaffolds based on FISH compared to the linkage map. Thick segments represent sequenced scaffolds, and thin black lines connecting adjacent scaffolds represent gaps. All scaffolds and gaps are proportional in length to the amount of DNA they represent. The 46 scaffolds shown in dark gray have the same order and orientation using both FISH and linkage methods, while the 45 colored scaffolds have different orders and/or orientations. The dark gray scaffolds represent 66% (500.2 Mb) of the sequenced genome and strongly tend to be distal and involve euchromatin. The colored scaffolds represent 34% (259.8 Mb) of the sequenced genome and tend to be proximal and involve heterochromatin. The 28 red scaffolds were changed in order only, the three blue scaffolds were changed in orientation only, and the 14 purple scaffolds were changed in both order and orientation. The bar represents 10 Mb.

Figure 4 shows a more detailed comparison of the linkage map-based pseudomolecule and the FISH-based pseudomolecule for chromosome *3*. Of the 13 scaffolds, nine (2-9, 12) differ in order and/or orientation. The most notable discrepancies include scaffold 2 that was placed in the euchromatin of the short arm by linkage mapping but was located by FISH in the heterochromatin of the long arm, scaffold 3 (a small scaffold of only ~ 400 kb) that was placed in the short arm near/in the heterochromatin but located by FISH in the euchromatin of the long arm, and scaffold 12 that was located in the middle of the euchromatic portion of the long arm by linkage mapping but located by FISH in the heterochromatin of the long arm. In addition, the kinetochore moves from scaffold 6 in the map-based pseudomolecule to the gap between scaffolds 6 and 9 in the FISH-based pseudomolecule.

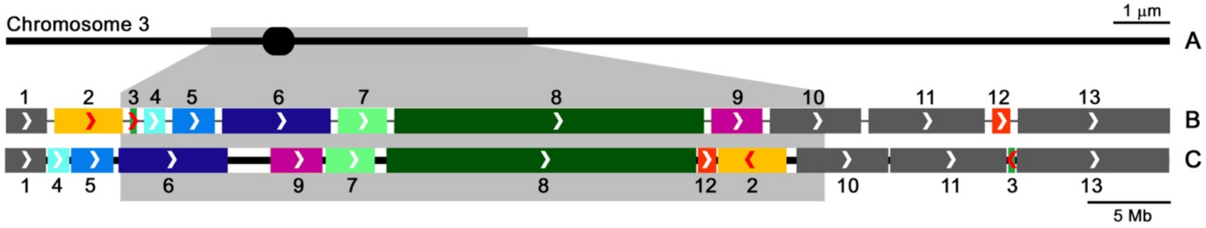

Figure 4. Diagrammatic representations of tomato SC*3* (A) with corresponding linkage map-based (B) and FISH-based (C) pseudomolecules. (A) The SC is represented as a horizontal black line with a black ellipsoid indicating the position of the kinetochore. The SC is oriented with its short arm at the left. Pericentric heterochromation is represented as a grey layer to either side of kinetochore, and the approximate location of this heterochromatin is projected onto the DNA pseudomolecules below. In the pairs of pseudomolecules (B and C), thick segments represent sequenced scaffolds, and gaps between scaffolds are represented by thin black lines. Arrowheads in the scaffolds indicate the orientation of each scaffold with regard to the linkage map from head to tail (*i.e.* toward the end of the long arm of the chromosome), and numbers above scaffolds indicate their order from the head to the tail of the pseudomolecule based on the linkage map. Because the linkage map was used to define scaffold order and orientation, the scaffolds in the linkage map-based pseudomolecule (B) are always in the "correct" order and orientation while the corresponding FISH-based pseudomolecule (C) differs in several respects from the linkage-based pseudomolecule. Scaffolds that are in the same order and orientation in the two pseudomolecules are black, while scaffolds that are different are presented in matching colors (along with scaffold numbers). Changes in order (position) are obvious and changes in orientation are shown by red arrowheads that are reversed in direction in the FISH-based pseudomolecules. In linkage-based pseudomolecules, all gaps are shown the same width because the linkage map is not useful for estimating gap sizes. In FISH-based pseudomolecules, the lengths of gaps are proportional to the amount of DNA estimated to be in the gaps. Names for scaffolds 1, 4, 5, and 6 are given in Fig. 1. Scaffolds 2, 3, 7 – 13 are named, respectively, SL2.40sc04822, SL2.40sc06911, SL2.40sc06725, SL2.40sc04704, SL2.40sc04616, SL2.40sc03806, SL2.40sc03796, SL2.40sc03721, and SL2.40sc03701. The upper bar represents 1 micrometer of SC length (A), and the lower bar represents 5 megabases for each pair of pseudomolecules (B and C).

Optical mapping strongly supports FISH-based scaffold arrangement. Optical mapping is an independent physical method for ordering and orienting scaffolds, which has been used for genome assembly in other higher eukaryotes (Young et al. 2011; Zhou et al. 2009; Dong et al. 2013). Using this method, we were able to order and orient 38 of the 91 tomato scaffolds. Optical mapping agreed with FISH results for all of these 38 scaffolds (100%), but agreed with map-based results for only 22 of these (58%).

FISH is useful for determining the sizes of gaps between scaffolds in pseudomolecules. The amounts of DNA in gaps between adjacent scaffolds in pseudomolecules were estimated by multiplying the gap lengths in micrometers of SC by the linear density of DNA appropriate for the chromatin type (euchromatin = 1.5 Mb/μm, heterochromatin = 8.1Mb/μm, kinetochores = 3.3 Mb/μm). The total amount of DNA estimated to be in gaps is 38.5 Mb or (38.5 MB/917 Mb =) roughly 4% of the genome (Michaelson et al. 1991). Individual gaps range in size from a high of 2.9 Mb to gaps too small to estimate by FISH.

Chromosome *0* BACs localize by FISH to gaps between scaffolds. Chromosome *0* BACs are defined as BACs that have been fingerprinted, partially sequenced, and/or completely sequenced but which do not fit into any of the twelve pseudomolecules because they lack both alignment with scaffold sequences and have no mapped marker sequences. Of the 93 chromosome *0* BACs that we have FISHed, 75 were successfully localized. Remarkably, 93% (70) of these were located in gaps between scaffolds.

CONCLUSIONS

FISH has improved the assembly of the tomato genome by correcting the order and/or orientation of sequenced scaffolds that originally were aligned using linkage maps. Most, but not all, of these changes were observed in heterochromatic regions, where linkage maps are inaccurate due to the low rate of recombination. Optical mapping, an independent physical method to assess genome sequence assembly, was useful in addressing the arrangement of 38 of the 91 scaffolds, and those results invariably agreed with FISH results. We estimated DNA density in different parts of the genome (euchromatin, heterochromatin and kinetochores) and, from that, calculated the amount of DNA in gap between scaffold sequences. In total, we estimate that only about 4% of the tomato genome remains un-sequenced. Chromosome *0* BACs that did not fit into any of the sequenced scaffolds were localized by FISH almost exclusively to gaps between scaffolds. These BACs are seed BACs to help complete the genome sequence. Finally, FISH-based order and orientation of scaffolds should be used to improve the linkage map for tomato.

ACKNOWLEDGEMENTS

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Evaluation of Near Isogenic Tomato Lines with and without the Bacterial Wilt Resistance Allele, *Bwr-12*

Peter Hanson, Chee-Wee Tan, Fang-I Ho, Shu-Fen Lu, Dolores Ledesma and Jaw-Fen Wang

AVRDC – The World Vegetable Center, 60 Yi-Min Liao, Shanhua, Tainan, Taiwan

Introduction

Bacterial wilt (BW) of tomato, caused by *Ralstonia solanacearum*, is one of the most important diseases limiting tomato production in the tropics (Hayward, 1991; Wang et al., 1998). The broad host range and vast genetic diversity of the pathogen as well as its widespread distribution complicate disease control. Resistant cultivars would provide farmers a cheap and effective means of control. However, the development of resistant cultivars has been difficult because resistance is often multigenic (Danesh et al., 1994; Carmeille et al., 2006; Wang et al., 2013), and its expression is often incomplete and strongly affected by pathogen strain and other environmental factors such temperature, soil moisture and pH. Resistance has been associated with negative horticultural traits such as small fruit size (Hayward, 1991; Hanson et al., 1996; Scott et al., 2005).

Effective screening and selection for BW resistance has challenged tomato breeders for many years. Screening segregating populations in pathogen-infested fields (sick plots) is often unreliable because of uneven pathogen distribution and differences in environment. AVRDC and some other programs use greenhouse seedling screening techniques to manage some sources of environmental variation, but differences in microenvironment in the greenhouse may cause variable responses. Furthermore, BW screening is most effective when mean temperatures are ≥ 25 °C, which limits screening to certain periods of the year unless heated greenhouses are available. Molecular markers linked to BW resistance genes would improve the effectiveness of BW screening, and help identify and combine key BW resistance genes in the same cultivar. Wang et al. (2013) identified two major quantitative trait loci (QTLs) in tomato cultivar 'Hawaii 7996' (H7996) associated with stable BW resistance: *Bwr-12* on chromosome 12 and *Bwr-6* on chromosome 6. *Bwr-12*, delimited by simple sequence repeat (SSR) markers SLM12-2 and SLM12-10, is important for resistance to Phylotype 1 (Asia) pathogen strains (Wang et al. 2013; Geethanjali et al., 2011). The objective of this study was to assess the gain in resistance due to *Bwr-12* by comparing near isogenic lines with and without *Bwr-12* and to confirm the usefulness of SLM12-2 and SLM12-10 for marker-assisted selection.

Materials and Methods

Plant materials. BW-resistant AVRDC line CLN2585D was crossed to BW-susceptible parent G2 in 2007 with the cross code CLN3125. BW resistance in CLN2585D was not derived from H7996 and originated from several possible sources, including lines from the University of the Philippines-Los Baños, cultivars 'Venus' and 'Saturn' from North Carolina State University, CRA-coded lines bred by the French National Institute for Agricultural Research (INRA) in Guadeloupe, French West Indies, and others (Daunay et al., 2010). Generation advance of CLN3125 from the F_2 to F_7 took place at AVRDC Taiwan from 2007-2010 following pedigree selection. During generation advance, segregating populations and lines of CLN3125 were screened and selected for Tomato yellow leaf curl disease resistance, fruit set, and fruit firmness, color, shape and size. BW reactions of CLN3125-coded lines were assessed in the greenhouse by drench inoculation (described below) in the F_5 (May-June 2009) and F_7 generations (May-June 2010). After SSR markers SLM12-2 and SLM12-10 became available, parents CLN2585D and G2, 6 F_7-derived F_8 lines ($F_{7:8}$) developed from CLN3125 were tested for presence of *Bwr-12* along with resistant check H7996. Marker analysis revealed that lines CLN3125A-23 and CLN3125L were heterogeneous (mixture of *Bwr-12* homozygotes and heterozygotes). CLN3125A-23 and CLN3125L originated from the F_2 plant but their pedigrees diverged at the F_3.

Development of Bwr-12 near-isogenic lines. From January-March 2011, 108 and 122 F_8 seedlings, respectively, from CLN3125A-23 and CLN3125L were grown in a plastic house and individually genotyped for *Bwr-12* with SLM12-2 and SLM12-10. Primer sequences were:

Marker	Forward primer	Reverse primer	PCR size (bp)
SLM12-2	ATCTCATTCAACGCACACCA	AACGGTGGAAACTATTGAAAGG	209
SLM12-10	ACCGCCCTAGCCATAAAGAC	TGCGTCGAAAATAGTTGCAT	242

Based on marker results, plants homozygous for *Bwr-12* or the susceptible allele were identified, transplanted to the field, and harvested individually to create near-isogenic lines (NILs). Within CLN3125A-23, 22 resistant and 19 susceptible NILs were developed; within CLN3125L, 23 resistant and 21 susceptible NILs were produced. NILs derived from CLN3125A-23 and CLN3125L were assigned to NIL Groups 1 and 2, respectively.

NIL evaluation for bacterial wilt reaction. Inoculations were conducted with virulent *Ralstonia solanacearum* strain *Pss*4, a Phylotype 1 (Asia), race 1 isolate from Taiwan (Wang et al., 2013). *Pss*4 has been used in routine AVRDC BW screening for many years. Four-week-old seedlings, approximately in the five-leaf stage, were inoculated by pouring 20 ml of 1 x 10^8 inoculum on the soil surface at the base of each plant. Plant roots were not wounded before inoculation. The number of wilted plants in each plot was counted weekly for four weeks beginning one week after inoculation and the percentage of healthy plants per plot was determined after the last evaluation. Plots included 20 plants and entries were replicated twice and arranged according to a randomized complete block design. Entries within NIL Groups 1 and 2 were randomized separately but screened in the same greenhouse at the same time. Checks included in both NIL groups were parents CLN2585D and G2, CLN3125A-23 and CLN3125L, H7996 (homozygous for *Bwr-12* and *Bwr-6*) and L390 (AVRDC susceptible check). Data were subjected to analysis of variance over years using the General Linear Models procedure of Statistical Analysis Systems software**.** Percent survival means for each plot were transformed by arc sine before analysis. Contrasts were constructed to compare group means of resistant and susceptible NILs within NIL groups.

Results and Discussion

The combined analysis of variance over years revealed highly significant means squares for entry and entry-by-year interactions for each NIL Group (Table 1). The entry-by-year interaction arose mainly from changes in the magnitude of differences among entries between years and not from major rank changes. Contrasts between group means of resistant (homozygous for *Bwr-12*) versus susceptible (homozygous for susceptible allele) NILs were highly significant within NIL groups. However, contrasts between group means of resistant NILs versus CLN3125A-23, and susceptible NILs versus CLN3125A-23 in NIL Group 1, and the susceptible NILs versus CLN3125L in NIL Group 2 were non-significant. Only the contrast of the group mean of resistant NILs versus CLN3125L in NIL Group 2 was significant. Variations within resistant NILs or susceptible NILs were not statistically significant.

Bacterial wilt pressure in the greenhouse trials was high, evidenced by the low percent survival means of the susceptible check L390, susceptible parent G2, and also the relatively high percentages of wilted plants in resistant check H7996 (14%) and resistant parent CLN2585D (~30%) (Table 2). The difference in percent survival between NILs with or without *Bwr-12* was 26.1% and 35.7% in NIL Groups 1 and 2, respectively. These differences are slightly lower than the 45% difference (reported as mean percentage of wilted plants) between recombinant inbred line (RIL) groups with or without *Bwr-12* and tested with Taiwan strain Pss4b (Wang et al., 2013). In this study, the ranges in mean percent survival of resistant NILs were wide (Table 2) but did not overlap with the ranges of the susceptible NIL means. It is interesting that the mean percent survival of CLN2585D was significantly greater than almost all resistant NILs; only one NIL in NIL Group 2 was not significantly different in percent survival from CLN2585D according to the Waller-Duncan k-ratio t test (data not shown).

Although CLN2585D does not possess *Bwr-6*, it is possible that it carries one or more minor BW resistance genes not present in CLN3125A-23 and CLN3125L.

It would seem that CLN2585D carries *Bwr-12* even though H7996 was not among its progenitors. Given the extensive exchange of BW resistant lines and sources among tomato breeding programs over many years (Daunay et al., 2010), it is not too surprising that *Bwr-12* was introduced and incorporated into some AVRDC lines. SSR markers SLM12-2 and SLM12-10 flanking *Bwr-12* are effective and inexpensive, enabling BW selection to occur in the F_2 generation. Marker-assisted selection for *Bwr-12* and other BW resistance genes has facilitated early elimination of susceptible plants, reduced the number of BW greenhouse confirmation screening trials during generation advance, and has enabled characterization of lines for the presence of specific resistance genes.

Table 1. Combined analysis of variance[1] over years for NILs with or without *Bwr-12* and checks screened for bacterial wilt reaction in the greenhouse, AVRDC, May-June 2011 and May-June 2013.

NIL Group 1	DF		Mean square	F Value
Year	1		1722.69	
Reps (Year)	2		408.21	
Entry	46		1001.53	6.39^{**}
Resistant NILs		21	158.69	1.01^{ns}
Susceptible NILs		18	117.57	0.75^{ns}
Resistant vs Susceptible NILs		1	24924.52	159.13^{**}
Resistant NILs vs. CLN3125A-23		1	156.21	1.00^{ns}
Susceptible NILs vs. CLN3125A-23		1	187.48	1.20^{ns}
Others		4	3307.60	21.12^{**}
Entry*Year	46		156.63	1.78^{**}
Error	92		88.08	
NIL Group 2	DF		Mean square	F Value
Year	1		4.38	
Reps (Year)	2		207.40	
Entry	49		1221.21	8.31^{**}
Resistant NILs		22	160.92	1.09^{ns}
Susceptible NILs		20	77.65	0.53^{ns}
Resistant vs Susceptible NILs		1	37148.17	252.76^{**}
Resistant NILs vs. CLN3125L		1	291.49	1.98^{*}
Susceptible NILs vs. CLN3125L		1	0.49	0.00^{ns}
Others		4	3911.21	26.61^{**}
Entry*Year	49		146.97	1.59^{*}
Error	98		92.66	

[1] Percent survival data were transformed by arcsine before analysis.

*,** Significant at $P<0.05$ and $P< 0.01$, respectively. ^{ns} non-significant

Table 2. Percent survival group means of near-isogenic lines with or without *Bwr-12,* and checks assessed for bacterial wilt reaction in the greenhouse, AVRDC, Taiwan

NIL Group 1	NIL Group/check	SLM 12-2	SLM 12-10	Entry no.	Range	Mean
					(% survival)[1]	
	NILs-Resistant	++	++	22	18.7–47.3	30.2
	NILs- Susceptible	--	--	19	0.0–13.9	4.1
	Difference					26.1**
	H7996	++	++	1		86.1 a
	CLN2585D	++	++	1		64.8 a
	CLN3125A-23	H	H	1		21.1 bc
	L390	--	--	1		6.4 cd
	G2	--	--	1		0.0 d
NIL Group 2	NILs-Resistant	++	++	23	19.8–64.5	42.4
	NILs- Susceptible	--	--	19	1.3–11.8	6.7
	Difference					35.7**
	H7996	++	++	1		86.3 a
	CLN2585D	++	++	1		74.8 a
	CLN3125L	H	H	1		5.2 b
	L390	--	--	1		1.3 b
	G2	--	--	1		0.0 b

[1] Mean percent survival four weeks after drench inoculation with *R. solanacearum Pss*4

[2] ++, = homozygous for *Bwr-12* allele; -- = homozygous for the susceptible allele; H= heterogeneous

*,** Significant at *P*<0.05 and *P*< 0.01, respectively. ns non-significant

Means within columns and NIL groups followed by the same letter are not significantly different by Waller-Duncan

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Distribution of major QTLs associated with resistance to *Ralstonia solanacearum* phylotype I strain in a global set of resistant tomato accessions

Fang-I Ho[1], Chi-Yun Chung, and Jaw-Fen Wang[1]
[1]AVRDC – The World Vegetable Center, 60 Yi-Min Liao, Shanhua, Tainan, Taiwan

Introduction

Bacterial wilt caused by *Ralstonia solanacearum* is one of the most devastating diseases of tomatoes, particularly in tropical and subtropical humid countries (Elphinstone, 2005). The bacterium displays a large genetic and phenotypic variation and has an exceptional ability to survive for a long time in water, soil, and the plant rhizosphere. The use of host resistance is the cheapest, most efficient, and most environmentally friendly method available for controlling the disease. However, breeding for stable resistance is challenging due to the location-specific and strain-specific nature of the resistance (Hanson et al., 1996; Lopes et al., 1994; Prior et al., 1990).

Traditionally, *R. solanacearum* has been classified into five races and six biovars according to host ranges and biochemical properties, respectively (Denny, 2006). Recent genetic and phylogeny studies indicate the presence of four different phylotypes related to the geographical origin of the strains (Fegan and Prior, 2005). Genetic and phenotypic variation exist among strains of the same phylotype. For example, variation in virulence of phylotype I strains has been reported in Taiwan (Jaunet and Wang, 1999). The virulence was measured based on interactions of the pathogen and tomato varieties with different levels of resistance.

Numerous tomato genotypes with resistance to bacterial wilt have been reported (Scott et al., 2005). Examination of the pedigrees and resistance sources used in major breeding programs worldwide showed the frequent exchange of plant genotypes among breeders (Daunay et al., 2010). Among the resistance sources used, Hawaii 7996 (*Solanum lycopersicum*) is one showing stable resistance (Wang et al., 1998). At least two major quantitative trait loci (QTL) associated with resistance in Hawaii 7996 have been identified (Thoquet et al., 1996a, b; Wang et al., 2000; Carmeille et al., 2006). Recently, the importance of the two major QTLs *Bwr-12* and *Bwr-6* contributing to the stable resistance of Hawaii 7996 was confirmed using a linkage map with good coverage and phenotype datasets collected against phylotype I and II strains under different environments (Wang et al., 2013). *Bwr-12* was located in a 2.8-cM interval of chromosome 12; it controlled 17.9% to 56.1% of resistance variation against all phylotype I strains in five countries, but not against phylotype II strains. *Bwr-6* on chromosome 6 explained 11.5% to 22.2% of the phenotypic variation against a few phylotype I strains and one phylotype II strain. The location of *Bwr-6* differed with phenotype datasets and varied along a 15.5-cM region. Such results may be due to the effect of the environment on symptom expression and the interactions with different pathogen strains.

Although *Bwr-12* and *Bwr-6* were associated with stable resistance to bacterial wilt in Hawaii 7996, it is not clear whether the same QTLs are present among the other sources of resistance, especially those showing stable resistance similar to Hawaii 7996. Therefore, the objectives of this study were to examine the distribution of *Bwr-12* and *Bwr-6* in a global set of resistant tomato accessions and to correlate their genotypes with disease reactions against phylotype I strains differing in virulence levels.

Materials and Methods

Plant materials

Tomato accessions resistant to bacterial wilt were selected based on the ancestry indicated by Daunay et al. (2010) and Lebeau et al. (2011). A total of 16 tomato accessions from different origins (Fig. 1) were used in this study. Tomato accession WVa700 was used as the susceptible control. Seeds were provided by AVRDC – The World Vegetable Center's Genetic Resources and Seed Unit and Tomato Breeding group.

Genotypes of SSR markers associated with Bwr-12 and Bwr-6

The simple sequence repeat (SSR) markers associated with *Bwr-12* and *Bwr-6* reported in Wang et al. (2013) were used in this study (Table 1). Genomic DNA of plants was purified from fresh leaves using GenEluteTM plant genomic DNA miniprep kit (Sigma, USA) following the instruction manual. PCR amplification of SSR markers was conducted in a reaction mixture consisting of 20 ng DNA, 0.3 µM of primer, 200 µM of deoxyribonucleotides, 50 mM KCl, 10 mM Tris HCl (pH 8.3), 1.5 mM $MgCl_2$, and 0.5 unit of hot start Taq DNA polymerase. The temperature profile used for PCR amplification included initial denaturation at 94 °C for 10 min, 30 cycles of 94 °C for 30 s, 55 °C for 45 s, 72 °C for 45 s, followed by a final extension at 72 °C for 7 min. PCR products were analyzed on 6% non-denaturing polyacrylamide gel in TBE buffer. After electrophoresis, the gels were stained with ethidium bromide. Capillary electrophoresis was conducted to verify genotypes of SLM6-94, SLM6-118, and SLM6-136 due to the small size difference of amplicons derived from VC 8-1-2-1, VC 11-3-1-8, UCPA 1169, CLN 1463, Saturn, and CRA 84-26-3. Forward primers of these markers were labeled with fluorescent dye TMARA, HEX and FAM individually. Amplicons of the three markers were mixed with equal concentration. Capillary electrophoresis was performed on an ABI3730XL DNA analyzer (Applied Biosystems) by Genomics Biosci & Tech, Taiwan. Three kinds of alleles were noted for each marker, i.e. "H" (resistance allele), "W" (susceptibility allele), or "-" (other allele), when the SSR marker showed the same size as Hawaii 7996, WVa700, or neither.

Bacterial strains and inoculation

R. solanacearum strains isolated from tomato (Pss190, Pss4, and Pss216) were used. They were selected to represent strains with high, medium and low virulence, respectively according to Jaunet et al. (1999). They all belong to phylotype I, race 1 and biovar 3, except Pss190, which is a biovar 4 strain. Cultures of *R. solanacearum* were routinely grown (2 days, 30 °C) on 2,3,5-triphenyl tetrazolium chloride medium (Kelman, 1954). For inoculum preparation, the bacteria were multiplied on 523 medium (Kado and Heskett, 1970) at 30 °C for 24 h, and a bacterial suspension was prepared in sterilized distilled water and adjusted to approximately 10^8 CFU per ml (OD_{600nm}=0.3). The experiment was conducted following a randomized complete block design with three replications and ten plants per accession. Trials were conducted twice in a greenhouse. The ranges of mean temperature and relative humidity were 25 °C to 33 °C and 53% to 95% for Trial 1; for Trial 2, they were 20 °C to 29 °C and 69% to 99%. Three-week-old plants were inoculated by drenching the bacterial suspension (10^8 CFU/ml) on the soil surface near the base of plants at the five fully expanded leaf stage (Wang et al., 2000). Percentage of wilted plants per replication was recorded four weeks after inoculation.

The data on percentage wilted plants was transformed to arcsine of its square root and analyzed using the PROC MIXED procedure of SAS (SAS v 9.2, SAS Institute, Cary, NC, USA). Tomato accessions were grouped according to the genotypes of SSR markers associated with *Bwr-12* and *Bwr-6* (Table 3). Group mean comparisons were performed using Tukey's test (HSD) at $P<0.05$.

Results and discussion

Bwr-12 and/or *Bwr-6* were commonly presented in the 16 tested tomato accessions resistant to bacterial wilt (Table 2). Based on the genotypes of *Bwr-12* and *Bwr-6*, the accessions could be grouped into three categories. Group A accessions were homozygous for the resistance allele of the two QTLs, Group B was homozygous for the *Bwr-12* resistance allele and variable alleles of the *Bwr-6* markers, while Group C was homozygous for the *Bwr-12* susceptibility allele and the resistance alleles of all 7 markers of *Bwr-6*. The presence of both *Bwr-12* and *Bwr-6* in accessions that originated from the University of North Carolina suggested these QTLs might have been utilized since the 1930s (Dauney et al., 2010). Bacterial wilt resistant lines bred in North Carolina were widely used by other breeding programs, and as a result, the two QTLs were commonly present in resistant accessions worldwide. Because the exact pedigrees of many resistant accessions, including Hawaii 7996, were not available, it is impossible to verify the exact sources of the two QTLs. The AVRDC breeding program has used UPCA116, Saturn, and CRA series as sources of resistance. These sources all possess *Bwr-12*, which is present in most of the resistant lines bred at AVRDC (unpublished data).

The disease reactions of the tested accessions were examined against three *R. solanacearum* strains. The disease pressure was higher in Trial 1, as evidenced by the higher wilting incidence resulting from the presence of higher temperature. The difference in virulence of the three *R. solanacearum* strains was more obvious in Trial 2 when the temperature was lower. The mean percentages of wilted plants over tested accessions caused by Pss190, Pss4, and Pss216, were 93.7%, 66.9%, and 68.6% in Trial 1, and 90.8%, 30.0%, and 17.5% in Trial 2. In order to examine the contribution of *Bwr-6* and *Bwr-12* to the resistance against different pathogen strains, a group mean comparison was conducted (Table 3). The ranking of the three groups was not consistent when interacting with different strains. Overall, Group A accessions, with the presence of both *Bwr-6* and *Bwr-12*, showed a significantly lower percentage of wilted plants than the other groups, except when interacting with Pss190 and Pss216 under lower temperatures. When interacting with Pss4, Group B, possessing *Bwr-12* only, had significantly lower disease incidence than Group C possessing *Bwr-6* only. These results are similar to those reported by Wang et al. (2013), when examining the effects of *Bwr-6* and *Bwr-12* using recombinant inbred lines derived from Hawaii 7996. Significant differences in disease reactions between accessions within the same group were observed in Group A when interacting with Pss190 in both trials, in Group B when interacting with Pss4 and Pss216 in Trial 1, and in Group C when interacting with Pss190 and Pss216 in Trial 1 and with Pss4 in Trial 2. This implies the performance of QTLs could vary depending on the genetic backgrounds. The presence of other minor QTLs may cause this kind of variation. All the four accessions in Group A, namely Hawaii 7996, TML114, TML46, and R3034, were among the tomato entries showing the best stable resistance based on evaluations conducted in 11 countries (Wang, et al., 1998). Wang et al. (2013) indicated *Bwr-12* contributes to resistance against phylotype I only, while *Bwr-6* contributes to resistance against both phylotype I and II. Therefore, pyramiding the two major QTLs is essential when breeding for stable resistance to bacterial wilt.

In conclusion, tomato accessions resistant to bacterial wilt from different origins possess *Bwr-6* and/or *Bwr-12*. Presence of both *Bwr-6* and *Bwr-12* contributes to stable resistance against the phylotype I strain with different virulence levels. The fact that few tested resistant accessions have both QTLs indicates that pyramiding both QTLs could not be achieved efficiently using conventional disease screening. Marker-assisted selection should increase the efficiency. *Bwr-12* markers have been used and found effective at AVRDC (Hanson et al., 2013 in this TGC Report). Fine-mapping of *Bwr-6* is underway at AVRDC to develop useful markers for pyramiding the two QTLs.

Table 1. Sequences of simple sequence repeat markers used in this study

Marker name	repeat motif	Primer sequence (5'-3')	Product size (bp)
SLM 12-2	(TA)11	f: ATCTCATTCAACGCACACCA	209
		r: AACGGTGGAAACTATTGAAAGG	
SLM 12-10	(AT) 21	f: ACCGCCCTAGCCATAAAGAC	242
		r: TGCGTCGAAAATAGTTGCAT	
SLM 6-124	(TAT) 10	f: CATGGGTTAGCAGATGATTCAA	292
		r: GCTAGGTTATTGGGCCAGAA	
SLM 6-118	(AAT) 18	f: TCCCAAAGTGCAATAGGACA	183
		r: CACATAACATGGAGTTCGACAGA	
SLM 6-119	(AT) 24	f: GCCTGCCCTACAACAACATT	255
		r: CGACATCAAACCTATGACTGGA	
SLM 6-136	(AT) 37	f: CCAGGCCACATAGAACTCAAG	290
		r: ACAGGTCTCCATACGGCATC	
SLM 6-17	(TA) 12	f: TCCTTCAAATCTCCCATCAA	186
		r: ACGAGCAATTGCAAGGAAAA	
SLM 6-94	(TA) 33	f: CTAAATTTAAATGGACAAGTAATAGCC	276
		r: CACGATAGGTTGGTATTTTCTGG	
SLM 6-110	(ATT) 22	f: AGAATGCGGAGGTCTGAGAA	274
		r: ATCCCACTGTCTTTCCACCA	

Table 2. Genotypes of simple sequence repeat markers associated with *Bwr-12* and *Bwr-6* in tested tomato accessions.

	Bwr-12		*Bwr-6a*		*Bwr-6b*		*Bwr-6c*		*Bwr-6d*
Accession	SLM 12-2	SLM 12-10	SLM 6-124	SLM 6-118	SLM 6-119	SLM 6-136	SLM 6-17	SLM 6-94	SLM 6-110
Hawaii 7996	H[a]	H	H	H	H	H	H	H	H
TML114	H	H	H	H	H	H	H	H	H
TML46	H	H	H	H	H	H	H	H	H
R3034	H	H	H	H	H	H	H	H	H
VC 8-1-2-1	H	H	W	-	-	W	-	W	-
UCPA 1169	H	H	W	-	H	-	-	H	H
CLN 1463A	H	H	W	-	-	W	-	-	-
Saturn	H	H	W	W	-	-	-	W	-
CRA 84-26-3	H	H	W	-	-	W	-	-	-
VC 11-3-1-8	H	H	W	-	-	-	-	-	-
BF-Okitsu	W	W	H	H	H	H	H	H	H
L285	W	W	H	H	H	H	H	H	H
CRA 66	W	W	H	H	H	H	H	H	H
NC72TR4-4	W	W	H	H	H	H	H	H	H
IRAT L3	W	W	H	H	H	H	H	H	H
Venus	W	W	H	H	H	H	H	H	H
WVa700 (Sus.)	W	W	W	W	W	W	W	W	W

[a] "H" means homozygous resistance allele as Hawaii 7996; "W" means homozygous susceptibility allele as WVa700; "-" means others alleles

Figure 1. Origins and relationships among tomato accessions resistant to bacterial wilt (modified from Lebeau et al., 2011 and Daunay et al., 2010). The presence of *Bwr-6* (▤, *Bwr-12* ░) or both ▒) in the accession is highlighted according to the results of marker assays. Accessions without highlights were not tested.

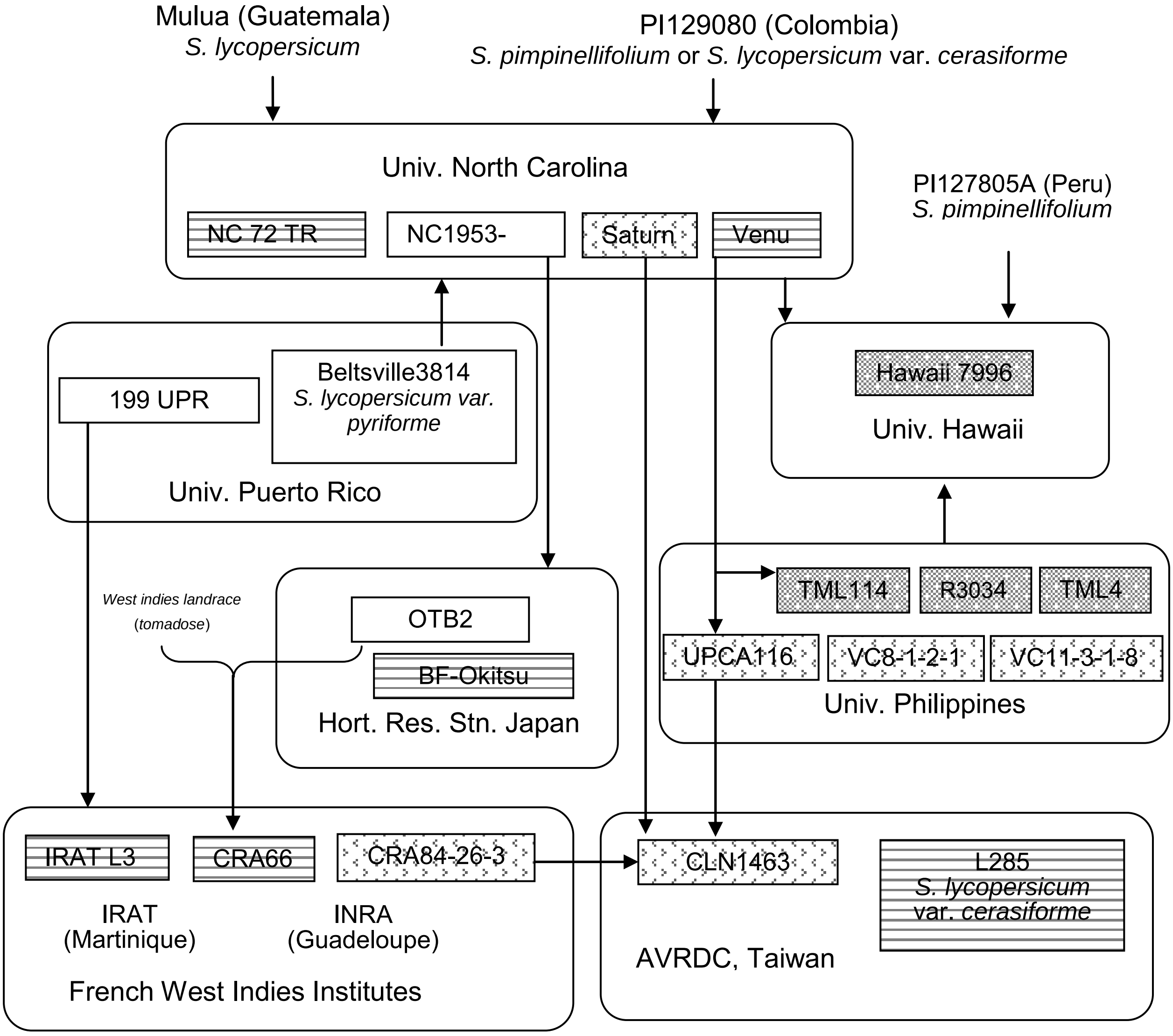

Table 3. Disease incidence of tomato accessions having different genotypes of two major QTLs against phylotype I strains of *Ralstonia solanacearum* in two trials.

	Accession	*Bwr -12*	*Bwr -6*	Trial 1[b]						Trial 2[b]					
				Pss190		Pss4		Pss216		Pss190		Pss4		Pss216	
Group A[a]	Hawaii 7996	H	H	80.0 [c]		26.7		36.7		86.7		3.3		10.0	
	TML114	H	H	83.3	70.2 A [c]	40.0	29.1 A	26.7	32.1 A	86.7	68.8 A	3.3	6.7 A	3.3	11.7 A
	TML46	H	H	73.3	(82.5)	20.0	(25.0)	20.0	(29.2)	73.3	(85.0)	3.3	(3.3)	6.7	(7.5)
	R3034	H	H	93.3		13.3		33.3		93.3		3.3		10.0	
Group B	VC 8-1-2-1	H	W/-	100.0		66.7		91.7		100.0		3.3		23.3	
	UCPA 1169	H	H/W/-	100.0		36.7		56.7		93.3		13.3		0.0	
	CLN 1463	H	W/-	100.0	89.1 B	60.0	55.8 B	93.3	72.5 C	100.0	85.7 B	6.7	17.2 B	23.3	22.1 B
	Saturn	H	W/-	100.0	(100.0)	96.7	(63.9)	86.7	(86.4)	100.0	(97.8)	26.7	(13.9)	23.3	(17.8)
	CRA 84-26-3	H	W/-	100.0		56.7		96.7		93.3		10.0		16.7	
	VC 11-3-1-8	H	W/-	100.0		66.7		93.3		100.0		23.3		20.0	
Group C	BF-Okitsu	W	H	80.0		80.0		76.7		80.0		40.0		23.3	
	L285	W	H	93.3		83.3		76.7		80.0		40.0		16.7	
	CRA 66	W	H	96.7	81.2 B	100.0	78.9 C	46.7	59.2 B	83.3	70.1 A	46.7	45.7 C	3.3	20.1 AB
	NC72 TR4-4	W	H	100.0	(93.9)	96.7	(92.2)	90.0	(7.1.7)	86.7	(87.2)	60.0	(55.0)	13.3	(17.2)
	IRAT L3	W	H	93.3		96.7		80.0		96.7		73.3		33.3	
	Venus	W	H	100.0		96.7		60.0		96.7		70.0		13.3	
Group D	WVa700 (Sus.)	W	W	100.0	89.1 B (100.0)	100.0	89.1 C (100.0)	100.0	89.1 C (100.0)	93.3	77.4 A (93.3)	83.3	69.8 D (83.3)	56.7	49.2 C (56.7)

[a] Tomato accessions were grouped based on genotypes of *Bwr-12* and *Bwr-6*. The genotypes were noted as "H", homozygous for the Hawaii7996 allele, "W" homozygous for the WVa700 allele, or " –" for the other alleles.

[b] The two trials were conducted in different seasons. The mean temperature and relative humidity range was 25°C to 33°C and 53% to 95% for Trial 1, and 20°C to 29°C and 63% to 99% for Trial 2.

[c] Percentage of wilted plants was transformed to arcsine of the square root for analysis of variance. Transformed data are used for column-wise mean comparisons. The actual means are presented in parentheses. The group means for each strain were compared using Tukey's test (HSD) at P<0.05. Comparison of means within and across groups was based on Least Significant Difference (LSD) at the P<0.05. The $\text{LSD}_{0.05}$ values for Pss190, Pss4, and Pss216 in Trial 1 are 13.3%, 23.3% and 20.0%, respectively. For Trial 2, the LSD values are 16.7%, 20.0%, and 30.0% for Pss190, Pss4 and Pss216, respectively.

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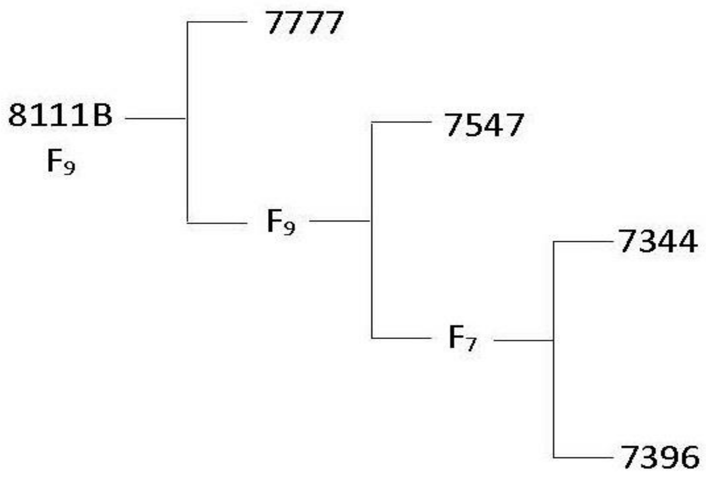
Varietal Pedigrees

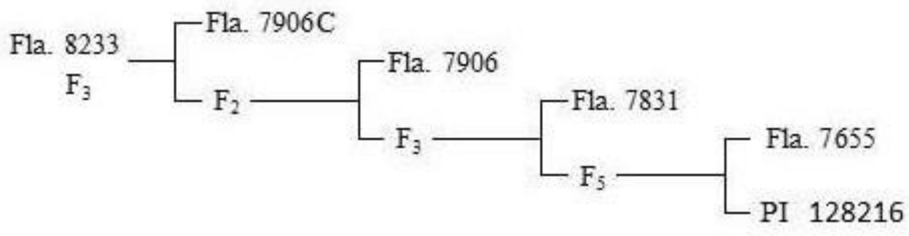
Scott, J.W. 2013. Fla. 8111B a large-fruited, globe shaped tomato breeding line
Pedigree:



<u>Characteristics:</u>
Fruit: Large, globe shaped, smooth, firm, light-green shoulders, moderate crack and check resistance, susceptible to stem scar water uptake, graywall resistant
Plant: *sp, I, I-2, Ve, Sm,* large somewhat open vine, very susceptible to bacterial spot
Utility and maturity: Fresh market inbred, mid-season maturity, good combiner in F_1 hybrids

Scott, J.W. and S.F. Hutton. 2013. Fla. 8233, a germplasm line with partial resistance to bacterial spot races T1, T2, T3, T4 and *Xanthomonas gardneri.*

Pedigree:



Characteristics:

Fruit: Medium size, flat round some with irregular shape, stellate to irregular blossom scars sometimes with holes, firm, light-green shoulders, good crack resistance, some zippering

Plant: *sp, I, I-2, Sm, Rx-4,* moderate vine size with dark green foliage, tendency for non-blighting when infected by foliar pathogens

Utility and maturity: Donor inbred with moderate heat-tolerant fruit setting for development of improved fresh market inbreds with bacterial spot resistance. Partial resistance to bacterial spot races T1, T2, T3 (hypersensitive resistance), T4, and *Xanthomonas gardneri*, *Rx-4* linked in cis with a QTL on chromosome 11 that provides broad spectrum bacterial spot resistance.

Revised List of Wild Species Stocks

Chetelat, R. T.

C.M. Rick Tomato Genetics Resource Center, Dept. of Plant Sciences, University of California, One Shields Ave., Davis, CA 95616

The following list of 1,153 accessions of wild tomatoes and allied *Solanum* species is a revision of the list published in TGC vol. 60, 2010. Other types of TGRC stocks are catalogued in TGC 61 (monogenic mutants) and TGC 62 (miscellaneous stocks).

Accessions no longer available for distribution have been dropped from this list. New items include 34 previously inactive, newly regenerated accessions (designated herein with an asterisk after the LA number). Most of these wild species collections were never grown at Davis, either because other populations from similar locations were already being maintained and resources were limited, or because they were simply overlooked until now.

Several of these 'rescued' accessions are noteworthy and interesting. Two *S. habrochaites* populations from Ecuador (LA2859, LA2868) were regenerated, one of which is the first collection of this species from the southern coastal region (Dept. El Oro). An accession of *S. habrochaites* (LA1986) from the underrepresented Rio Moche drainage of Peru is noteworthy for its unusually vigorous growth and large flowers and fruit. New *S. pennellii* accessions include a collection from the Rio Casma (LA1773), only the second from that valley, and which displays the pedicel articulation in the 'mid' rather than the more common basal position. A new population of *S. chilense* (LA1931) from the underrepresented Rio Acari drainage showed the distinctive morphology of other accessions from the region. We also grew a *S. chilense* from Quebrada Socaire, notable for being near the southeastern geograhic limit of this species' distribution. Several *S. pimpinellifolium* collections from the Lambayeque and Cajamarca regions in northern Peru were grown. We were especially happy to rescue these collections because many of the *S. pimpinellifolium* populations have been eliminated in this region of Peru due to intensification of agricultural practices, including use of sugarcane monocultures and widespread use of herbicides.

Seed samples will be provided, upon request, for research, breeding or educational purposes. In most cases we provide 25 seed per accession for the self-pollinated accessions, 50 for the outcrossing accessions, and 5-10 for the allied *Solanum* species (*S. juglandifolium, S. lycopersicoides, S. ochranthum* and *S. sitiens*). These seed samples are meant to enable researchers to multiply seed for their future needs. NB: some accessions on this list may be temporarily unavailable for distribution during seed multiplication.

The following list is sorted by species name, using the classification system of Peralta et al. (2008)[1]. More detailed information on each accession, including the collectors, field notes, geographic coordinates, images, etc, is available on our website, http://tgrc.ucdavis.edu.

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[1] Peralta, I. E., D. M. Spooner, S. Knapp (2008) Taxonomy of wild tomatoes and their relatives (*Solanum* sect. *Lycopersicoides*, sect. *Juglandifolia*, and sect. *Lycopersicon*; Solanaceae). *Systematic Botany Monographs* 84: 1-186.

Solanum arcanum (L. peruvianum or L. peruvianum **var.** ***humifusum***			
LA0378	Cascas	Cajamarca	Peru
LA0385	San Juan (Rio Jequetepeque)	Cajamarca	Peru
LA0389	Abra Gavilan	Cajamarca	Peru
LA0392	Llallan	Cajamarca	Peru
LA0441	Cerro Campana	La Libertad	Peru
LA1027	Chilete	Cajamarca	Peru
LA1031	Balsas	Amazonas	Peru
LA1032	Aricapampa	La Libertad	Peru
LA1346	Casmiche	La Libertad	Peru
LA1350	Chauna	Cajamarca	Peru
LA1351	Rupe	Cajamarca	Peru
LA1394	Balsas - Rio Utcubamba	Amazonas	Peru
LA1395	Chachapoyas	Amazonas	Peru
LA1396	Balsas (Chachapoyas)	Amazonas	Peru
LA1626	Mouth of Rio Rupac	Ancash	Peru
LA1708	Chamaya to Jaen	Cajamarca	Peru
LA1984	Otuzco	La Libertad	Peru
LA1985	Casmiche	La Libertad	Peru
LA2150	Puente Muyuna	Cajamarca	Peru
LA2151	Morochupa	Cajamarca	Peru
LA2152	San Juan #1	Cajamarca	Peru
LA2153	San Juan #2	Cajamarca	Peru
LA2157	Tunel Chotano	Cajamarca	Peru
LA2163	Cochabamba to Yamaluc	Cajamarca	Peru
LA2164	Yamaluc	Cajamarca	Peru
LA2172	Cuyca	Cajamarca	Peru
LA2185	Pongo de Rentema	Amazonas	Peru
LA2326	Above Balsas	Amazonas	Peru
LA2327	Aguas Calientes	Cajamarca	Peru
LA2328	Aricapampa	La Libertad	Peru
LA2330	Chagual	La Libertad	Peru
LA2331	Agallpampa	La Libertad	Peru
LA2333	Casmiche	La Libertad	Peru
LA2334	San Juan	Cajamarca	Peru
LA2388	Cochabamba to Huambos (Chota)	Cajamarca	Peru
LA2548	La Moyuna	Cajamarca	Peru
LA2550	El Tingo, Chorpampa-San Juan	Cajamarca	Peru
LA2553	Balconcillo de San Marcos	Cajamarca	Peru
LA2555	Marical - Castilla	La Libertad	Peru
LA2565	Potrero de Panacocha a Llamellin	Ancash	Peru
LA2566*	Cullachaca	Ancash	Peru
LA2582	San Juan	Cajamarca	Peru
LA2583	(autotetraploid)		Peru
LA2813*	San Juan	Cajamarca	Peru
LA2917	Chullchaca	Ancash	Peru

Solanum cheesmaniae (L. cheesmanii)			
LA0166	Santa Cruz: Barranco, N of Punta	Galapagos	Ecuador
LA0421	San Cristobal: cliff East of Wreck Bay	Galapagos	Ecuador
LA0422	San Cristobal: Wreck Bay, Puerto	Galapagos	Ecuador
LA0428	Santa Cruz: Trail Bellavista to Miconia	Galapagos	Ecuador
LA0429	Santa Cruz: Crater in highlands	Galapagos	Ecuador
LA0434	Santa Cruz: Rambech Trail	Galapagos	Ecuador
LA0437	Isabela: Ponds North of Villamil	Galapagos	Ecuador
LA0521	Fernandina: Inside Crater	Galapagos	Ecuador
LA0522	Fernandina: Outer slopes	Galapagos	Ecuador
LA0524	Isabela: Punta Essex	Galapagos	Ecuador
LA0528B	Santa Cruz: Academy Bay	Galapagos	Ecuador
LA0529	Fernandina: Crater	Galapagos	Ecuador
LA0531	Baltra: Barranco slope, N side	Galapagos	Ecuador
LA0746	Isabela: Punta Essex	Galapagos	Ecuador
LA0749	Fernandina: North side	Galapagos	Ecuador
LA0927	Santa Cruz: Academy Bay	Galapagos	Ecuador
LA0932	Isabela: Tagus Cove	Galapagos	Ecuador
LA1035	Fernandina: Low elevation	Galapagos	Ecuador
LA1036	Isabela: far north end	Galapagos	Ecuador
LA1037	Isabela: Alcedo crater	Galapagos	Ecuador
LA1039	Isabela: Cape Berkeley	Galapagos	Ecuador
LA1040	San Cristobal: Caleta Tortuga	Galapagos	Ecuador
LA1041	Santa Cruz: El Cascajo	Galapagos	Ecuador
LA1042	Isabela: Cerro Santo Tomas	Galapagos	Ecuador
LA1043	Isabela: Cerro Santo Tomas	Galapagos	Ecuador
LA1138	Isabela: E of Cerro Azul	Galapagos	Ecuador
LA1139	Isabela: W of Cerro Azul	Galapagos	Ecuador
LA1402	Fernandina: W of Punta Espinoza	Galapagos	Ecuador
LA1404	Fernandina: W flank caldera	Galapagos	Ecuador
LA1406	Fernandina: SW rim caldera	Galapagos	Ecuador
LA1407	Fernandina: caldera, NW bench	Galapagos	Ecuador
LA1409	Isabela: Punta Albemarle	Galapagos	Ecuador
LA1412	San Cristobal: opposite Isla Lobos	Galapagos	Ecuador
LA1414	Isabela: Cerro Azul	Galapagos	Ecuador
LA1427	Fernandina: WSW rim of caldera	Galapagos	Ecuador
LA1447	Santa Cruz: Charles Darwin Station-	Galapagos	Ecuador
LA1448	Santa Cruz: Puerto Ayora, Pelican Bay	Galapagos	Ecuador
LA1449	Santa Cruz: Charles Darwin Station,	Galapagos	Ecuador
LA1450	Isabela: Bahia San Pedro	Galapagos	Ecuador
LA3124	Santa Fe: near E landing	Galapagos	Ecuador

Solanum chilense (L. chilense)			
LA0130	Moquegua	Moquegua	Peru
LA0294	Tacna	Tacna	Peru
LA0456	Clemesi	Moquegua	Peru

Solanum chilense (L. chilense)			
LA0458	Tacna	Tacna	Peru
LA0460	Palca	Tacna	Peru
LA0470	Taltal	Antofagasta	Chile
LA1029	Moquegua	Moquegua	Peru
LA1030	N of Tacna	Tacna	Peru
LA1782	Quebrada de Acari	Arequipa	Peru
LA1917	Llauta	Ayacucho	Peru
LA1930	Quebrada Calapampa	Arequipa	Peru
LA1931*	Mina Santa Rosa	Arequipa	Peru
LA1932	Minas de Acari	Arequipa	Peru
LA1938	Quebrada Salsipuedes	Arequipa	Peru
LA1958	Pampa de la Clemesi	Moquegua	Peru
LA1959	Huaico Moquegua	Moquegua	Peru
LA1960	Rio Osmore	Moquegua	Peru
LA1961	Toquepala	Tacna	Peru
LA1962*	Huaico Tacna	Tacna	Peru
LA1963	Rio Caplina	Tacna	Peru
LA1965	Causuri	Tacna	Peru
LA1967	Pachia, Rio Caplina	Tacna	Peru
LA1968	Cause Seco, Tacna to Tarata	Tacna	Peru
LA1969	Estique Pampa	Tacna	Peru
LA1970	Tarata	Tacna	Peru
LA1971	Palquilla	Tacna	Peru
LA1972	Rio Sama	Tacna	Peru
LA2404	Arica to Tignamar	Arica-Parinacota	Chile
LA2405	Tignamar	Arica-Parinacota	Chile
LA2406	Arica to Putre	Arica-Parinacota	Chile
LA2729*	Pacahua quebrada	Tarapaca	Chile
LA2731	Moquella	Tarapaca	Chile
LA2737	Yala-yala	Tarapaca	Chile
LA2739	Crossroads Nama to Camina	Tarapaca	Chile
LA2743*	La Puntilla	Arica-Parinacota	Chile
LA2746	Asentamiento-18	Arica-Parinacota	Chile
LA2747	Alta Azapa	Arica-Parinacota	Chile
LA2748	Soledad	Tarapaca	Chile
LA2749	Mina La Buena Esperanza	Antofagasta	Chile
LA2750	Mina La Despreciada	Antofagasta	Chile
LA2751	Pachica (Rio Tarapaca)	Tarapaca	Chile
LA2753	Laonzana	Tarapaca	Chile
LA2754	W of Chusmisa	Tarapaca	Chile
LA2755	Banos de Chusmisa	Tarapaca	Chile
LA2757	W of Chusmisa	Tarapaca	Chile
LA2759	Mamina	Tarapaca	Chile
LA2762	Quebradas de Mamina a Parca	Tarapaca	Chile
LA2764	Codpa	Arica-Parinacota	Chile

Solanum chilense (L. chilense)			
LA2765	Timar	Arica-Parinacota	Chile
LA2767	Chitita	Arica-Parinacota	Chile
LA2768	Empalme Codpa	Arica-Parinacota	Chile
LA2771	Above Poconchile	Arica-Parinacota	Chile
LA2773	Zapahuira	Arica-Parinacota	Chile
LA2774	Socorama	Arica-Parinacota	Chile
LA2778	Chapiquina	Arica-Parinacota	Chile
LA2779	Cimentario Belen	Arica-Parinacota	Chile
LA2780	Belen to Lupica	Arica-Parinacota	Chile
LA2879	Peine	Antofagasta	Chile
LA2880	Quebrada Tilopozo	Antofagasta	Chile
LA2881*	Quebrada Socaire	Antofagasta	Chile
LA2882	Camar	Antofagasta	Chile
LA2884	Ayaviri	Antofagasta	Chile
LA2887	Quebrada Bandurria	Antofagasta	Chile
LA2888	Loma Paposo	Antofagasta	Chile
LA2891	Quebrada Taltal	Antofagasta	Chile
LA2930	Quebrada Taltal	Antofagasta	Chile
LA2931	Guatacondo	Tarapaca	Chile
LA2932	Quebrada Gatico, Mina Escalera	Antofagasta	Chile
LA2946	Guatacondo	Tarapaca	Chile
LA2947*	Guatacondo	Tarapaca	Chile
LA2949	Chusmisa	Tarapaca	Chile
LA2952	Camiña	Tarapaca	Chile
LA2955	Quistagama-Quisama	Tarapaca	Chile
LA2957*	Pozo	Tarapaca	Chile
LA2965*	Pachia	Tacna	Peru
LA2980	Yacango	Moquegua	Peru
LA2981A	Torata	Moquegua	Peru
LA3111	Tarata	Tacna	Peru
LA3112	Estique Pampa	Tacna	Peru
LA3113	Apacheta	Tacna	Peru
LA3114	Quilla	Tacna	Peru
LA3115	W of Quilla	Tacna	Peru
LA3153	Desvio Omate (Rio de Osmore)	Moquegua	Peru
LA3155	Quinistaquillas	Moquegua	Peru
LA4106	Taltal	Antofagasta	Chile
LA4107	Catarata Taltal	Antofagasta	Chile
LA4108	Caleta Punta Grande	Antofagasta	Chile
LA4109	Quebrada Canas	Antofagasta	Chile
LA4117A	San Pedro - Paso Jama	Antofagasta	Chile
LA4117B	San Pedro - Paso Jama	Antofagasta	Chile
LA4118	Toconao	Antofagasta	Chile
LA4119	Socaire	Antofagasta	Chile
LA4120	Cahuisa	Tarapaca	Chile

Solanum chilense (L. chilense)			
LA4121	Pachica - Poroma	Tarapaca	Chile
LA4122	Chiapa	Tarapaca	Chile
LA4127	Alto Umayani	Arica-Parinacota	Chile
LA4129	Pachica (Rio Camarones)	Arica-Parinacota	Chile
LA4132	Esquina	Arica-Parinacota	Chile
LA4319	Alto Rio Lluta	Arica-Parinacota	Chile
LA4321	Quebrada Cardones	Arica-Parinacota	Chile
LA4324	Estacion Puquio	Arica-Parinacota	Chile
LA4327	Pachica, Rio Camarones	Arica-Parinacota	Chile
LA4329	Puente del Diablo, Rio Salado	Antofagasta	Chile
LA4330	Caspana	Antofagasta	Chile
LA4332	Rio Grande	Antofagasta	Chile
LA4334	Quebrada Sicipo	Antofagasta	Chile
LA4335	Quebrada Tucuraro	Antofagasta	Chile
LA4336	Quebrada Cascabeles	Antofagasta	Chile
LA4337	Quebrada Paposo	Antofagasta	Chile
LA4338	Quebrada Taltal, Estacion Breas	Antofagasta	Chile
LA4339	Quebrada Los Zanjones	Antofagasta	Chile

Solanum chmielewskii (L. chmielewskii)			
LA1028	Casinchihua	Apurimac	Peru
LA1306	Tambo	Ayacucho	Peru
LA1316	Ocros	Ayacucho	Peru
LA1317	Hacienda Pajonal	Ayacucho	Peru
LA1318	Auquibamba	Apurimac	Peru
LA1325	Puente Cunyac	Apurimac	Peru
LA1327	Sorocata	Apurimac	Peru
LA1330	Chalhuanca	Apurimac	Peru
LA2639B	Puente Cunyac	Apurimac	Peru
LA2663	Tujtohaiya	Cusco	Peru
LA2677	Huaypachaca #1	Cusco	Peru
LA2678	Huaypachaca #2	Cusco	Peru
LA2679	Huaypachaca #3	Cusco	Peru
LA2680	Puente Apurimac #1	Cusco	Peru
LA2681	Puente Apurimac #2	Cusco	Peru
LA2695	Chihuanpampa	Cusco	Peru

Solanum corneliomulleri (L. peruvianum* or *L. peruv.* f. *gladulosum)			
LA0103	Cajamarquilla, Rio Rimac	Lima	Peru
LA0107	Hacienda San Isidro, Rio Canete	Lima	Peru
LA0364	Canta	Lima	Peru
LA0366	12 Km W of Canta	Lima	Peru
LA0444	Chincha #1	Ica	Peru
LA0451	Arequipa	Arequipa	Peru
LA1133	Huachipa	Lima	Peru

Solanum corneliomulleri (L. peruvianum **or** ***L. peruv.*** **f.** ***gladulosum)***			
LA1271	Horcon	Lima	Peru
LA1274	Pacaibamba	Lima	Peru
LA1281	Sisacaya	Lima	Peru
LA1283	Santa Cruz de Laya	Lima	Peru
LA1284	Espiritu Santo	Lima	Peru
LA1292	San Mateo	Lima	Peru
LA1293	Matucana	Lima	Peru
LA1294	Surco	Lima	Peru
LA1296	Tornamesa	Lima	Peru
LA1300	Santa Rosa de Quives	Lima	Peru
LA1304	Pampano	Huancavelica	Peru
LA1305	Ticrapo	Huancavelica	Peru
LA1331	Nazca	Ica	Peru
LA1339	Capillucas	Lima	Peru
LA1369	San Geronimo	Lima	Peru
LA1373	Asia	Lima	Peru
LA1377	Navan	Lima	Peru
LA1379	Caujul	Lima	Peru
LA1473	Callahuanca, Santa Eulalia valley	Lima	Peru
LA1551	Rimac Valley, Km 71	Lima	Peru
LA1552	Rimac Valley, Km 93	Lima	Peru
LA1554	Huaral to Cerro de Pasco, Rio Chancay	Lima	Peru
LA1609	Asia - El Pinon	Lima	Peru
LA1646	Yaso	Lima	Peru
LA1647	Huadquina, Topara	Ica	Peru
LA1653	Uchumayo, Arequipa	Arequipa	Peru
LA1677	Fundo Huadquina, Topara	Ica	Peru
LA1694	Cacachuhuasiin, Cacra	Lima	Peru
LA1722	Ticrapo Viejo	Huancavelica	Peru
LA1723	La Quinga	Ica	Peru
LA1744	Putinza	Lima	Peru
LA1910	Tambillo	Huancavelica	Peru
LA1937	Quebrada Torrecillas	Arequipa	Peru
LA1944	Rio Atico	Arequipa	Peru
LA1945	Caraveli	Arequipa	Peru
LA1973	Yura	Arequipa	Peru
LA2717	Chilca	Lima	Peru
LA2721	Putinza	Lima	Peru
LA2724	Huaynilla	Lima	Peru
LA2962	Echancay	Arequipa	Peru
LA2981B	Torata	Moquegua	Peru
LA3154	Otora-Puente Jaguay	Moquegua	Peru
LA3156	Omate Valley	Moquegua	Peru
LA3157*	Quebrada Tinajas	Lima	Peru
LA3219	Catarindo	Arequipa	Peru

Solanum galapagense (L. cheesmanii* f. *minor)			
LA0317	Bartolome	Galapagos	Ecuador
LA0426	Bartolome: E of landing	Galapagos	Ecuador
LA0436	Isabela: Villamil	Galapagos	Ecuador
LA0438	Isabela: coast at Villamil	Galapagos	Ecuador
LA0480A	Isabela: Cowley Bay	Galapagos	Ecuador
LA0483	Fernandina: inside crater	Galapagos	Ecuador
LA0526	Pinta: W Side	Galapagos	Ecuador
LA0527	Bartolome: W side, Tower Bay	Galapagos	Ecuador
LA0528	Santa Cruz: Academy Bay	Galapagos	Ecuador
LA0530	Fernandina: crater	Galapagos	Ecuador
LA0532	Pinzon: NW side	Galapagos	Ecuador
LA0747	Santiago: Cape Trenton	Galapagos	Ecuador
LA0748	Santiago: E Trenton Islet	Galapagos	Ecuador
LA0929	Isabela: Punta Flores	Galapagos	Ecuador
LA0930	Isabela: Punta Tortuga	Galapagos	Ecuador
LA1044	Bartolome	Galapagos	Ecuador
LA1136	Gardner-near-Floreana Islet	Galapagos	Ecuador
LA1137	Rabida: N side	Galapagos	Ecuador
LA1141	Santiago: N crater	Galapagos	Ecuador
LA1400	Isabela: N of Punta Tortuga	Galapagos	Ecuador
LA1401	Isabela: N of Punta Tortuga	Galapagos	Ecuador
LA1403	Fernandina: W of Punta Espinoza	Galapagos	Ecuador
LA1408	Isabela: SW volcano, Cape Berkeley	Galapagos	Ecuador
LA1410	Isabela: Punta Ecuador	Galapagos	Ecuador
LA1411	Santiago: N James Bay	Galapagos	Ecuador
LA1452	Isabela: E slope, Volcan Alcedo	Galapagos	Ecuador
LA1508	Floreana: Corona del Diablo Islet	Galapagos	Ecuador
LA1627	Isabela: Darwin's Lake	Galapagos	Ecuador

Solanum habrochaites (L. hirsutum* or *L. hirsutum* f. *glabratum)			
LA0094	Canta-Yangas	Lima	Peru
LA0361	Canta	Lima	Peru
LA0386	Cajamarca	Cajamarca	Peru
LA0387	Santa Apolonia	Cajamarca	Peru
LA0407	El Mirador, Guayaquil	Guayas	Ecuador
LA1033	Hacienda Taulis	Lambayeque	Peru
LA1223	Alausi	Chimborazo	Ecuador
LA1252	Loja, Jardin Botanico	Loja	Ecuador
LA1253	Pueblo Nuevo - Landangue	Loja	Ecuador
LA1255	Loja	Loja	Ecuador
LA1264	Bucay	Chimborazo	Ecuador
LA1265	Rio Chimbo	Chimborazo	Ecuador
LA1266	Pallatanga	Chimborazo	Ecuador
LA1295	Surco	Lima	Peru
LA1298	Yaso	Lima	Peru

Solanum habrochaites (L. hirsutum* or *L. hirsutum* f. *glabratum)			
LA1347	Empalme Otusco	La Libertad	Peru
LA1352	Rupe	Cajamarca	Peru
LA1353	Contumaza	Cajamarca	Peru
LA1354	Contumaza to Cascas	Cajamarca	Peru
LA1361	Pariacoto	Ancash	Peru
LA1362	Chacchan	Ancash	Peru
LA1363	Alta Fortaleza	Ancash	Peru
LA1366	Cajacay	Ancash	Peru
LA1378	Navan	Lima	Peru
LA1391	Bagua to Olmos	Cajamarca	Peru
LA1392	Huaraz - Casma Road	Ancash	Peru
LA1393	Huaraz - Caraz	Ancash	Peru
LA1557	Huaral to Cerro de Pasco, Rio Chancay	Lima	Peru
LA1559	Desvio Huamantanga-Canta	Lima	Peru
LA1560	Matucana	Lima	Peru
LA1624	Jipijapa	Manabi	Ecuador
LA1625	S of Jipijapa	Manabi	Ecuador
LA1648	Above Yaso	Lima	Peru
LA1681	Mushka	Lima	Peru
LA1691	Yauyos	Lima	Peru
LA1695	Cacachuhuasiin, Cacra	Lima	Peru
LA1696	Huanchuy to Cacra	Lima	Peru
LA1717	Sopalache	Piura	Peru
LA1718	Huancabamba	Piura	Peru
LA1721	Ticrapo Viejo	Huancavelica	Peru
LA1731	Rio San Juan	Huancavelica	Peru
LA1736	Pucutay	Piura	Peru
LA1737	Cashacoto	Piura	Peru
LA1738	Desfiladero	Piura	Peru
LA1739	Canchaque to Cerran	Piura	Peru
LA1740	Huancabamba	Piura	Peru
LA1741	Sondorillo	Piura	Peru
LA1753	Surco	Lima	Peru
LA1761	Rio Chillon	Lima	Peru
LA1764	West of Canta	Lima	Peru
LA1772	West of Canta	Lima	Peru
LA1775	Rio Casma	Ancash	Peru
LA1777	Rio Casma	Ancash	Peru
LA1778	Rio Casma	Ancash	Peru
LA1779	Rio Casma	Ancash	Peru
LA1918	Llauta	Ayacucho	Peru
LA1927	Ocobamba	Ayacucho	Peru
LA1928	Ocana	Ayacucho	Peru
LA1978	Colca	Ancash	Peru
LA1986*	Casmiche	La Libertad	Peru

Solanum habrochaites (L. hirsutum* or *L. hirsutum* f. *glabratum)			
LA2092	Chinuko	Chimborazo	Ecuador
LA2098	Sabianga	Loja	Ecuador
LA2099	Sabiango to Zozoranga	Loja	Ecuador
LA2100	Sozoranga	Loja	Ecuador
LA2101	San Pedro de Cariamanga	Loja	Ecuador
LA2103	Lansaca	Loja	Ecuador
LA2104	Pena Negra	Loja	Ecuador
LA2105	Jardin Botanico, Loja	Loja	Ecuador
LA2106	Yambra - La Providencia	Loja	Ecuador
LA2107	Los Lirios	Loja	Ecuador
LA2108	Portete de Anganuma	Loja	Ecuador
LA2109	Yangana #1	Loja	Ecuador
LA2110	Yangana #2	Loja	Ecuador
LA2114	San Juan	Loja	Ecuador
LA2115	Pucala	Loja	Ecuador
LA2116	Las Juntas	Loja	Ecuador
LA2119	Saraguro	Loja	Ecuador
LA2124	Cumbaratza	Zamora-Chinchipe	Ecuador
LA2128	Zumbi	Zamora-Chinchipe	Ecuador
LA2144	Chanchan	Chimborazo	Ecuador
LA2155	Maydasbamba	Cajamarca	Peru
LA2156	Ingenio Montan	Cajamarca	Peru
LA2158	Rio Chotano	Cajamarca	Peru
LA2159	Atonpampa	Cajamarca	Peru
LA2167	Cementerio Cajamarca	Cajamarca	Peru
LA2171	El Molino	Piura	Peru
LA2174	Rio Chinchipe, San Augustin	Cajamarca	Peru
LA2175	Timbaruca	Cajamarca	Peru
LA2196	Caclic	Amazonas	Peru
LA2204	Balsapata	Amazonas	Peru
LA2314	San Francisco	Amazonas	Peru
LA2321	Chirico	Amazonas	Peru
LA2324	Leimebamba	Amazonas	Peru
LA2329	Aricapampa	La Libertad	Peru
LA2409	Rio Miraflores	Lima	Peru
LA2541*	Olmos-Jaen	Lambayeque	Peru
LA2552	Las Flores	Cajamarca	Peru
LA2556	Puente Moche	La Libertad	Peru
LA2567	Quita	Ancash	Peru
LA2574	Cullaspungro	Ancash	Peru
LA2648	Santo Domingo	Piura	Peru
LA2650	Ayabaca	Piura	Peru
LA2651	Puente Tordopa	Piura	Peru
LA2722	Puente Auco	Lima	Peru
LA2812	Lambayeque	Lambayeque	Peru

Solanum habrochaites (L. hirsutum **or** ***L. hirsutum*** **f.** ***glabratum)***			
LA2855	Mollinomuna	Loja	Ecuador
LA2859*	Yangana	Loja	Ecuador
LA2860	Cariamanga	Loja	Ecuador
LA2861	Las Juntas	Loja	Ecuador
LA2863	Macara	Loja	Ecuador
LA2864	Sozorango	Loja	Ecuador
LA2868*	Arenillas	El Oro	Ecuador
LA2869	Matala	Loja	Ecuador
LA2975	Coltao	Ancash	Peru
LA2976	Huangra	Ancash	Peru

Solanum huaylasense (L. peruvianum)			
LA0110	Cajacay	Ancash	Peru
LA1358	Yautan	Ancash	Peru
LA1360	Pariacoto	Ancash	Peru
LA1364	Alta Fortaleza	Ancash	Peru
LA1365	Caranquilloc	Ancash	Peru
LA1979*	Colca (Rio Fortaleza)	Ancash	Peru
LA1981	Vocatoma	Ancash	Peru
LA1982	Huallanca	Ancash	Peru
LA1983	Rio Manta	Ancash	Peru
LA2068	Chasquitambo	Ancash	Peru
LA2561	Huallanca	Ancash	Peru
LA2562	Canon del Pato	Ancash	Peru
LA2563	Canon del Pato	Ancash	Peru
LA2575	Valle de Casma	Ancash	Peru
LA2808	Huaylas	Ancash	Peru
LA2809	Huaylas	Ancash	Peru

Solanum juglandifolium			
LA2120	Sabanilla	Zamora-Chinchipe	Ecuador
LA2134	Tinajillas	Zamora-Chinchipe	Ecuador
LA2788	Quebrada La Buena	Antioquia	Colombia
LA3322	San Juan - Chiriboga	Pichincha	Ecuador
LA3324	Sabanillas	Zamora-Chinchipe	Ecuador
LA3325	Cosanga	Napo	Ecuador

Solanum lycopersicoides			
LA1964	Chupapalca	Tacna	Peru
LA1966	Palca	Tacna	Peru
LA1990	Palca	Tacna	Peru
LA1991	Causiri	Tacna	Peru
LA2385	Chupapalca to Ingenio	Tacna	Peru
LA2386	Chupapalca	Tacna	Peru
LA2387	Lago Aricota	Tacna	Peru

Solanum lycopersicoides			
LA2407	Arica to Putre	Arica-Parinacota	Chile
LA2408	Above Putre	Arica-Parinacota	Chile
LA2730	Moquella	Tarapaca	Chile
LA2772	Zapahuira	Arica-Parinacota	Chile
LA2776	Catarata de Perquejeque	Arica-Parinacota	Chile
LA2777	Putre	Arica-Parinacota	Chile
LA2781	Desvio a Putre	Arica-Parinacota	Chile
LA2951	Quistagama	Tarapaca	Chile
LA4123	Camina	Tarapaca	Chile
LA4126	Camina - Nama	Tarapaca	Chile
LA4130	Pachica (Rio Camarones)	Arica-Parinacota	Chile
LA4131	Esquina	Arica-Parinacota	Chile
LA4320	Rio Lluta	Arica-Parinacota	Chile
LA4322	Quebrada Cardones	Arica-Parinacota	Chile
LA4323	Putre	Arica-Parinacota	Chile
LA4326	Cochiza, Rio Camarones	Arica-Parinacota	Chile

Solanum lycopersicum (L. esculentum* var. *cerasiforme)			
LA0168		New Caledonia	
LA0292	Santa Cruz	Galapagos	Ecuador
LA0349	(unknown origin)		Unknown
LA0384	Chilete (Rio Jequetepeque)	Cajamarca	Peru
LA0475	Sucua	Morona-Santiago	Ecuador
LA0476	Sucua	Morona-Santiago	Ecuador
LA1025	Oahu: Wahiawa	Hawaii	USA
LA1203	Ciudad Vieja		Guatemala
LA1204	Quetzaltenango		Guatemala
LA1205	Copan		Honduras
LA1206	Copan Ruins		Honduras
LA1207			Mexico
LA1208	Sierra Nevada		Colombia
LA1209			Colombia
LA1226	Sucua	Morona-Santiago	Ecuador
LA1227	Sucua	Morona-Santiago	Ecuador
LA1228	Macas, San Jacinto de los Monos	Morona-Santiago	Ecuador
LA1229	Macas	Morona-Santiago	Ecuador
LA1230	Macas	Morona-Santiago	Ecuador
LA1231	Tena	Napo	Ecuador
LA1247	La Toma	Loja	Ecuador
LA1268	Chaclacayo	Lima	Peru
LA1286	San Martin de Pangoa	Junin	Peru
LA1287	Fundo Ileana #1	Junin	Peru
LA1289	Fundo Ileana #3	Junin	Peru
LA1290	Mazamari	Junin	Peru
LA1291	Satipo Granja	Junin	Peru

Solanum lycopersicum (L. esculentum **var.** ***cerasiforme)***			
LA1307	Hotel Oasis	Ayacucho	Peru
LA1308	San Francisco	Ayacucho	Peru
LA1310	Hacienda Santa Rosa	Ayacucho	Peru
LA1311-1	Santa Rosa Puebla	Ayacucho	Peru
LA1311-	Santa Rosa Puebla	Ayacucho	Peru
LA1311-	Santa Rosa Puebla	Ayacucho	Peru
LA1311-	Santa Rosa Puebla	Ayacucho	Peru
LA1311-	Santa Rosa Puebla	Ayacucho	Peru
LA1311-	Santa Rosa Puebla	Ayacucho	Peru
LA1311-	Santa Rosa Puebla	Ayacucho	Peru
LA1311-	Santa Rosa Puebla	Ayacucho	Peru
LA1311-	Santa Rosa Puebla	Ayacucho	Peru
LA1311-	Santa Rosa Puebla	Ayacucho	Peru
LA1311-	Santa Rosa Puebla	Ayacucho	Peru
LA1311-2	Santa Rosa Puebla	Ayacucho	Peru
LA1311-3	Santa Rosa Puebla	Ayacucho	Peru
LA1311-4	Santa Rosa Puebla	Ayacucho	Peru
LA1311-5	Santa Rosa Puebla	Ayacucho	Peru
LA1311-6	Santa Rosa Puebla	Ayacucho	Peru
LA1311-7	Santa Rosa Puebla	Ayacucho	Peru
LA1311-8	Santa Rosa Puebla	Ayacucho	Peru
LA1311-9	Santa Rosa Puebla	Ayacucho	Peru
LA1312-2	Paisanato	Cusco	Peru
LA1312-3	Paisanto	Cusco	Peru
LA1312-4	Paisanato	Cusco	Peru
LA1314	Granja Pichari	Cusco	Peru
LA1320	Hacienda Carmen	Apurimac	Peru
LA1323	Pfacchayoc	Cusco	Peru
LA1324	Hacienda Potrero, Quillabamba	Cusco	Peru
LA1328	Rio Pachachaca	Apurimac	Peru
LA1334	Pescadores	Arequipa	Peru
LA1338	Puyo	Napo	Ecuador
LA1372	Santa Eulalia	Lima	Peru
LA1385	Quincemil	Cusco	Peru
LA1386	Balsas	Amazonas	Peru
LA1387	Quincemil	Cusco	Peru
LA1388	San Ramon	Junin	Peru
LA1423	Near Santo Domingo	Pichincha	Ecuador
LA1429	La Estancilla	Manabi	Ecuador
LA1453	Kauai: Poipu	Hawaii	USA
LA1454	unknown		Mexico
LA1455	Gral Teran	Nuevo Leon	Mexico
LA1456	Papantla	Vera Cruz	Mexico
LA1457	Tehuacan	Puebla	Mexico
LA1458	Huachinango	Puebla	Mexico

Solanum lycopersicum (L. esculentum* var. *cerasiforme)			
LA1461	Los Banos		Philippines
LA1464	El Progreso, Yoro		Honduras
LA1465	Taladro, Comayagua		Honduras
LA1467	Cali	Cauca	Colombia
LA1468	Fte. Casa, Cali	Cauca	Colombia
LA1479	Sucua	Morona-Santiago	Ecuador
LA1480	Sucua	Morona-Santiago	Ecuador
LA1481	Sucua	Morona-Santiago	Ecuador
LA1482	Segamat		Malaysia
LA1483	Trujillo		Saipan
LA1509	Tawan	Sabah, Borneo	Malaysia
LA1510			Mexico
LA1511	Sete Lagoas	Minas Gerais	Brazil
LA1512	Lago de Llopango		El Salvador
LA1519	Vitarte	Lima	Peru
LA1540	Cali - Popayan	Cauca	Colombia
LA1542	Turrialba		Costa Rica
LA1543	Upper Parana		Brazil
LA1545	Becan Ruins	Campeche	Mexico
LA1548	Fundo Liliana	Junin	Peru
LA1549	Chontabamba	Pasco	Peru
LA1569	Jalapa	Vera Cruz	Mexico
LA1574	Nana	Lima	Peru
LA1619	Pichanaki	Junin	Peru
LA1620	Castro Alves	Bahia	Brazil
LA1621	Rio Venados	Hidalgo	Mexico
LA1622	Lusaka		Zambia
LA1623	Muna	Yucatan	Mexico
LA1654	Tarapoto	San Martin	Peru
LA1655	Tarapoto	San Martin	Peru
LA1662	El Ejido	Merida	Venezuela
LA1667	Cali	Cauca	Colombia
LA1668	Acapulco	Guerrero	Mexico
LA1673	Nana	Lima	Peru
LA1701	Trujillo	La Libertad	Peru
LA1705		Sinaloa	Mexico
LA1709	Desvio Yojoa		Honduras
LA1710	Cariare	Limon	Costa Rica
LA1711	Zamorano		Honduras
LA1712	Pejibaye	San Jose	Costa Rica
LA1713	CATIE, Turrialba		Costa Rica
LA1909	Quillabamba	Cusco	Peru
LA1953	La Curva	Arequipa	Peru
LA2076	Naranjitos		Bolivia
LA2077	Paco, Coroica	La Paz	Bolivia

Solanum lycopersicum (L. esculentum **var.** ***cerasiforme)***			
LA2078	Mosardas	Rio Grande de Sol	Brazil
LA2079	Maui: Kihei	Hawaii	USA
LA2080	Maui: Kihei	Hawaii	USA
LA2081	Maui: Kihei	Hawaii	USA
LA2082	Arenal Valley		Honduras
LA2085	Kempton Park		S. Africa
LA2095	La Cidra, Olmedo	Loja	Ecuador
LA2121	Yacuambi-Guadalupe	Zamora-Chinchipe	Ecuador
LA2122A	Yacuambi-Guadalupe	Zamora-Chinchipe	Ecuador
LA2122B	Yacuambi-Guadalupe	Zamora-Chinchipe	Ecuador
LA2122C	Yacuambi-Guadalupe	Zamora-Chinchipe	Ecuador
LA2122D	Yacuambi-Guadalupe	Zamora-Chinchipe	Ecuador
LA2123A	La Saquea	Zamora-Chinchipe	Ecuador
LA2123B	La Saquea	Zamora-Chinchipe	Ecuador
LA2126A	El Dorado	Zamora-Chinchipe	Ecuador
LA2126B	El Dorado	Zamora-Chinchipe	Ecuador
LA2126C	El Dorado	Zamora-Chinchipe	Ecuador
LA2126D	El Dorado	Zamora-Chinchipe	Ecuador
LA2127	Zumbi	Zamora-Chinchipe	Ecuador
LA2129	San Roque	Zamora-Chinchipe	Ecuador
LA2130	Gualaquiza	Zamora-Chinchipe	Ecuador
LA2131	Bomboiza	Zamora-Chinchipe	Ecuador
LA2135	Limon	Morona-Santiago	Ecuador
LA2136	Bella Union	Morona-Santiago	Ecuador
LA2137	Tayusa	Morona-Santiago	Ecuador
LA2138A	Chinimpimi	Morona-Santiago	Ecuador
LA2138B	Chinimpimi	Morona-Santiago	Ecuador
LA2139A	Logrono	Morona-Santiago	Ecuador
LA2139B	Logrono	Morona-Santiago	Ecuador
LA2140A	Huambi	Morona-Santiago	Ecuador
LA2140B	Huambi	Morona-Santiago	Ecuador
LA2140C	Huambi	Morona-Santiago	Ecuador
LA2141	Rio Blanco	Morona-Santiago	Ecuador
LA2142	Cambanaca	Morona-Santiago	Ecuador
LA2143	Nuevo Rosario	Morona-Santiago	Ecuador
LA2177A	San Ignacio	Cajamarca	Peru
LA2177B	San Ignacio	Cajamarca	Peru
LA2177C	San Ignacio	Cajamarca	Peru
LA2177E	San Ignacio	Cajamarca	Peru
LA2177F	San Ignacio	Cajamarca	Peru
LA2205A	Santa Rosa de Mirador	San Martin	Peru
LA2205B	Santa Rosa de Mirador	San Martin	Peru
LA2308	San Francisco	San Martin	Peru
LA2312	Jumbilla #1	Amazonas	Peru
LA2313	Jumbilla #2	Amazonas	Peru

Solanum lycopersicum (L. esculentum* var. *cerasiforme)			
LA2392	Jakarta?		Indonesia
LA2393	Mercedes	Guanacaste	Costa Rica
LA2394	San Rafael de Hojancha	Guanacaste	Costa Rica
LA2411	Yanamayo	Puno	Peru
LA2587			
LA2616	Naranjillo	Huanuco	Peru
LA2617	El Oropel	Huanuco	Peru
LA2618	Santa Lucia, Tulumayo	Huanuco	Peru
LA2619	Caseria San Augustin	Loreto	Peru
LA2620	La Divisoria	Loreto	Peru
LA2621	3 de Octubre	Loreto	Peru
LA2624	Umashbamba	Cusco	Peru
LA2625	Chilcachaca	Cusco	Peru
LA2626	Pacchac-chico	Cusco	Peru
LA2627	Pacchac-chico	Cusco	Peru
LA2629	Echarate/Tornillochayoc	Cusco	Peru
LA2630	Calzada	Cusco	Peru
LA2631	Chontachayoc	Cusco	Peru
LA2632	Maranura	Cusco	Peru
LA2633	Huayopata	Cusco	Peru
LA2635	Huayopata	Cusco	Peru
LA2636	Sicre	Cusco	Peru
LA2637	Sicre	Cusco	Peru
LA2640	Molinopata	Apurimac	Peru
LA2642	Molinopata	Apurimac	Peru
LA2643	Bella Vista	Apurimac	Peru
LA2660	San Ignacio de Moxos	Beni	Bolivia
LA2664	Yanahuaya	Puno	Peru
LA2667	Pajchani	Puno	Peru
LA2668	Cruz Playa	Puno	Peru
LA2669	Huayvaruni #1	Puno	Peru
LA2670	Huayvaruni #2	Puno	Peru
LA2671	San Juan del Oro, School	Puno	Peru
LA2673	Chuntopata	Puno	Peru
LA2674	Huairurune	Puno	Peru
LA2675	Casahuiri	Puno	Peru
LA2683	Consuelo	Cusco	Peru
LA2684	Patria	Cusco	Peru
LA2685	Gavitana	Madre de Dios	Peru
LA2686	Yunguyo	Madre de Dios	Peru
LA2687	Mansilla	Madre de Dios	Peru
LA2688	Santa Cruz near Shintuyo #1	Madre de Dios	Peru
LA2689	Santa Cruz near Shintuyo #2	Madre de Dios	Peru
LA2690	Atalaya	Cusco	Peru
LA2691	Rio Pilcopata	Cusco	Peru

Solanum lycopersicum (L. esculentum* var. *cerasiforme)			
LA2692	Pilcopata #1	Cusco	Peru
LA2693	Pilcopata #2	Cusco	Peru
LA2694	Aguasantas	Cusco	Peru
LA2700	Aoti, Satipo	Junin	Peru
LA2702	Kandy #1		Sri Lanka
LA2709	Bidadi, Bangalore	Karnataka	India
LA2710	Porto Firme		Brazil
LA2782	El Volcan #1 - Pajarito	Antioquia	Colombia
LA2783	El Volcan #2 - Titiribi	Antioquia	Colombia
LA2784	La Queronte, Andes	Antioquia	Colombia
LA2785	El Bosque, Andes	Antioquia	Colombia
LA2786	Andes #1	Antioquia	Colombia
LA2787	Andes #2	Antioquia	Colombia
LA2789	Canaveral	Antioquia	Colombia
LA2790	Buenos Aires	Antioquia	Colombia
LA2791	Rio Frio	Antioquia	Colombia
LA2792	Tamesis	Antioquia	Colombia
LA2793	La Mesa	Antioquia	Colombia
LA2794	El Libano	Antioquia	Colombia
LA2795	Camilo	Antioquia	Colombia
LA2807	Taypiplaya	Yungas	Bolivia
LA2811	Cerro Huayrapampa	Apurimac	Peru
LA2814	Ccascani, Sandia	Puno	Peru
LA2841	Chinuna	Amazonas	Peru
LA2842	Santa Rita	San Martin	Peru
LA2843	Moyobamba mercado	San Martin	Peru
LA2844	Shanhao	San Martin	Peru
LA2845	Mercado Moyobamba	San Martin	Peru
LA2871	Chamaca	La Paz	Bolivia
LA2873	Lote Pablo Luna #2	La Paz	Bolivia
LA2874	Playa Ancha	La Paz	Bolivia
LA2933	Jipijapa	Manabi	Ecuador
LA2977	Belen	Beni	Bolivia
LA2978	Belen	Beni	Bolivia
LA3135	Pinal del Jigue	Holguin	Cuba
LA3136	Arroyo Rico	Holguin	Cuba
LA3137	Pinares de Mayari	Holguin	Cuba
LA3138	El Quemada	Holguin	Cuba
LA3139	San Pedro de Cananova	Holguin	Cuba
LA3140	Los Platanos	Holguin	Cuba
LA3141	Guira de Melena	La Habana	Cuba
LA3162	N of Copan		Honduras
LA3452	CATIE, Turrialba	Turrialba	Costa Rica
LA3633	Botanical garden		Ghana
LA3842	El Limon, Maracay	Aragua	Venezuela

Solanum lycopersicum (L. esculentum* var. *cerasiforme)			
LA3843	El Limon, Maracay	Aragua	Venezuela
LA3844	Algarrobito	Guarico	Venezuela
LA4352	Bamoa	Sinaloa	Mexico
LA4353	Guasave	Sinaloa	Mexico

Solanum neorickii (L. parviflorum)			
LA0247	Chavinillo	Huanuco	Peru
LA0735	Huariaca	Huanuco	Peru
LA1319	Abancay	Apurimac	Peru
LA1321	Curahuasi	Apurimac	Peru
LA1322	Limatambo	Cusco	Peru
LA1326	Rio Pachachaca	Apurimac	Peru
LA1329	Yaca	Apurimac	Peru
LA1626A	Mouth of Rio Rupac	Ancash	Peru
LA1716	Huancabamba	Piura	Peru
LA2072	Huanuco	Huanuco	Peru
LA2073	Huanuco, N of San Rafael	Huanuco	Peru
LA2074	Huanuco	Huanuco	Peru
LA2075	Huanuco	Huanuco	Peru
LA2113	La Toma	Loja	Ecuador
LA2133	Ona	Azuay	Ecuador
LA2190	Tialango	Amazonas	Peru
LA2191	Campamento Ingenio	Amazonas	Peru
LA2192	Pedro Ruiz	Amazonas	Peru
LA2193	Churuja	Amazonas	Peru
LA2194	Chachapoyas West	Amazonas	Peru
LA2195	Caclic	Amazonas	Peru
LA2197	Caclic - Luya	Amazonas	Peru
LA2198	Chachapoyas East	Amazonas	Peru
LA2200	Choipiaco	Amazonas	Peru
LA2201	Pipus	Amazonas	Peru
LA2202	Tingobamba	Amazonas	Peru
LA2315	Sargento	Amazonas	Peru
LA2317	Zuta	Amazonas	Peru
LA2318	Lima Tambo	Amazonas	Peru
LA2319	Chirico	Amazonas	Peru
LA2325	Above Balsas	Amazonas	Peru
LA2403	Wandobamba	Huanuco	Peru
LA2613	Matichico-San Rafael	Huanuco	Peru
LA2614	San Rafael	Huanuco	Peru
LA2615	Ayancocho	Huanuco	Peru
LA2639A	Puente Cunyac	Apurimac	Peru
LA2641	Nacchera	Apurimac	Peru
LA2727	Ona	Azuay	Ecuador
LA2847	Suyubamba	Amazonas	Peru

Solanum neorickii (L. parviflorum)			
LA2848	Pedro Ruiz	Amazonas	Peru
LA2862	Saraguro-Cuenca	Azuay	Ecuador
LA2865	Rio Leon	Azuay	Ecuador
LA2913	Uchucyaco - Hujainillo	Huanuco	Peru
LA4020	Gonozabal	Loja	Ecuador
LA4021	Guancarcucho	Azuay	Ecuador
LA4022	Pueblo Nuevo	Azuay	Ecuador
LA4023	Paute	Azuay	Ecuador

Solanum ochranthum			
LA2118	San Lucas	Loja	Ecuador
LA2160	Acunac	Cajamarca	Peru
LA2161	Cruz Roja	Cajamarca	Peru
LA2162	Yatun	Cajamarca	Peru
LA2166	Pacopampa	Cajamarca	Peru
LA2203	Pomacochas	Amazonas	Peru
LA2682	Chinchaypujio	Cusco	Peru

Solanum pennellii (L. pennellii or L. pennellii var. puberulum)			
LA0716	Atico	Arequipa	Peru
LA0750	Palpa to Nazca	Ica	Peru
LA0751	Sisacaya	Lima	Peru
LA1272	Pisaquera	Lima	Peru
LA1273	Cayan	Lima	Peru
LA1275	Quilca road junction	Lima	Peru
LA1277	Trapiche	Lima	Peru
LA1282	Sisacaya	Lima	Peru
LA1297	Pucara	Lima	Peru
LA1299	Santa Rosa de Quives	Lima	Peru
LA1302	Quita Sol	Ica	Peru
LA1303	Pampano	Huancavelica	Peru
LA1340	Pacaran	Lima	Peru
LA1356	Moro	Ancash	Peru
LA1367	Santa Eulalia	Lima	Peru
LA1376	Sayan	Lima	Peru
LA1515	Sayan to Churin	Lima	Peru
LA1522	Quintay	Lima	Peru
LA1523*	Irrigacion Santa Rosa	Lima	Peru
LA1649	Molina	Ica	Peru
LA1656	Marca to Chincha	Ica	Peru
LA1657	Buena Vista to Yautan	Ancash	Peru
LA1674	Toparilla Canyon	Lima	Peru
LA1693	Quebrada Machuranga	Lima	Peru
LA1724	La Quinga	Ica	Peru
LA1732	Rio San Juan	Huancavelica	Peru

Solanum pennellii (L. pennellii or L. pennellii var. puberulum)			
LA1733	Rio Canete	Lima	Peru
LA1734	Rio Canete	Lima	Peru
LA1735	Rio Canete	Lima	Peru
LA1773	Rio Casma	Ancash	Peru
LA1809	El Horador (playa)	Piura	Peru
LA1911	Locari	Ica	Peru
LA1912	Cerro Locari	Ica	Peru
LA1920	Cachiruma	Ayacucho	Peru
LA1926	Agua Perdida	Ica	Peru
LA1940	Rio Atico, Km 26	Arequipa	Peru
LA1941	Rio Atico, Km 41	Arequipa	Peru
LA1942	Rio Atico, Km 54	Arequipa	Peru
LA1943	Rio Atico, Km 61	Arequipa	Peru
LA1946	Caraveli	Arequipa	Peru
LA2560	Santa to Huaraz	Ancash	Peru
LA2580	Valle de Casma	Ancash	Peru
LA2657	Bayovar	Piura	Peru
LA2720*	Pacaran-Catahuasi	Lima	Peru
LA2963	Acoy	Arequipa	Peru

Solanum peruvianum (L. peruvianum)			
LA0098	Chilca	Lima	Peru
LA0111	Supe	Lima	Peru
LA0153	Culebras	Ancash	Peru
LA0370	Hacienda Huampani	Lima	Peru
LA0371	Supe	Lima	Peru
LA0372	Culebras #1	Ancash	Peru
LA0374	Culebras #2	Ancash	Peru
LA0445	Chincha #2	Ica	Peru
LA0446	Lomas de Atiquipa	Arequipa	Peru
LA0448	Chala	Arequipa	Peru
LA0453	Yura #2	Arequipa	Peru
LA0454	Tambo	Arequipa	Peru
LA0455	Tambo	Arequipa	Peru
LA0462	Sobraya	Arica-Parinacota	Chile
LA0464	Hacienda Rosario	Arica-Parinacota	Chile
LA0752	Sisicaya	Lima	Peru
LA1161	Huachipa	Lima	Peru
LA1270	Pisiquillo	Lima	Peru
LA1278	Trapiche	Lima	Peru
LA1333	Loma Camana	Arequipa	Peru
LA1336	Atico	Arequipa	Peru
LA1337	Atiquipa	Arequipa	Peru
LA1368	San Jose de Palla	Lima	Peru
LA1474	Lomas de Camana	Arequipa	Peru

***Solanum peruvianum* (*L. peruvianum*)**			
LA1475	Fundo 'Los Anitos', Barranca	Lima	Peru
LA1513	Atiquipa	Arequipa	Peru
LA1517	Irrigacion Santa Rosa	Lima	Peru
LA1537	Azapa Valley	Arica-Parinacota	Chile
LA1556	Hacienda Higuereta	Lima	Peru
LA1616	La Rinconada	Lima	Peru
LA1675	Toparilla Canyon	Lima	Peru
LA1692	Putinza	Lima	Peru
LA1913	Tinguiayog	Ica	Peru
LA1929	La Yapana	Ica	Peru
LA1935	Lomas de Atiquipa	Arequipa	Peru
LA1947	Puerto Atico	Arequipa	Peru
LA1949	Las Calaveritas	Arequipa	Peru
LA1951	Ocona	Arequipa	Peru
LA1952*	Lomas de Camana	Arequipa	Peru
LA1954	Mollendo	Arequipa	Peru
LA1955	Matarani	Arequipa	Peru
LA1975	Desvio Santo Domingo	Lima	Peru
LA1977	Orcocoto	Lima	Peru
LA1989	(self-compatible selection)		
LA2573	Valle de Casma	Ancash	Peru
LA2581	Chacarilla (autotetraploid)	Arica-Parinacota	Chile
LA2732	Moquella	Tarapaca	Chile
LA2742	Camarones-Guancarane	Arica-Parinacota	Chile
LA2744	Sobraya	Arica-Parinacota	Chile
LA2745	Pan de Azucar	Arica-Parinacota	Chile
LA2770	Lluta valley	Arica-Parinacota	Chile
LA2834	Hacienda Asiento	Ica	Peru
LA2955B	Quistagama-Quisama	Tarapaca	Chile
LA2957B	Pozo	Tarapaca	Chile
LA2958*	Caleta Vitor	Arica-Parinacota	Chile
LA2959	Chaca to Caleta Vitor	Arica-Parinacota	Chile
LA2964	Quebrada de Burros	Tacna	Peru
LA3218	Quebrada Guerrero	Arequipa	Peru
LA3220	Cocachacra	Arequipa	Peru
LA3640	Mexico City		Mexico
LA3858	Canta	Lima	Peru
LA3900	(CMV tolerant selection)		
LA4125	Camina	Tarapaca	Chile
LA4317	Rio Lluta, desembocadura	Arica-Parinacota	Chile
LA4318	Sora - Molinos, Rio Lluta	Arica-Parinacota	Chile
LA4325	Caleta Vitor	Arica-Parinacota	Chile
LA4328	Pachica, Rio Camarones	Arica-Parinacota	Chile
LA4445	Azapa Valley, 27 km from Arica	Arica-Parinacota	Chile
LA4446	Azapa Valley, Km 37 from Arica	Arica-Parinacota	Chile

Solanum peruvianum (L. peruvianum)			
LA4447	Azapa Valley, Km 27 and Km 37 from	Tarapaca	Chile

Solanum pimpinellifolium (L. pimpinellifolium)			
LA0100	La Cantuta (Rimac Valley)	Lima	Peru
LA0114	Pacasmayo	La Libertad	Peru
LA0121	Trujillo	La Libertad	Peru
LA0122	Poroto	La Libertad	Peru
LA0369	La Cantuta (Rimac Valley)	Lima	Peru
LA0373	Culebras #1	Ancash	Peru
LA0375	Culebras #2	Ancash	Peru
LA0376	Hacienda Chiclin	La Libertad	Peru
LA0381	Pongo	La Libertad	Peru
LA0391	Magdalena (Rio Jequetepeque)	Cajamarca	Peru
LA0397	Hacienda Tuman	Lambayeque	Peru
LA0398	Hacienda Carrizal	Cajamarca	Peru
LA0400	Hacienda Buenos Aires	Piura	Peru
LA0411	Pichilingue	Los Rios	Ecuador
LA0412	Pichilingue	Los Rios	Ecuador
LA0413	Cerecita	Guayas	Ecuador
LA0417	Punta Polvora, Isla Puna	Guayas	Ecuador
LA0418	Daule	Guayas	Ecuador
LA0420	El Empalme	Guayas	Ecuador
LA0442	Sechin	Ancash	Peru
LA0443	Pichilingue	Los Rios	Ecuador
LA0480	Hacienda Santa Inez	Ica	Peru
LA0722	Trujillo	La Libertad	Peru
LA0753	Lurin	Lima	Peru
LA1236	Hotel Tinalandia, Santo Domingo	Pichincha	Ecuador
LA1237	Atacames	Esmeraldas	Ecuador
LA1242	Los Sapos	Guayas	Ecuador
LA1243	Murillo finca	Guayas	Ecuador
LA1245	Santa Rosa	El Oro	Ecuador
LA1246	La Toma	Loja	Ecuador
LA1248	Hacienda Monterrey	Loja	Ecuador
LA1256	Naranjal	Guayas	Ecuador
LA1257	Las Mercedes	Guayas	Ecuador
LA1258	Voluntario de Dios	Guayas	Ecuador
LA1259	Catarama	Los Rios	Ecuador
LA1260	Pueblo Viejo	Los Rios	Ecuador
LA1261	Babahoyo	Los Rios	Ecuador
LA1262	Milagro Empalme	Guayas	Ecuador
LA1263	Barranco Chico	Guayas	Ecuador
LA1269	Pisiquillo	Lima	Peru
LA1279	Cieneguilla	Lima	Peru
LA1280	Chontay	Lima	Peru

Solanum pimpinellifolium (L. pimpinellifolium)

LA1301	Hacienda San Ignacio	Ica	Peru
LA1332	Nazca area?	Ica	Peru
LA1335	Pescadores	Arequipa	Peru
LA1341	Huampani	Lima	Peru
LA1342	Casma	Ancash	Peru
LA1343	Puente Chao	La Libertad	Peru
LA1344	Laredo	La Libertad	Peru
LA1345	Samne	La Libertad	Peru
LA1348	Pacasmayo	La Libertad	Peru
LA1349	Cuculi	Lambayeque	Peru
LA1355	Nepena	Ancash	Peru
LA1357	Jimbe	Ancash	Peru
LA1359	La Crau	Ancash	Peru
LA1370	San Jose de Palla	Lima	Peru
LA1371	Santa Eulalia	Lima	Peru
LA1374	El Ingenio	Ica	Peru
LA1375	San Vicente de Canete	Lima	Peru
LA1380	Chanchape	Piura	Peru
LA1381	Naupe	Lambayeque	Peru
LA1382	Chachapoyas to Balsas	Amazonas	Peru
LA1383	Chachapoyas to Bagua	Amazonas	Peru
LA1384	Quebrada Parca	Lima	Peru
LA1416	Las Delicias	Pichincha	Ecuador
LA1428	La Estancilla	Manabi	Ecuador
LA1466	Chongoyape	Lambayeque	Peru
LA1469	El Pilar, Olmos	Lambayeque	Peru
LA1470	Motupe to Desvio Olmos-Bagua	Lambayeque	Peru
LA1471	Motupe to Jayanca	Lambayeque	Peru
LA1472	Quebrada Topara	Lima	Peru
LA1478	Santo Tome (Pabur)	Piura	Peru
LA1514	Sayan to Churin	Lima	Peru
LA1520	Sayan to Churin	Lima	Peru
LA1521	El Pinon, Asia	Lima	Peru
LA1547	Chota to El Angel	Carchi	Ecuador
LA1561	San Eusebio	Lima	Peru
LA1562	Cieneguilla	Lima	Peru
LA1571	San Jose de Palle	Lima	Peru
LA1572	Hacienda Huampani	Lima	Peru
LA1573	Nana	Lima	Peru
LA1575	Huaycan	Lima	Peru
LA1576	Manchay Alta	Lima	Peru
LA1577	Cartavio	La Libertad	Peru
LA1578	Santa Marta	La Libertad	Peru
LA1579	Colegio Punto Cuatro #1	Lambayeque	Peru
LA1580	Colegio Punto Cuatro #2	Lambayeque	Peru

Solanum pimpinellifolium (L. pimpinellifolium)			
LA1581	Punto Cuatro	Lambayeque	Peru
LA1582	Motupe	Lambayeque	Peru
LA1583	Tierra de la Vieja	Lambayeque	Peru
LA1584	Jayanca to La Vina	Lambayeque	Peru
LA1585	Cuculi	Lambayeque	Peru
LA1586	Zana, San Nicolas	La Libertad	Peru
LA1587	San Pedro de Lloc	La Libertad	Peru
LA1588	Laredo to Barraza	La Libertad	Peru
LA1589	Viru - Galunga	La Libertad	Peru
LA1590	Viru to Tomaval	La Libertad	Peru
LA1591	Ascope	La Libertad	Peru
LA1592	Moche	La Libertad	Peru
LA1593	Puente de Chao	La Libertad	Peru
LA1594	Cerro Sechin	Ancash	Peru
LA1595	Nepena to Samanco	Ancash	Peru
LA1596	Santa to La Rinconada	Ancash	Peru
LA1597	Rio Casma	Ancash	Peru
LA1598	Culebras to La Victoria	Ancash	Peru
LA1599	Huarmey	Ancash	Peru
LA1600	Las Zorras, Huarmey	Ancash	Peru
LA1601	La Providencia	Lima	Peru
LA1602	Punchauca	Lima	Peru
LA1603	Quilca	Lima	Peru
LA1604	Horcon	Lima	Peru
LA1605	Canete - San Antonio	Lima	Peru
LA1606	Tambo de Mora	Ica	Peru
LA1607	Canete - La Victoria	Lima	Peru
LA1608	Canete - San Luis	Lima	Peru
LA1610	Asia - El Pinon	Lima	Peru
LA1611	Rio Mala	Lima	Peru
LA1612	Rio Chilca	Lima	Peru
LA1613	Hacienda Santa Eusebia	Lima	Peru
LA1614	Huaura -- Pampa Chumbes	Lima	Peru
LA1615	Piura to Simbala	Piura	Peru
LA1617	Tumbes South	Tumbes	Peru
LA1618	Tumbes North	Tumbes	Peru
LA1628	Huanchaco	La Libertad	Peru
LA1629	Barrancos de Miraflores	Lima	Peru
LA1630	Fundo La Palma	Ica	Peru
LA1631	Planta Envasadora San Fernando	La Libertad	Peru
LA1633	Coop. Huayna Capac	Ica	Peru
LA1634	Fundo Bogotalla #1	Ica	Peru
LA1635	Fundo Bogotalla #2	Ica	Peru
LA1636	Laran	Ica	Peru
LA1637	La Calera	Ica	Peru

Solanum pimpinellifolium (L. pimpinellifolium)			
LA1638	Fundo El Portillo	Lima	Peru
LA1645	Banos de Miraflores	Lima	Peru
LA1651	Vivero, La Molina	Lima	Peru
LA1652	Cieneguilla	Lima	Peru
LA1659	Pariacoto	Ancash	Peru
LA1660	Yautan to Pariacoto	Ancash	Peru
LA1661	Esquina de Asia	Lima	Peru
LA1670	Rio Sama	Tacna	Peru
LA1676	Fundo Huadquina, Topara	Ica	Peru
LA1678	San Juan Lucumo de Topara	Ica	Peru
LA1679	Tambo de Mora	Ica	Peru
LA1680	La Encanada	Lima	Peru
LA1682	Montalban - San Vicente	Lima	Peru
LA1683	Miramar	Piura	Peru
LA1684	Chulucanas	Piura	Peru
LA1685	Marcavelica	Piura	Peru
LA1686	Valle Hermoso #1	Piura	Peru
LA1687	Valle Hermoso #2	Piura	Peru
LA1688	Pedregal	Piura	Peru
LA1689	Castilla #1	Piura	Peru
LA1690	Castilla #2	Piura	Peru
LA1697	Hacienda Quiroz, Santa Anita	Lima	Peru
LA1719	E of Arenillas	El Oro	Ecuador
LA1720	Yautan	Ancash	Peru
LA1728	Rio San Juan	Ica	Peru
LA1729	Rio San Juan	Ica	Peru
LA1742	Olmos-Marquina	Lambayeque	Peru
LA1781	Bahia de Caraquez	Manabi	Ecuador
LA1921	Majarena	Ica	Peru
LA1923	Coop. Cabildo	Ica	Peru
LA1924	Piedras Gordas	Ica	Peru
LA1925	Pangavari, Nazca	Ica	Peru
LA1933	Jaqui	Arequipa	Peru
LA1936	Huancalpa	Arequipa	Peru
LA1950	Pescadores	Arequipa	Peru
LA1987	Viru - Fundo Luis Enrique	La Libertad	Peru
LA1992	Pichicato	Lima	Peru
LA1993	Chicama Valley?	Lima	Peru
LA2093	La Union	El Oro	Ecuador
LA2096	Playa, near Catacocha	Loja	Ecuador
LA2097	Macara	Loja	Ecuador
LA2102	El Lucero	Loja	Ecuador
LA2112	Hacienda Monterrey	Loja	Ecuador
LA2145	Juan Montalvo	Los Rios	Ecuador
LA2146	Hacienda Limoncarro	La Libertad	Peru

Solanum pimpinellifolium (L. pimpinellifolium)			
LA2147	Yube	Cajamarca	Peru
LA2149	Puente Muyuna	Cajamarca	Peru
LA2170	Pai Pai	Cajamarca	Peru
LA2173	Cruz de Huayquillo	Cajamarca	Peru
LA2176	Timbaruca	Cajamarca	Peru
LA2178	Tororume	Cajamarca	Peru
LA2179	Tamboripa - La Manga	Cajamarca	Peru
LA2180	La Coipa	Cajamarca	Peru
LA2181	Balsa Huaico	Cajamarca	Peru
LA2182	Cumba	Amazonas	Peru
LA2183	Corral Quemado	Amazonas	Peru
LA2184	Bagua	Amazonas	Peru
LA2186	El Salao	Amazonas	Peru
LA2187	La Caldera	Amazonas	Peru
LA2188	Manchungal #1	Amazonas	Peru
LA2189	Manchungal #2	Amazonas	Peru
LA2335	(autotetraploid)		
LA2340	(autotetraploid)		
LA2345	(autodiploid)		
LA2346	(autodiploid)		
LA2347	(autodiploid)		
LA2348	Trujillo	La Libertad	Peru
LA2389	Tembladera	Cajamarca	Peru
LA2390	Chungal	Cajamarca	Peru
LA2391	Chungal to Monte Grande	Cajamarca	Peru
LA2401	Moxeque	Ancash	Peru
LA2412	Fundo Don Javier, Chilca	Lima	Peru
LA2533	Lomas de Latillo	Lima	Peru
LA2534*	Vista Florida, Chiclayo	Lambayeque	Peru
LA2535*	Patapo	Lambayeque	Peru
LA2536*	Patapo-La Cria	Lambayeque	Peru
LA2537*	Malpaso	Lambayeque	Peru
LA2538*	Malpaso	Lambayeque	Peru
LA2539*	Cuculi	Lambayeque	Peru
LA2540*	La Cria	Lambayeque	Peru
LA2543*	Pacanguilla-Pacasmayo	La Libertad	Peru
LA2544*	Pacasmayo-Huabal	La Libertad	Peru
LA2545*	Tembladera	Cajamarca	Peru
LA2546*	Tonan	Cajamarca	Peru
LA2547*	Yatahual	Cajamarca	Peru
LA2549*	La Muyuna	Cajamarca	Peru
LA2576	Valle de Casma	Ancash	Peru
LA2578	Tuturo	Ancash	Peru
LA2585	(autotetraploid)		
LA2628	Echarate/Tornillochayoc	Cusco	Peru

Solanum pimpinellifolium (L. pimpinellifolium)			
LA2645	Desvio Chulucanas	Piura	Peru
LA2646	Chalaco	Piura	Peru
LA2647	Morropon-Chalaco	Piura	Peru
LA2649*	Chulucanas	Piura	Peru
LA2652	Sullana	Piura	Peru
LA2653	San Francisco de Chocon Querecotillo	Piura	Peru
LA2655	La Huaca - Sullana	Piura	Peru
LA2656	Suarez	Tumbes	Peru
LA2659	Castilla, Univ. Nac. de Piura	Piura	Peru
LA2718	Chilca	Lima	Peru
LA2725	Tambo Colorado	Ica	Peru
LA2805	(‘Indehiscent currant’)		
LA2831	Rio Nazca	Ica	Peru
LA2832	Chichictara	Ica	Peru
LA2833	Hacienda Asiento	Ica	Peru
LA2836	Rio Aja	Ica	Peru
LA2839	Tialango	Amazonas	Peru
LA2840	San Hilarion de Tomaque	Amazonas	Peru
LA2850	Santa Rosa, Manta	Manabi	Ecuador
LA2851	La Carcel de Montecristo	Manabi	Ecuador
LA2852	Cirsto Rey de Charapoto	Manabi	Ecuador
LA2853	Experiment Station, Portoviejo-INIAP	Manabi	Ecuador
LA2854	Jipijapa	Manabi	Ecuador
LA2857	Isabela: Puerto Villamil	Galapagos	Ecuador
LA2866	Via a Amaluza	Loja	Ecuador
LA2914A	Urb. La Castellana, Surco	Lima	Peru
LA2914B	Urb. La Castellana, Surco	Lima	Peru
LA2915	El Remanso de Olmos	Lambayeque	Peru
LA2934	Carabayllo	Lima	Peru
LA2966	La Molina	Lima	Peru
LA2974	Huaca del Sol	La Libertad	Peru
LA2982	Chilca #1	Lima	Peru
LA2983	Chilca #2	Lima	Peru
LA3123	Santa Cruz: summit	Galapagos	Ecuador
LA3158	Los Mochis	Sinaloa	Mexico
LA3159	Los Mochis	Sinaloa	Mexico
LA3160	Los Mochis	Sinaloa	Mexico
LA3161	Los Mochis	Sinaloa	Mexico
LA3859	(TYLCV resistant selection)		
LA4138	El Corregidor, La Molina	Lima	Peru
LA4431	(*sun* in LA1589)		

Solanum sitiens (S. rickii)			
LA1974	Chuquicamata	Antofagasta	Chile
LA2876	Chuquicamata	Antofagasta	Chile

Solanum sitiens (S. rickii)			
LA2877	El Crucero	Antofagasta	Chile
LA2878	Mina La Exotica	Antofagasta	Chile
LA2885	Caracoles	Antofagasta	Chile
LA4105	Mina La Escondida	Antofagasta	Chile
LA4110	Mina San Juan	Antofagasta	Chile
LA4112	Aguada Limon Verde	Antofagasta	Chile
LA4113	Estacion Cere	Antofagasta	Chile
LA4114	Pampa Carbonatera	Antofagasta	Chile
LA4115	Quebrada desde Cerro Oeste de Paqui	Antofagasta	Chile
LA4116	Quebrada de Paqui	Antofagasta	Chile
LA4331	Cerro Quimal	Antofagasta	Chile

*Previously inactive, newly regenerated accession

Membership List

Aarden, Harriette Monsanto Holland BV, Dept. Tomato Breeding, LAAN VAN BRAAT, 21, DELFT, THE NETHERLANDS 2627CL h.aarden@gmail.com

Ballardini, Massimiliano Edasem Spa, Via G. Marconi 56, Casaleone, Verona, ITALY, 37052 mballardini@esasem.com

Barker, Susan University of Western Australia, School of Plant Biology M084, 35 Stirling Hwy, Crawley, WA, AUSTRALIA, 6009 sjbarker@plants.uwa.edu.au

Brown, Loretta Rijk Zwaan USA, 19040 Portola Dr Ste B, Salinas, CA, USA, 93908 L.brown@rijkzwaan.com

Buonfiglioli, Carlo Della Rimembranze nr. 6A, San Lazzaro di Savena, Bologna, ITALY 40068 red@prorainbow.com

Chen, Dei Wei Bucolic Seeds Co. Ltd., P.O. 2-39, Tantzu, Taichung Co., TAIWAN, 427 bucolic.seeds@msa.hinet.net

Chetelat, Roger University of California, Dept of Veg Crops, One Shields Ave, Davis, CA, USA 95616-8746 trchetelat@ucdavis.edu

deHoop, Simon Jan Hortigenetics Research LTD S.E. Asia, No. 7 Moo 9 Maefackmai, Sansai district, Chiang Mai, THAILAND 50290 simon.dehoop@eastwestseed.com

Galvez, Hayde U Philippines Los Banos, Genetics Lab, CSC-1PB, CA, UP Los Banos College Laguna, PHILIPPINES 4031 haydegalvez@gmail.com

Haga, Emily Johnny's Selected Seeds, 184 Foss Hill Rd, Albion, ME, USA, 04910 ehaga@johnnyseeds.com

Hanson, Peter AVRDC , PO Box 42, Shanhua, Tainan, TAIWAN, REPUBLIC of CHINA 741 peter.hanson@worldveg.org

Herlaar, Fritz Enza Zaden Export B.V., Research and Development, P.O. Box 7, Enkhuizen, THE NETHERLANDS, 1600 AA info@enzazaden.nl

Holloway, Heather M. Nightshade LLC, 816 E. Pennsylvania Dr., Boise, ID, USA, 83706 heather-4wildlife@hotmail.com

Hoogstraten, Jaap Seminis Veg Seeds, Postbus 97, 6700 AB Wageningen, THE NETHERLANDS jaap.hoogstraten@monsanto.com

Hutton, Sam University of Florida, Gulf Coast Research and Education Center, 14625 County Rd 672, Wimuama, FL, USA, 33598 sfhutton@ufl.edu

Inai, Shuji Nippon Del Monte Corp., Research and Development, 3748 Shimizu-Cho, Numata-shi, Gunma-ken, JAPAN, 378-0016 sinai@delmonte.co.jp

Joly, Marie-Pierre Vilmorin, Route du Manoir, La Menitre, FRANCE, 49250 marie-pierre.joly@vilmorin.com

Kaplan, Boaz Nirit Seeds LTD Ltd, P.O. Box 95, Moshav Hadar, Am, ISRAEL, 42935 boazk@niritseeds.com

Karwa, Anup Krishidhan Veg Seeds Private LTD, Krishidhan Bhanwan,, Additional MIDCJalna, Maharashtra, INDIA, 431203 anupkarwa@gmail.com

Kobori, Romulo F. Sakata Seed Sudamerica Ltda, PO Box 427, Av Dr. Plinio Salgado N, 4320, Bairro, Braganca Paulista, Sao Paulo, BRAZIL, 12-906-840 romulo.kobori@sakata.com.br

Kuehn, Michael HM Clause, 25757 CR 21A, Esparto, CA, USA, 95627
M.Kuehn@hmclause.com
Massoudi, Mark Ag Biotech Inc., P.O. Box 1325, San Juan Bautista, CA, USA, 95045
info@agbiotech.net
Maxwell, Douglas P. Max- Tach Services, 7711 Midtown Rd, Verona, WI, USA, 53593
douglas.maxwell08@gmail.com
Moisson, Chloe Technisem, Zone d' activite Anjou Actiparc de Jumelles, Longue
Jumelles, FRANCE, 49160 chloe.moisson@technisem.com
Myers, Jim Oregon State University, Dept. of Horticulture, rm 4017, Ag & Life
Sci Bldg., Corvallis, OR, USA, 97331 myersja@hort.oregonstate.edu
Nakamura, Kosuke Kagome Co. Ltd., 17 Nishitomiyama, Nasushiobarashi, Tochigi,
JAPAN, 329-2762 Kosuke_Nakamura@kagome.co.jp
Nukal, Balaji SeedWorks, 155 Ocean Lane Dr, #515, Key Biscayne, FL 33149
bnukal@seedworks.com
O'Brochta, William Roanoke Valley Governor's School, 3226 Pearwood Dr, Roanoke,
VA, USA, 24014 william@obrochta.net
Peters, Susan Nunhems USA, 7087 E. Peltier Rd., Acampo, CA, USA, 95220
susan.peters@bayer.com
Randhawa, Parm California Seed and Plant Lab , 7877 Pleasant Grove Rd, Elverta,
CA, USA, 95626 randhawa@calspl.com
Rascle, Christine CLAUSE, Centre de Recherche, Domaine de Maninet, Route de
Beaumont, Valence, FRANCE, 26000 christine.rascle@hmclause.com
Schuit, C.A. Bejo Zaden B.V., Molecular Market Technology & Genomics,
Trambaan 2, Warmenhuizen, CZ, Netherlands, 1747 c.schuit@bejo.nl
Scott, Jay University of Florida, Tomato Breeders, 14625 County Rd 672,
Wimauma, Fl, USA, 33598 jwsc@ufl.edu
Serquen, Felix Syngenta Seeds, 21435 Road 98, Woodland, CA, USA, 95695
felix.serquen@syngenta.com
Sharma, Sundrish Syngenta Seeds, Inc., 10290 Greenway Rd, Naples, FL, USA, 34114
sundrish.sharma@syngenta.com
Shekaste band, Reza University of Florida, Gulf Coast Research and Education Center,
14625 County Rd 672 Wimuama FL USA 33598 rezash@ufl.edu
Shintaku, Yurie 2-10-2, Shimizu, Suginami-ku, Tokyo, JAPAN , 167-0033
napoleon@jcom.home.ne.jp
Stack, Stephen Colorado State U, Dept of Biology, 1878 Campus Delivery, Fort
Collins, CO, USA, 80523-1878 sstack@lamar.colostate.edu
Stommel, Ph.D., John USDA-ARS, Genetic Improvement Fruits & Vegetables Laboratory,
Bldg. 010A, BARC-West, 10300 Baltimore Ave., Beltsville, MD, USA, 20705
john.stommel@ars.usda.gov
Thome, Catherine United Genetics Seeds Co., 764 Carr Ave., Aromas, CA, USA, 65004
cathy@unitedgenetics.com
Tikoo, Surinder K. Tierra Seed Science Pvt. Ltd., Breeding & Develoopment, Malaxmi
Courtyard, Khajaguda, Golconda Post, Hyderabad, INDIA, 500 008
suren@tierraseeds.com

van der Knaap, Koen Axia Vegetable Seeds, Delft, The Netherlands, 262gHH
koen@axiaseeds.com

van der Knaap, Ben FutureSupport Consultancy
ben_vanderknaap@hotmail.com

van Vuuren, Ansa Starke Ayres Seed (Pty) Ltd, Pepper and Tomato Researcher, P.O. Box 14366, Gauteng, BREDELL, SOUTH AFRICA, 1625 ansa@starkeayres.co.za

Vecchio, Franco Nunhems Italy SRL, Via Ghiarone 2, Sant' Agata, Bolognese (BO), ITALY, 40019

Verschave, Philippe Vilmorin, Route de Meynes, Ledenon, FRANCE, 30210
philippe.verschave@vilmorin.com

Volpin, Hanne Hazera Genetics Ltd., R&D Division, M.P. Lachish Darom, Lachish Darom, M.P., ISRAEL, 79354 hannav@hazera.com

Williamson, Valerie UC Davis, Dept. of Nematology, 1 Shields Ave, DavisCA, USA, 95616 vmwilliamson@ucdavis.edu

Zhiqi Jia Henan Agricultural Universityroom 313, no 2 building, No 95, Wenhua Rd, Jinshui District, Zhengzhou City, Henan Province, CHINA, 450002
zhiqijia@yahoo.com.cn

AUTHOR INDEX