# **Research Paper**

# Isolation and characterisation of *Ralstonia solanacearum* strains from *Solanaceae* crops in Ethiopia

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Eighty one isolates of *Ralstonia solanacearum*-like bacteria on triphenyl tetrazolium chloride (TTC) medium were collected from different *Solanaceae* crops (i.e. potato, tomato and pepper plants and potato tubers) at various sites in Ethiopia. Of these, 62 strains were identified as *R. solanacearum* based on their cultural characteristics on TTC medium, tomato pathogenicity bioassay, carbon source utilisation patterns and a specific PCR-based assay. By Hayward's classification method, based on carbon source utilisation, 19 of the 62 *R. solanacearum* strains were identified as biovar I and 43 strains were identified as biovar II. The biovar I strains exhibited a high growth rate at high temperatures (37 °C). Whereas the growth rate of biovar II strains, which were limited to potato, tomato, and eggplant. To our knowledge, this is the first report of *R. solanacearum* biovar I in Ethiopia. The existence of biovar II strains in Ethiopia raises concerns because they have a broader host range than biovar II strains.

Keywords: Bacterial wilt / biovar / characteristics / Ethiopia / Ralstonia solanacearum

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Ralstonia solanacearum (basonym Pseudomonas solanacearum [Smith 1896] Smith 1914; other synonyms Burkholderia solanacearum (Yabucchi et al. 1993, "Bacillus solanacearum" SMITH 1896) is a widespread and economically important bacterial plant pathogen in tropical, subtropical, and temperate regions (Hayward 1991, Horita and Tsuchiya 2001). Ralstonia solanacearum causes "bacterial wilt", a major disease that limits production of diverse crops such as potato, tomato, eggplant, pepper, tobacco, banana and peanut (French and Sequeria 1970, Williamson et al. 2002). The pathogen has an extended host range including hundreds of plant species in 50 families (Hayward 1995).

*R. solanacearum* is one of the most important and wide spread bacterial plant pathogens in Ethiopia, mainly in the off cropping season. Yaynu (1989) indicated that bacterial wilt is an important disease threatening the production of potato and tomato in many regions of Ethiopia. Moreover, incidence of the disease has been increasing. Disease incidence as high as 45% (Yaynu and Korobko 1986) and 63% (Bekele 1996) on potato and 55% (EARO 2002) on tomato were recorded in major potato producing areas of Ethiopia.

Based upon carbon source utilisation patterns R. solanacearum has been divided into five biovars (Hayward 1964, Hayward et al. 1990, He et al. 1983). In a previous study, 58 strains of R. solanacearum from potato and tomato collected at different sites in Ethiopia were identified as R. solanacearum biovar II (Yaynu 1989). Biovar II was reported to infect potatoes and tomatoes, and rarely eggplant (French and Sequeira 1970). However, in Ethiopia, pepper plants are infected by the pathogen and the intensity of bacterial wilt is increasing. This may be due to introduction of new strains to Ethiopia from other parts of the world through latently infected planting materials. The aim of this study was to isolate and characterise the strains isolated from potato, tomato, and pepper plants from different localities in Ethiopia based on their cultural and physiological characteristics and to determine biovars of R. solanacearum in Ethiopia.



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# Materials and methods

Origin and isolation: Initially 81 strains were isolated from potato, tomato, and pepper plants and potato tubers from various locations of Ethiopia during the 2003 off cropping season (February to May). Collections were from Jimma, Dedo, and Agaro in south west; Awassa and Shashemene in the south; Qarsa and Kombolcha in the east; Arjo, Kejo, and Bako in the west; and Guder, Ambo, Holeta, Gedo, Ginchi, Jeldu, Adam Tulu, and Ziway in central Ethiopia. Additional six strains were obtained from the collection of the Plant Protection Research Centre (PPRC), Ambo, Ethiopia. For comparison, five strains of R. solanacearum of the Göttingen Collection of Phytopathogenic Bacteria (GCPB), Göttingen University, Germany were included. The novel bacterial isolates investigated in this study were obtained from various diseased plants (potato, tomato and pepper roots and potato tubers) with symptoms of bacterial wilt. Isolations were performed at the the Plant Protection Laboratory at the Jimma University College of Agriculture and Veterinary Medicine (JUCAVM), Jimma, Ethiopia. Rootlets and tubers were thoroughly washed in tap water, and surface sterilized by dipping into 70% (vol/vol) ethanol and flamed (OEPP/EPPO 1990). Subsequently, plant material was chopped into sterile water using a disinfected scalpel. Rootlets and tuber pieces were maintained in the water for 30 min (Wullings et al. 1998) to allow bacteria to migrate from plant material. After 30 min two loopfuls of the suspension was streaked onto triphenyl tetrazolium chloride (TTC) agar (Kelman 1954). After 48 h incubation, colonies with morphology similar to R. solanacearum were purified and individual isolates were maintained temporarily in distilled water until they were transported to the Federal Biological Research Centre for Agriculture and Forestry (BBA), Darmstadt (Germany) for further analysis.

**Maintenance of cultures:** All the 81 strains were stored at room temperature in test tubes containing sterile distilled water (Kelman and Person 1961, Lozano and Sequeira 1970, Wullings *et al.* 1998). Strains were routinely subcultured on TTC agar (aerobic, 30 °C) and on casamino acids-peptone-glucose (CPG) agar (Smith *et al.* 1995).

**Strain identification:** World-wide the most frequently used method for detection and identification of *R. solanacearum* is the isolation on TTC agar (Kelman 1954) because of the relatively low cost and simplicity. Tomato bioassay also is currently recommended by the European Plant Protection Organization (EPPO) for detection of *R. solanacearum* in soil and on potato tubers

and for pathogenicity test (Elphinstone *et al.* 1996). With the development of *R. solanacearum* specific PCR methods, Ito *et al.* (1998) and Opina *et al.* (1997) were able to identify and detect viable cells of *R. solanacearum*. We combined the three methods so that the advantages of each method could be utilised and compared.

The 81 isolates, as well as the reference strains, were cultured on TTC agar on replicated plates and were incubated at 28 °C. Presumptive identification as *R. solanacearum* was made when colonies showed a characteristic red center and whitish margin on TTC medium as described by Kelman (1954).

Bioassay on tomato seedlings was performed according to Janse (1988). All isolates presumptively identified as R. solanacearum were inoculated on two week old tomato seedlings (cv. Matina) grown in 12 cm pots. Three replicate seedlings were inoculated with a sterile needle dipped in a suspension (~10<sup>9</sup> cfu/ml) of the isolates and the stem was punctured between the two cotyledons. Three replicates per bacterial suspension were used as inocula giving nine seedlings inoculated for each bacterial isolate. Seedlings inoculated with a needle dipped in sterile water was a negative control. Seedlings were held at 25 °C in greenhouse and development of typical wilt symptoms was recorded weekly. When typical symptoms were observed, the bacteria were re-isolated on TTC to confirm the presence of the bacterium (Koch's rule). In symptomless plants, stem segments around the point of inoculation were washed, surface-disinfected with ethanol, and the cut of the stem was imprinted five times on TTC medium (Prior et al. 1996) to check for the presence of latent infection.

Molecular identification: All presumptive R. solanacearum isolates that produced typical wilt symptoms in the tomato bioassay were subjected to PCR for identification. Genomic DNA was extracted using the "DNeasy Tissue" kit (Qiagen, Hilden, Germany) according to the manufacturer's instructions. For PCR amplification, a thermal cycler (PeQlab Cyclone 25) was used. Reaction volumes were 50 µl and contained 1 × PCR buffer (10 mM Tris HCl [pH 8.3], 50 mM KCl), 1.5 mM MgCl<sub>2</sub>, 0.05 mM of each dNTP, 25 pmol of primers 759 (5'-GTCGCCGTCAACTCACTTTCC-3') and 760 (5'-GTCGCCGTCAGCAATGCGGAATCG-3'), 1 µl of genomic template DNA and 0.5 U of Taq DNA polymerase (Metabion, Martinsried, Germany). Samples were denaturated at 94 °C for 3 min, annealed at 53 °C for 1 min and extended at 72 °C for 1.5 min, followed by 30 cycles of 94 °C for 15 s, 60 °C for 15 s, 72 °C for 15 s, and a final extension of 72 °C for 5 min (Opina et al. 1997). PCR products were separated in 1.5%

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(wt/vol) agarose gels, stained with ethidium bromide at 0.5 µg/ml and visualized and photographed under UV (302 nm) irradiation.

Phenotypic characterisation: The strains identified as R. solanacearum by PCR and the tomato bioassay were cultured on TTC and CPG agar at 30 °C for 48 h and colony characteristics were noted. Production of fluorescent pigments was tested on KING's B agar (King et al. 1954). After 48 h at 30 °C plates were examined with a UV lamp (366 nm) according to Sands (1990). Tests for catalase and oxidase activity followed standard procedures (Schaad et al. 2001, Gerhardt et al. 1981). Starch hydrolysis, H<sub>2</sub>S production, gelatineliquefication, and Tween 80 hydrolysis were tested as described by He et al. (1983). Nitrate reduction and NaCl tolerance tests were done as described by Hayward (1964). Temperature tolerance was tested according to Sands (1990) and Gram reaction was determined by the KOH solubility test (Fahy and Hayward 1983).

For the carbon source utilisation tests, the basal medium of Hayward (1964) was used. Lactose, maltose, cellobiose, fructose and sucrose solutions were filtersterilized, while D-glucose, mannitol and sorbitol were autoclaved for 20 min as 10% (wt/vol) stock solutions (Hayward 1964). Dulcitol was added directly to the basal medium and was autoclaved for 20 min. Five ml of each carbon source stock solution was added to 45 ml Hayward's basal medium and 10 ml samples were distributed into test tubes (Hayward 1964); Hayward's medium without carbon source served as control.

Bacterial suspensions were prepared in 300  $\mu$ l sterile water from cells grown on CPG agar for 48 h at 30 °C (Williamson *et al.* 2002). Hayward's medium amended with various carbon sources was with 30  $\mu$ l of the prepared-suspension incubated at 30 °C and checked for acid production (yellow colour) for up to 5 weeks (Hayward 1964, He *et al.* 1983).

Growth experiments under static culture conditions were performed in 5 ml CPG broth in a water bath. Ten strains of biovar I, 15 of biovar II, and 3 of biovar III were investigated. Each bacterial suspension ( $OD_{660} = 0.05$ ) was prepared in duplicate test tubes and incubated at 22, 27, 32, and 37 °C. Absorbance after 48 h was determined using a spectrophotometer. To determine single or interaction effects of factors (temperature by biovar), data were subjected to statistical analysis using the general linear model procedure of the SAS version 8 (SAS Institute 1999). Significant factor effects were detected by ANOVA and treatment means at different levels of the respective factors were compared using Tukey's multiple means comparison procedure.

Pathogenicity test: To assess pathogenicity on different host plants, bacterial strains were cultured on CPG agar (Smith et al. 1995) and inoculated (~10<sup>9</sup> cfu/ml) on potato (c.v. 'Secura'), tomato (c.v. 'Matina'), eggplant (c.v. 'Lange Violete'), pepper (c.v. 'Neusiedler ideal') and tobacco (c.v. 'White Burley'). Inoculation was made at the three to four true leaf stage by puncturing the stem at the axils of the third fully expanded leaves from the apex with a needle dipped in inoculum (Winstead and Kelman 1952). Nine plants of each host were inoculated with each strain. Plants inoculated with sterile water served as negative control. Inoculated plants were maintained in greenhouse at 26 to 30 °C with 12 h light and 12 h dark. Prior to inoculation, plants were not watered for 24 h (Williamsson et al. 2002, OEPP/EPPO 1990). The experiment was conducted two times.

Severity of wilting was recorded at weekly intervals (Horita and Tsuchiya 2001) after inoculation on the following scale: 1 = no symptom, 2 = leaf above inoculation point wilted, 3 = two or three leaves wilted, 4 = four or more leaves wilted, and 5 = plant died.

# **Results and discussion**

#### Identification

All the collected 81 Ethiopian isolates showed the same colony morphology as R. solanacearum on TTC agar. However, in the tomato bioassay only 62 of the strains produced typical symptoms of wilting. The remaining 19 strains did not cause wilt symptoms on tomato and were presumed to be saprophytic strains. Subsequently, when the 62 strains (Table 1) that produced typical symptoms on tomato were subjected to a PCR using species specific primers 759 and 760, all produced a single 281 bp fragment (Fig. 1) which is typical of R. solanacearum as reported by Opina et al. (1997) and Ito et al. (1998). We concluded that cultivation on TTC agar is less accurate for identification of R. solanacearum, although it is less costly and simple. This is because some saprophytic bacteria have a colony morphology similar to R. solanacearum, which may decrease the accuracy of TTC. The tomato bioassay as recommended by the European Plant Protection Organization (EPPO) (Elphinstone et al. 1996) was a useful assay because all the isolates that produced typical wilt symptom on tomato were confirmed as R. solanacearum with the PCR assay.

#### Phenotypic characteristics

On the basis of cultural characteristics, all virulent *R. solanacearum* strains from Ethiopia resembled those

Table 1. LIST OF MAISTOFILA SUBMACEALUTT STRATTS USED FOR THIS STU	Table
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1     IEC Pot 1     Solumum tuberstum     Murulu, Guder, Ethiopia     2000       3     IEC Pot 34     Solumum tuberstum     Jato, Gedo, Ethiopia     1700       4     BC Pot 341     Solumum tuberstum     Tscedy, Holta, Ethiopia     2400       5     IEC Pot 311     Solumum tuberstum     Tscedy, Holta, Ethiopia     2400       7     IEC Pot 1011     Solumum tuberstum     Tscedy, Holta, Ethiopia     2000       9     IEC Pot 1011     Solumum tuberstum     Tscedy, Holta, Ethiopia     1700       10     IEC Pot 1011     Solumum tuberstum     Jimma, Ethiopia     1700       11     IEC Pot 4JU     Solumum tuberstum     Jimma, Ethiopia     1700       12     IEC Pot 4JU     Solumum tuberstum     Jimma, Ethiopia     1650       13     IEC Pot 1011     Solumum tuberstum     Hako, Ethiopia     1650       14     IEC Pot 1011     Solumum tuberstum     Hako, Ethiopia     250       14     IEC Pot 1011     Solumum tuberstum     Hako, Ethiopia     250       15     IEC Pot 1011     Solumum tuberstum     Hako,	Number	Strain designation	Origin	Country	Altitude (m)
2     IRC Pot 5     Solumur tubersum     Murulu, Guder, Ethiopia     2000       4     IRC Pot 34     Solumur tubersum     Tsedey, Holeta, Ethiopia     2400       5     IRC Pot 511     Solumur tubersum     Tsedey, Holeta, Ethiopia     2400       6     IRC Pot 511     Solumur tubersum     Tsedey, Holeta, Ethiopia     2400       7     IRC Pot 1011     Solumur tubersum     Murulu, Guder, Ethiopia     2400       9     IRC Pot 1011     Solumur tubersum     Jimma, Ethiopia     1700       10     IRC Pot 6101     Solumur tubersum     Jimma, Ethiopia     1700       11     IRC Pot 6101     Solumur tubersum     Jimma, Ethiopia     1650       12     IRC Pot 6101     Solumur tubersum     Kejo, Ethiopia     1650       13     IRC Pot 1011     Solumur tubersum     Kejo, Ethiopia     2350       14     IRC Pot 1011     Solumur tubersum     Kejo, Ethiopia     2350       15     IRC Pot 1011     Solumur tubersum     Kejo, Ethiopia     2350       15     IRC Pot 231U     Solumur tubersum     Kejo, Ethiopia <td>1</td> <td>IBC Pot 1</td> <td>Solanum tuberosum</td> <td>Mutulu, Guder, Ethiopia</td> <td>2000</td>	1	IBC Pot 1	Solanum tuberosum	Mutulu, Guder, Ethiopia	2000
3     IRC Pot 34     Solamum tuberosum     jato, Gedo, Ethiopia     1700       4     IRC Pot 411     Solamum tuberosum     Tsedey, Holeta, Ethiopia     2400       5     IRC Pot 911     Solamum tuberosum     Tsedey, Holeta, Ethiopia     2400       7     IRC Pot 911     Solamum tuberosum     Tsedey, Holeta, Ethiopia     2400       8     IRC Pot 1511     Solamum tuberosum     Tsedey, Holeta, Ethiopia     2000       10     DE CP of 101     Solamum tuberosum     Himan, Ethiopia     1700       11     IRC Pot 6[U     Solamum tuberosum     Himan, Ethiopia     1700       12     IRC Pot 6[U     Solamum tuberosum     Kejo, Ethiopia     1650       13     IRC Pot 1011     Solamum tuberosum     Kejo, Ethiopia     1650       14     IRC Pot 1011     Solamum tuberosum     Bako, Ethiopia     2350       16     IRC Pot 1011     Solamum tuberosum     Job Ethiopia     2350       16     For 1311     Solamum tuberosum     Job Ethiopia     2350       17     IRC Pot 1311     Solamum tuberosum     Job Ethiopia </td <td>2</td> <td>IBC Pot 5</td> <td>Solanum tuberosum</td> <td>Mutulu, Guder, Ethiopia</td> <td>2000</td>	2	IBC Pot 5	Solanum tuberosum	Mutulu, Guder, Ethiopia	2000
4     IBC Pot 4II     Solamun Iuterosum     Tsedey, Holeta, Ethiopia     2400       5     IBC Pot 5II     Solamun Iuterosum     Tsedey, Holeta, Ethiopia     2400       6     IBC Pot 10II     Solamun Iuterosum     Tsedey, Holeta, Ethiopia     2400       7     IBC Pot 13II     Solamun Iuterosum     Mutulu, Cuder, Ethiopia     2400       9     IBC Pot 14U     Solamun Iuterosum     Mutulu, Cuder, Ethiopia     1700       10     JBC Pot 4JU     Solamun Iuterosum     JIIIma, Ethiopia     1700       11     IBC Pot 6JU     Solamun Iuterosum     JIIIma, Ethiopia     1650       12     IBC Pot 6JII     Solamun Iuterosum     Kejo, Ethiopia     1650       13     IBC Pot 16III     Solamun Iuterosum     Rejo, Ethiopia     1650       14     IBC Pot 16III     Solamun Iuterosum     Rejo, Ethiopia     2350       15     IBC Pot 16III     Solamun Iuterosum     JIIIo, Ethiopia     2350       16     IBC Pot 20III     Solamun Iuterosum     JIIIo, Ethiopia     2350       16     Fot 23UU     Solamun Iuterosum <t< td=""><td>3</td><td>IBC Pot 34</td><td>Solanum tuberosum</td><td>Jato, Gedo, Ethiopia</td><td>1700</td></t<>	3	IBC Pot 34	Solanum tuberosum	Jato, Gedo, Ethiopia	1700
5 IRC Pot 511 Solamun Iuberosum Tsedey, Holeta, Ethiopia 2400   7 IRC Pot 1011 Solamun Iuberosum Tsedey, Holeta, Ethiopia 2400   8 IRC Pot 1511 Solamun Iuberosum Tsedey, Holeta, Ethiopia 2000   9 IRC Pot 1511 Solamun Iuberosum Jimma, Ethiopia 1700   10 IRC Pot 4[U Solamun Iuberosum Jimma, Ethiopia 1700   11 IRC Pot 4[U Solamun Iuberosum Jimma, Ethiopia 1700   12 IRC Pot 3[U Solamun Iuberosum Jimma, Ethiopia 1700   13 IRC Pot 3[U Solamun Iuberosum Jimma, Ethiopia 1650   14 HC Pot 10111 Solamun Iuberosum Kako, Ethiopia 1650   15 IRC Pot 10111 Solamun Iuberosum Arjo, Ethiopia 2350   16 IRC Pot 10111 Solamun Iuberosum Arjo, Ethiopia 2350   17 IRC Pot 31[U Solamun Iuberosum Jimma, Ethiopia 1700   21 BC Pot 31[U Solamun Iuberosum Jimma, Ethiopia 200   22 BC Pot 31[U Solamun Iuberosum Jimma, Ethiopia 200   23 BC Pot 32[U Solamun Iuberosum Ginchi, Ethiopia 200	4	IBC Pot 4II	Solanum tuberosum	Tsedey, Holeta, Ethiopia	2400
6     IBC Pot 10II     Solamum Interessum     Tseedey, Holeta, Ethiopia     2400       8     IBC Pot 15II     Solamum Interessum     Mutulu, Cuder, Ethiopia     2400       9     IBC Pot 2JU     Solamum Interessum     Mutulu, Cuder, Ethiopia     1700       10     IBC Pot 4JU     Solamum Interessum     Jimma, Ethiopia     1700       11     IBC Pot 6JU     Solamum Interessum     Jimma, Ethiopia     1700       12     IBC Pot 6JU     Solamum Interessum     Jimma, Ethiopia     1630       13     IBC Pot 10II     Solamum Interessum     Kejo, Ethiopia     1630       16     IBC Pot 10III     Solamum Interessum     Bako, Ethiopia     230       17     IBC Pot 21III     Solamum Interessum     Jima, Ethiopia     230       18     Pot 21III     Solamum Interessum     Jima, Ethiopia     200       21     HC Pot 31JU     Solamum Interessum     Jima, Ethiopia     200       23     IBC Pot 42     Solamum Interessum     Jima, Ethiopia     200       23     IBC Pot 42     Solamum Interessum     Jinthi, Ethiopi	5	IBC Pot 5II	Solanum tuberosum	Tsedey, Holeta, Ethiopia	2400
7     JBC Pot 1011     Solamum Interessum     Tseedy, Holefa, Ethopia     2000       9     JBC Pot 1511     Solamum Interessum     Jimma, Ethiopia     2000       10     JBC Pot 4[U     Solamum Interessum     Jimma, Ethiopia     1700       11     JBC Pot 4[U     Solamum Interessum     Jimma, Ethiopia     1700       12     JBC Pot 3[U     Solamum Interessum     Jimma, Ethiopia     1700       13     JBC Pot 3[U     Solamum Interessum     Kejo, Ethiopia     1650       14     JBC Pot 0[U     Solamum Interessum     Kejo, Ethiopia     1650       15     JBC Pot 10[U     Solamum Interessum     Kejo, Ethiopia     260       18     IBC Pot 10[U     Solamum Interessum     Arjo, Ethiopia     2350       19     IBC Pot 21[U     Solamum Interessum     Jimma, Ethiopia     200       21     BC Pot 410     Solamum Interessum     Ginchi, Ethiopia     200       22     IBC Pot 42     Solamum Interessum     Ginchi, Ethiopia     200       23     IBC Pot 44     Solamum Interessum     Ginchi, Ethiopia	6	IBC Pot 911	Solanum tuberosum	Tsedey, Holeta, Ethiopia	2400
8     IBC bot 1511     Solaniam luberosam     Mutulu, Guder, Ethiopia     2000       10     IBC bot 4[U     Solaniam luberosam     Jimma, Ethiopia     1700       11     IBC bot 4[U     Solaniam luberosam     Jimma, Ethiopia     1700       12     IBC bot 6[U     Solaniam luberosam     Jimma, Ethiopia     1700       12     IBC bot 6[U     Solaniam luberosam     Kejo, Ethiopia     1650       13     IBC bot 10III     Solaniam luberosam     Kejo, Ethiopia     1650       15     IBC bot 10III     Solaniam luberosam     Bako, Ethiopia     1550       16     IBC bot 10III     Solaniam luberosam     Bako, Ethiopia     2330       19     IBC bot 21III     Solaniam luberosam     Jimma, Ethiopia     2300       21     IBC bot 21III     Solaniam luberosam     Jimma, Ethiopia     2000       22     IBC bot 40     Solaniam luberosam     Jickia, Ethiopia     2000       23     IBC bot 42     Solaniam luberosam     Ginchi, Ethiopia     2000       24     IBC bot 48     Solaniam luberosam     KarafIdicha, Shas	7	IBC Pot 10II	Solanum tuberosum	Tsedey, Holeta, Ethiopia	2400
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12IBC Pot SIUSolarum tuberosumJimmä, Ethiopia170013IBC Pot SIUSolarum tuberosumJimma, Ethiopia170014IBC Pot SIIISolarum tuberosumKejo, Ethiopia165015IBC Pot 16IIISolarum tuberosumBako, Ethiopia165016IBC Pot 16IIISolarum tuberosumBako, Ethiopia235017IBC Pot 20IIISolarum tuberosumArjo, Ethiopia235019IBC Pot 21IIISolarum tuberosumArjo, Ethiopia235020IBC Pot 23IIISolarum tuberosumJimma, Ethiopia170021IBC Pot 23IIISolarum tuberosumJimma, Ethiopia220023IBC Pot 44Solarum tuberosumJeduc, Ethiopia220024IBC Pot 45Solarum tuberosumGinchi, Ethiopia220025IBC Pot 46Solarum tuberosumGinchi, Ethiopia220026IBC Pot 55Solarum tuberosumKarafildicha, Shashermene, Ethiopia190028IBC Pot 56Solarum tuberosumKarafildicha, Shashermene, Ethiopia190030IBC Pot 58Solarum tuberosumKarafildicha, Shashermene, Ethiopia190031IBC Pot 60Solarum tuberosumKarafildicha, Shashermene, Ethiopia190032IBC Pot 62Solarum tuberosumKarafildicha, Shashermene, Ethiopia190033IBC Pot 64Solarum tuberosumKarafildicha, Shashermene, Ethiopia20034IBC Pot 64Solarum tuberosum <td< td=""><td>11</td><td>IBC Pot 6JU</td><td>Solanum tuberosum</td><td>Jimma, Ethiopia</td><td>1700</td></td<>	11	IBC Pot 6JU	Solanum tuberosum	Jimma, Ethiopia	1700
13IBC Pot 900Solatum tuberosumKejo, Ethiopia170015IBC Pot 16111Solatum tuberosumKejo, Ethiopia165016IBC Pot 16111Solatum tuberosumBako, Ethiopia165017IBC Pot 17111Solatum tuberosumBako, Ethiopia235018IBC Pot 20111Solatum tuberosumArjo, Ethiopia235020IBC Pot 21111Solatum tuberosumArjo, Ethiopia235021IBC Pot 21111Solatum tuberosumJirma, Ethiopia220022IBC Pot 311USolatum tuberosumGinchi, Ethiopia220023IBC Pot 42Solatum tuberosumJirma, Ethiopia220024IBC Pot 44Solatum tuberosumGinchi, Ethiopia220025IBC Pot 44Solatum tuberosumGinchi, Ethiopia220026IBC Pot 55Solatum tuberosumGinchi, Ethiopia220027IBC Pot 55Solatum tuberosumKarafildicha, Shashemene, Ethiopia190028IBC Pot 57Solatum tuberosumKarafildicha, Shashemene, Ethiopia190029IBC Pot 58Solatum tuberosumKarafildicha, Shashemene, Ethiopia190030IBC Pot 58Solatum tuberosumKarafildicha, Shashemene, Ethiopia190031IBC Pot 62Solatum tuberosumKarafildicha, Shashemene, Ethiopia190032IBC Pot 65Solatum tuberosumKarafildicha, Shashemene, Ethiopia200034IBC Pot 58Solatum tuberosumKara	12	IBC Pot 8JU	Solanum tuberosum	Jimma, Ethiopia	1700
14IBC Pot 6IIISolarum tuberosumKejo, Ethiopia165015IBC Pot 16IIISolarum tuberosumBako, Ethiopia165016IBC Pot 17IIISolarum tuberosumBako, Ethiopia165017IBC Pot 20IIISolarum tuberosumArjo, Ethiopia235018IBC Pot 20IIISolarum tuberosumArjo, Ethiopia235020IBC Pot 21IIISolarum tuberosumArjo, Ethiopia235021IBC Pot 23JUSolarum tuberosumJimma, Ethiopia270022IBC Pot 40Solarum tuberosumJedu, Ethiopia260023IBC Pot 44Solarum tuberosumJedu, Ethiopia260024IBC Pot 45Solarum tuberosumGinchi, Ethiopia220025IBC Pot 48Solarum tuberosumGinchi, Ethiopia220026IBC Pot 55Solarum tuberosumGinchi, Ethiopia220027IBC Pot 55Solarum tuberosumKarafildicha, Shashemene, Ethiopia190028IBC Pot 55Solarum tuberosumKarafildicha, Shashemene, Ethiopia190030IBC Pot 58Solarum tuberosumKarafildicha, Shashemene, Ethiopia190031IBC Pot 59Solarum tuberosumKarafildicha, Shashemene, Ethiopia190032IBC Pot 65Solarum tuberosumKarafildicha, Shashemene, Ethiopia190033IBC Pot 65Solarum tuberosumCad, Jimma, Ethiopia220034IBC Pot 64Solarum tuberosumPedo, Jimma, Ethiopia </td <td>13</td> <td>IBC Pot 9JU</td> <td>Solanum tuberosum</td> <td>Jimma, Ethiopia</td> <td>1700</td>	13	IBC Pot 9JU	Solanum tuberosum	Jimma, Ethiopia	1700
15BC, For 10111Solatum tuberosumRejo, Ethiopia165016IBC, Pot 15111Solatum tuberosumBako, Ethiopia165017IBC, Pot 17111Solatum tuberosumArjo, Ethiopia235018IBC, Pot 20111Solatum tuberosumArjo, Ethiopia235019IBC, Pot 21111Solatum tuberosumJimma, Ethiopia170020IBC, Pot 291USolatum tuberosumJimma, Ethiopia220021IBC, Pot 40Solatum tuberosumGinchi, Ethiopia220023IBC, Pot 42Solatum tuberosumJedu, Ethiopia260024IBC, Pot 44Solatum tuberosumGinchi, Ethiopia220025IBC, Pot 45Solatum tuberosumGinchi, Ethiopia220026IBC, Pot 55Solatum tuberosumKarafildicha, Shashemene, Ethiopia190028IBC, Pot 55Solatum tuberosumKarafildicha, Shashemene, Ethiopia190029IBC, Pot 58Solatum tuberosumKarafildicha, Shashemene, Ethiopia190030IBC, Pot 59Solatum tuberosumKarafildicha, Shashemene, Ethiopia190031IBC, Pot 62Solatum tuberosumKarafildicha, Shashemene, Ethiopia190033IBC, Pot 65Solatum tuberosumKarafildicha, Shashemene, Ethiopia190034IBC, Pot 64Solatum tuberosumKarafildicha, Shashemene, Ethiopia220035IBC, Pot 65Solatum tuberosumMarafildicha, Shashemene, Ethiopia200034 <t< td=""><td>14</td><td>IBC Pot 6III</td><td>Solanum tuberosum</td><td>Kejo, Ethiopia</td><td>1650</td></t<>	14	IBC Pot 6III	Solanum tuberosum	Kejo, Ethiopia	1650
1616. Pot 16111Solutium tuberosumBako, Ethiopia165017IRC Pot 20111Solanum tuberosumArjo, Ethiopia235018IRC Pot 20111Solanum tuberosumArjo, Ethiopia235020IRC Pot 23JUSolanum tuberosumJimma, Ethiopia170021IRC Pot 3JUSolanum tuberosumJimma, Ethiopia20022IRC Pot 40Solanum tuberosumGinchi, Ethiopia260023IRC Pot 44Solanum tuberosumGinchi, Ethiopia220024IRC Pot 45Solanum tuberosumGinchi, Ethiopia220025IRC Pot 50Solanum tuberosumGinchi, Ethiopia220026IRC Pot 55Solanum tuberosumGinchi, Ethiopia220027IRC Pot 56Solanum tuberosumKarafildicha, Shashemene, Ethiopia190028IRC Pot 57Solanum tuberosumKarafildicha, Shashemene, Ethiopia190030IRC Pot 58Solanum tuberosumKarafildicha, Shashemene, Ethiopia190031IRC Pot 61Solanum tuberosumKarafildicha, Shashemene, Ethiopia190032IRC Pot 65Solanum tuberosumAwasa, Ethiopia220033IRC Pot 65Solanum tuberosumAwasa, Ethiopia220034IRC Pot 65Solanum tuberosumAwasa, Ethiopia220035IRC Pot 64Solanum tuberosumDedo, Jimma, Ethiopia220036IRC Pot 64Solanum tuberosumDedo, Jimma, Ethiopia2200 </td <td>15</td> <td>IBC Pot 10III</td> <td>Solanum tuberosum</td> <td>Kejo, Ethiopia</td> <td>1650</td>	15	IBC Pot 10III	Solanum tuberosum	Kejo, Ethiopia	1650
17IBC Pot 1/111Solutiun tuberosumArjo, Ethiopia153018IBC Pot 21111Solanum tuberosumArjo, Ethiopia235019IBC Pot 21111Solanum tuberosumArjo, Ethiopia235021IBC Pot 31JUSolanum tuberosumJimma, Ethiopia170022IBC Pot 40Solanum tuberosumGinchi, Ethiopia220023IBC Pot 42Solanum tuberosumJeldu, Ethiopia260024IBC Pot 45Solanum tuberosumJeldu, Ethiopia220025IBC Pot 48Solanum tuberosumGinchi, Ethiopia220026IBC Pot 50Solanum tuberosumGinchi, Ethiopia190027IBC Pot 55Solanum tuberosumKarafildicha, Shashemene, Ethiopia190028IBC Pot 57Solanum tuberosumKarafildicha, Shashemene, Ethiopia190030IBC Pot 58Solanum tuberosumKarafildicha, Shashemene, Ethiopia190031IBC Pot 60Solanum tuberosumKarafildicha, Shashemene, Ethiopia190032IBC Pot 61Solanum tuberosumAvassa, Ethiopia180033IBC Pot 62Solanum tuberosumAvassa, Ethiopia220034IBC Pot 65Solanum tuberosumDedo, Jimma, Ethiopia220035IBC Pot 66Solanum tuberosumDedo, Jimma, Ethiopia220036IBC Pot 68Solanum tuberosumDedo, Jimma, Ethiopia220037IBC Pot 64Solanum tuberosumDedo, Jimma, Ethiopia	16	IBC Pot 16111	Solanum tuberosum	Bako, Ethiopia	1650
18   IBC Pot 20111   Solarum tuberosum   Arjo, Ethiopia   2350     20   IBC Pot 2JUL   Solarum tuberosum   Jimma, Ethiopia   1700     21   IBC Pot 3JU   Solarum tuberosum   Jimma, Ethiopia   1700     22   IBC Pot 40   Solarum tuberosum   Ginchi, Ethiopia   2600     24   IBC Pot 44   Solarum tuberosum   Ginchi, Ethiopia   2600     25   IBC Pot 45   Solarum tuberosum   Ginchi, Ethiopia   2200     26   IBC Pot 50   Solarum tuberosum   Ginchi, Ethiopia   2200     27   IBC Pot 55   Solarum tuberosum   Karafildicha, Shashemene, Ethiopia   1900     28   IBC Pot 55   Solarum tuberosum   Karafildicha, Shashemene, Ethiopia   1900     30   IBC Pot 58   Solarum tuberosum   Karafildicha, Shashemene, Ethiopia   1900     31   IBC Pot 61   Solarum tuberosum   Karafildicha, Shashemene, Ethiopia   1900     32   IBC Pot 62   Solarum tuberosum   Awassa, Ethiopia   2200     33   IBC Pot 64   Solarum tuberosum   Pot 60, Jimma, Ethiopia   2200     34	17	IBC Pot 17III	Solanum tuberosum	Bako, Ethiopia	1650
1910. Pot 21111Solanum tuberosum Solanum tuberosum Jinma, Ethiopia23.5021IBC Pot 31JUSolanum tuberosum Solanum tuberosumJinma, Ethiopia170021IBC Pot 40Solanum tuberosum Ginchi, Ethiopia220023IBC Pot 42Solanum tuberosum Ginchi, Ethiopia260024IBC Pot 48Solanum tuberosum Ginchi, Ethiopia220025IBC Pot 55Solanum tuberosum Ginchi, Ethiopia220026IBC Pot 55Solanum tuberosum Ginchi, Ethiopia220027IBC Pot 55Solanum tuberosum Karafildicha, Shashemene, Ethiopia190028IBC Pot 57Solanum tuberosum Karafildicha, Shashemene, Ethiopia190030IBC Pot 58Solanum tuberosum Karafildicha, Shashemene, Ethiopia190031IBC Pot 60Solanum tuberosum Ararafildicha, Shashemene, Ethiopia190032IBC Pot 61Solanum tuberosum Avassa, Ethiopia180034IBC Pot 62Solanum tuberosum Avassa, Ethiopia220035IBC Pot 66Solanum tuberosum Dedo, Jimma, Ethiopia220036IBC Pot 71Solanum tuberosum Dedo, Jimma, Ethiopia220037IBC Pot 73Solanum tuberosum Dedo, Jimma, Ethiopia220038IBC Pot 74Solanum tuberosum Dedo, Jimma, Ethiopia220039IBC Pot 75Solanum tuberosum Ambo, Ethiopia220030IBC Pot 71Solanum tuberosum Ambo, Ethiopia220034<	18	IBC Pot 20111	Solanum tuberosum	Arjo, Ethiopia	2350
20IBC Pot 23]USolanum tuberosumJimma, Ethiopia170021IBC Pot 40Solanum tuberosumGinchi, Ethiopia220022IBC Pot 40Solanum tuberosumGinchi, Ethiopia260023IBC Pot 46Solanum tuberosumJeldu, Ethiopia220024IBC Pot 46Solanum tuberosumGinchi, Ethiopia220025IBC Pot 50Solanum tuberosumGinchi, Ethiopia220026IBC Pot 55Solanum tuberosumKarafildicha, Shashemene, Ethiopia190028IBC Pot 55Solanum tuberosumKarafildicha, Shashemene, Ethiopia190029IBC Pot 57Solanum tuberosumKarafildicha, Shashemene, Ethiopia190030IBC Pot 59Solanum tuberosumKarafildicha, Shashemene, Ethiopia190031IBC Pot 61Solanum tuberosumAvarafildicha, Shashemene, Ethiopia190033IBC Pot 61Solanum tuberosumAvarafildicha, Shashemene, Ethiopia220034IBC Pot 65Solanum tuberosumAvassa, Ethiopia220035IBC Pot 66Solanum tuberosumDedo, Jimma, Ethiopia220036IBC Pot 70Solanum tuberosumDedo, Jimma, Ethiopia220037IBC Pot 70Solanum tuberosumDedo, Jimma, Ethiopia220040IBC Pot 81Solanum tuberosumKejo, Ethiopia190041IBC Pot 84Solanum tuberosumKejo, Ethiopia190042IBC Pot 93Solanum tuberosum <td< td=""><td>19</td><td>IBC Pot 21111</td><td>Solanum tuberosum</td><td>Arjo, Ethiopia</td><td>2350</td></td<>	19	IBC Pot 21111	Solanum tuberosum	Arjo, Ethiopia	2350
21IBC Pot 3JDSouthum luberosumJimma, Ethiopia170022IBC Pot 42Solanum tuberosumJeldu, Ethiopia220023IBC Pot 42Solanum tuberosumJeldu, Ethiopia260024IBC Pot 43Solanum tuberosumGinchi, Ethiopia220025IBC Pot 48Solanum tuberosumGinchi, Ethiopia220026IBC Pot 55Solanum tuberosumGinchi, Ethiopia20027IBC Pot 55Solanum tuberosumKarafildicha, Shashemene, Ethiopia190028IBC Pot 56Solanum tuberosumKarafildicha, Shashemene, Ethiopia190030IBC Pot 57Solanum tuberosumKarafildicha, Shashemene, Ethiopia190031IBC Pot 60Solanum tuberosumKarafildicha, Shashemene, Ethiopia190032IBC Pot 61Solanum tuberosumAwassa, Ethiopia180033IBC Pot 65Solanum tuberosumAwassa, Ethiopia220034IBC Pot 65Solanum tuberosumDedo, Jimma, Ethiopia220035IBC Pot 66Solanum tuberosumDedo, Jimma, Ethiopia220036IBC Pot 68Solanum tuberosumDedo, Jimma, Ethiopia220037IBC Pot 81Solanum tuberosumDedo, Jimma, Ethiopia200038IBC Pot 71Solanum tuberosumMoso. Jimma, Ethiopia200040IBC Pot 84Solanum tuberosumKarafildicha, Shashemene, Ethiopia190041IBC Pot 93Solanum tuberosumKarafild	20	IBC Pot 29JU	Solanum tuberosum	Jimma, Ethiopia	1700
22IBC Pot 40Solarum füberosumLinch, Ethiopia220023IBC Pot 42Solarum füberosumJeldu, Ethiopia260024IBC Pot 46Solarum füberosumGinchi, Ethiopia220025IBC Pot 50Solarum füberosumGinchi, Ethiopia220026IBC Pot 55Solarum füberosumGinchi, Ethiopia220028IBC Pot 56Solarum füberosumKarafildicha, Shashemene, Ethiopia190028IBC Pot 57Solarum füberosumKarafildicha, Shashemene, Ethiopia190029IBC Pot 58Solarum füberosumKarafildicha, Shashemene, Ethiopia190030IBC Pot 59Solarum füberosumKarafildicha, Shashemene, Ethiopia190031IBC Pot 61Solarum füberosumAvassa, Ethiopia180033IBC Pot 61Solarum füberosumAvassa, Ethiopia220034IBC Pot 65Solarum füberosumDedo, Jimma, Ethiopia220035IBC Pot 66Solarum füberosumDedo, Jimma, Ethiopia220036IBC Pot 68Solarum füberosumDedo, Jimma, Ethiopia220037IBC Pot 81Solarum füberosumDedo, Jimma, Ethiopia220038IBC Pot 81Solarum füberosumKarafildicha, Shashemene, Ethiopia190041IBC Pot 86Solarum füberosumKarafildicha, Shashemene, Ethiopia190042IBC Pot 86Solarum füberosumKarafildicha, Shashemene, Ethiopia190043IBC Pot 86So	21	IBC Pot 31JU	Solanum tuberosum	Jimma, Ethiopia	1700
24IBC Pot 42Solarum füberosum peldu, Ethiopia260025IBC Pot 46Solarum tuberosum Ginchi, Ethiopia220026IBC Pot 50Solarum tuberosum Ginchi, Ethiopia220027IBC Pot 55Solarum tuberosum Karafildicha, Shashemene, Ethiopia190028IBC Pot 55Solarum tuberosum Karafildicha, Shashemene, Ethiopia190029IBC Pot 57Solarum tuberosum Karafildicha, Shashemene, Ethiopia190030IBC Pot 59Solarum tuberosum Karafildicha, Shashemene, Ethiopia190031IBC Pot 60Solarum tuberosum Karafildicha, Shashemene, Ethiopia190032IBC Pot 61Solarum tuberosum Karafildicha, Shashemene, Ethiopia190033IBC Pot 62Solarum tuberosum Avassa, Ethiopia180034IBC Pot 65Solarum tuberosum Dedo, Jimma, Ethiopia220035IBC Pot 66Solarum tuberosum Dedo, Jimma, Ethiopia220036IBC Pot 71Solarum tuberosum Dedo, Jimma, Ethiopia220037IBC Pot 84Solarum tuberosum Dedo, Jimma, Ethiopia220040IBC Pot 71Solarum tuberosum Arabo, Ethiopia220041IBC Pot 84Solarum tuberosum Arabo, Ethiopia200042IBC Pot 84Solarum tuberosum Arabo, Ethiopia200043IBC Pot 91Solarum tuberosum Arabo, Ethiopia190044IBC Pot 92Solarum tuberosum Arabo, Ethiopia190045IBC Pot 93<	22	IBC Pot 40	Solanum tuberosum	Ginchi, Ethiopia	2200
24IBC Pot 48Solarum Intersum Detain un tubersumJetut, Entiopia260025IBC Pot 58Solarum tubersumGinchi, Ethiopia220026IBC Pot 55Solarum tubersumKarafildicha, Shashemene, Ethiopia190028IBC Pot 55Solarum tubersumKarafildicha, Shashemene, Ethiopia190029IBC Pot 57Solarum tubersumKarafildicha, Shashemene, Ethiopia190030IBC Pot 58Solarum tubersumKarafildicha, Shashemene, Ethiopia190031IBC Pot 59Solarum tubersumKarafildicha, Shashemene, Ethiopia190033IBC Pot 61Solarum tubersumAwassa, Ethiopia180034IBC Pot 62Solarum tubersumAwassa, Ethiopia220035IBC Pot 65Solarum tubersumDedo, Jimma, Ethiopia220036IBC Pot 66Solarum tubersumDedo, Jimma, Ethiopia220037IBC Pot 66Solarum tubersumDedo, Jimma, Ethiopia220038IBC Pot 70Solarum tubersumDedo, Jimma, Ethiopia220039IBC Pot 71Solarum tubersumDedo, Jimma, Ethiopia220041IBC Pot 84Solarum tubersumMombolicha, Shashemene, Ethiopia190042IBC Pot 91Solarum tubersumKarafildicha, Shashemene, Ethiopia190044IBC Pot 93Solarum tubersumKarafildicha, Shashemene, Ethiopia190045IBC Pot 93Solarum tubersumKarafildicha, Shashemene, Ethiopia1900	23	IBC Pot 42	Solanum tuberosum	Jeldu, Ethiopia	2600
25IBC Pot 50Solumin luberosumGinchi, Ethiopia220027IBC Pot 55Solanum tuberosumKarafildicha, Shashemene, Ethiopia190028IBC Pot 55Solanum tuberosumKarafildicha, Shashemene, Ethiopia190029IBC Pot 57Solanum tuberosumKarafildicha, Shashemene, Ethiopia190030IBC Pot 58Solanum tuberosumKarafildicha, Shashemene, Ethiopia190031IBC Pot 59Solanum tuberosumKarafildicha, Shashemene, Ethiopia190032IBC Pot 60Solanum tuberosumKarafildicha, Shashemene, Ethiopia180034IBC Pot 62Solanum tuberosumAwassa, Ethiopia220035IBC Pot 65Solanum tuberosumDedo, Jimma, Ethiopia220036IBC Pot 66Solanum tuberosumDedo, Jimma, Ethiopia220037IBC Pot 68Solanum tuberosumDedo, Jimma, Ethiopia220038IBC Pot 71Solanum tuberosumDedo, Jimma, Ethiopia220040IBC Pot 81Solanum tuberosumDedo, Jimma, Ethiopia220041IBC Pot 84Solanum tuberosumKejo, Ethiopia190042IBC Pot 91Solanum tuberosumKarafildicha, Shashemene, Ethiopia190044IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia190045IBC Pot 94Solanum tuberosumKarafildicha, Shashemene, Ethiopia190046IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia <td>24</td> <td>IBC Pol 46</td> <td>Solanum luberosum</td> <td>Jeldu, Ethiopia</td> <td>2600</td>	24	IBC Pol 46	Solanum luberosum	Jeldu, Ethiopia	2600
26IBC Pot 5:0Solanum tuberosumCinCni, Etniopia22/0027IBC Pot 5:5Solanum tuberosumKarafildicha, Shashemene, Ethiopia190028IBC Pot 5:6Solanum tuberosumKarafildicha, Shashemene, Ethiopia190030IBC Pot 5:8Solanum tuberosumKarafildicha, Shashemene, Ethiopia190031IBC Pot 5:9Solanum tuberosumKarafildicha, Shashemene, Ethiopia190032IBC Pot 6:0Solanum tuberosumKarafildicha, Shashemene, Ethiopia190033IBC Pot 6:1Solanum tuberosumAvassa, Ethiopia180034IBC Pot 6:5Solanum tuberosumAvassa, Ethiopia220035IBC Pot 6:5Solanum tuberosumDedo, Jimma, Ethiopia220036IBC Pot 6:6Solanum tuberosumDedo, Jimma, Ethiopia220037IBC Pot 6:8Solanum tuberosumDedo, Jimma, Ethiopia220038IBC Pot 70Solanum tuberosumDedo, Jimma, Ethiopia220040IBC Pot 8:1Solanum tuberosumDedo, Jimma, Ethiopia220041IBC Pot 8:4Solanum tuberosumKarafildicha, Shashemene, Ethiopia190042IBC Pot 9:3Solanum tuberosumKarafildicha, Shashemene, Ethiopia190043IBC Pot 9:4Solanum tuberosumKarafildicha, Shashemene, Ethiopia190044IBC Pot 8:4Solanum tuberosumKarafildicha, Shashemene, Ethiopia190045IBC Pot 9:3Solanum tuberosumKarafildicha, Shas	25	IBC Pot 48	Solanum tuberosum	Ginchi, Ethiopia	2200
24IBC Pot 35Solumin inberosimKarafildicha, Shashemene, Ethiopia190028IBC Pot 56Solanum tuberosimKarafildicha, Shashemene, Ethiopia190029IBC Pot 57Solanum tuberosimKarafildicha, Shashemene, Ethiopia190030IBC Pot 58Solanum tuberosimKarafildicha, Shashemene, Ethiopia190031IBC Pot 60Solanum tuberosimKarafildicha, Shashemene, Ethiopia190032IBC Pot 61Solanum tuberosimAwassa, Ethiopia180034IBC Pot 62Solanum tuberosimAwassa, Ethiopia220035IBC Pot 65Solanum tuberosimDedo, Jimma, Ethiopia220036IBC Pot 66Solanum tuberosimDedo, Jimma, Ethiopia220037IBC Pot 68Solanum tuberosimDedo, Jimma, Ethiopia220038IBC Pot 71Solanum tuberosimDedo, Jimma, Ethiopia220040IBC Pot 81Solanum tuberosimDedo, Jimma, Ethiopia260041IBC Pot 84Solanum tuberosimMochcha, Shashemene, Ethiopia165043IBC Pot 91Solanum tuberosimKarafildicha, Shashemene, Ethiopia190044IBC Pot 93Solanum tuberosimKarafildicha, Shashemene, Ethiopia190045IBC Pot 94Solanum tuberosimKarafildicha, Shashemene, Ethiopia190046IBC Pot 93Solanum tuberosimKarafildicha, Shashemene, Ethiopia190047IBC Tom 3Lycopersicon esculentumKarafildicha, Shas	26	IBC POL 50	Solanum tuberosum	GIICII, ELIIOPIA Karafildiaha, Shashamana, Ethionia	2200
25IBC Pot 56Solanum tuberosumKarafildicha, Shashemene, Ethiopia190030IBC Pot 57Solanum tuberosumKarafildicha, Shashemene, Ethiopia190031IBC Pot 58Solanum tuberosumKarafildicha, Shashemene, Ethiopia190032IBC Pot 60Solanum tuberosumKarafildicha, Shashemene, Ethiopia190033IBC Pot 61Solanum tuberosumKarafildicha, Shashemene, Ethiopia180034IBC Pot 62Solanum tuberosumAwassa, Ethiopia180035IBC Pot 65Solanum tuberosumDedo, Jimma, Ethiopia220036IBC Pot 66Solanum tuberosumDedo, Jimma, Ethiopia220037IBC Pot 68Solanum tuberosumDedo, Jimma, Ethiopia220038IBC Pot 70Solanum tuberosumDedo, Jimma, Ethiopia220039IBC Pot 71Solanum tuberosumDedo, Jimma, Ethiopia200041IBC Pot 84Solanum tuberosumKarafildicha, Shashemene, Ethiopia200042IBC Pot 91Solanum tuberosumKarafildicha, Shashemene, Ethiopia190044IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia190045IBC Pot 94Solanum tuberosumKarafildicha, Shashemene, Ethiopia190046IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia190047IBC Tom 31Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190048IBC Tom 54Lycopersicon esculen	27	IBC Pol 55	Solanum luberosum	Karafildicha, Shashemene, Ethiopia	1900
2210C POT 58Soluluu luberosumKarafildicha, Shashemene, Ethiopia1900311BC Pot 58Solunum tuberosumKarafildicha, Shashemene, Ethiopia1900321BC Pot 60Solunum tuberosumKarafildicha, Shashemene, Ethiopia1900331BC Pot 61Solunum tuberosumAwassa, Ethiopia1800341BC Pot 62Solunum tuberosumAwassa, Ethiopia1800351BC Pot 65Solunum tuberosumDedo, Jimma, Ethiopia2200361BC Pot 66Solunum tuberosumDedo, Jimma, Ethiopia2200371BC Pot 68Solunum tuberosumDedo, Jimma, Ethiopia220038IBC Pot 70Solunum tuberosumDedo, Jimma, Ethiopia2200391BC Pot 71Solunum tuberosumDedo, Jimma, Ethiopia2200401BC Pot 81Solunum tuberosumMoboCha, east Hararge, Ethiopia2600411BC Pot 84Solunum tuberosumKarafildicha, Shashemene, Ethiopia1900441BC Pot 93Solunum tuberosumKarafildicha, Shashemene, Ethiopia1900451BC Pot 93Solunum tuberosumKarafildicha, Shashemene, Ethiopia190046IBC Pot 93Solunum tuberosumKarafildicha, Shashemene, Ethiopia190047IBC Fot 93Solunum tuberosumKarafildicha, Shashemene, Ethiopia190048IBC Tom 611Lycopersicon esculentumTseday, Holeta, Ethiopia240049IBC Tom 53Lycopersicon esculentumTseday, Holeta, Et	20	IBC POL 56	Solanum tuberosum	Karafildicha, Shashemene, Ethiopia	1900
3010C Pot 39Solarum tuberosumKarafildicha, Shashemene, Ethiopia1900311BC Pot 59Solarum tuberosumKarafildicha, Shashemene, Ethiopia1900321BC Pot 60Solarum tuberosumAwassa, Ethiopia1800331BC Pot 61Solarum tuberosumAwassa, Ethiopia1800341BC Pot 62Solarum tuberosumAwassa, Ethiopia2200351BC Pot 65Solarum tuberosumDedo, Jimma, Ethiopia2200361BC Pot 66Solarum tuberosumDedo, Jimma, Ethiopia2200371BC Pot 68Solarum tuberosumDedo, Jimma, Ethiopia2200381BC Pot 70Solarum tuberosumDedo, Jimma, Ethiopia2200401BC Pot 84Solarum tuberosumKombolcha, east Hararge, Ethiopia2000411BC Pot 84Solarum tuberosumKarafildicha, Shashemene, Ethiopia1900421BC Pot 91Solarum tuberosumKarafildicha, Shashemene, Ethiopia1900441BC Pot 93Solarum tuberosumKarafildicha, Shashemene, Ethiopia190045IBC Pot 94Solarum tuberosumKarafildicha, Shashemene, Ethiopia190046IBC Pot 93Solarum tuberosumKarafildicha, Shashemene, Ethiopia190047IBC Tom 31Lycopersicon esculentumTseday, Holeta, Ethiopia200048IBC Tom 54Lycopersicon esculentumTseday, Holeta, Ethiopia240050IBC Tom 55Lycopersicon esculentumTseday, Holeta, Ethiopia </td <td>29</td> <td>IBC Pot 57</td> <td>Solunum tuberosum</td> <td>Karafildicha, Shashamana, Ethiopia</td> <td>1900</td>	29	IBC Pot 57	Solunum tuberosum	Karafildicha, Shashamana, Ethiopia	1900
116C FOI 59Solunium tuberosumKarafildicha, Shashemene, Ethiopia190033IBC Pot 60Solanum tuberosumAwassa, Ethiopia180034IBC Pot 61Solanum tuberosumAwassa, Ethiopia180035IBC Pot 65Solanum tuberosumDedo, Jimma, Ethiopia220036IBC Pot 66Solanum tuberosumDedo, Jimma, Ethiopia220037IBC Pot 68Solanum tuberosumDedo, Jimma, Ethiopia220038IBC Pot 70Solanum tuberosumDedo, Jimma, Ethiopia220039IBC Pot 71Solanum tuberosumDedo, Jimma, Ethiopia220040IBC Pot 81Solanum tuberosumMobo, Ethiopia260041IBC Pot 84Solanum tuberosumAmbo, Ethiopia260042IBC Pot 86Solanum tuberosumKarafildicha, Shashemene, Ethiopia190044IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia190045IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia192546IBC Pot 94Solanum tuberosumKarafildicha, Shashemene, Ethiopia240047IBC Tom 31Lycopersicon esculentumTseday, Holeta, Ethiopia240048IBC Tom 611Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia240050IBC Tom 58Lycopersicon esculentumAdam Tulu, Ethiopia200051IBC Tom 58Lycopersicon esculentumMarafildicha, Shashemene, Ethiopia2000<	30 21	IBC Pot 50	Solunum tuberosum	Karafildicha, Shashamana, Ethiopia	1900
1210c 101 00Solanum tuberosumKatanitation, Stashenier, Ethiopia190033IBC Pot 61Solanum tuberosumAwassa, Ethiopia180034IBC Pot 62Solanum tuberosumAwassa, Ethiopia220035IBC Pot 65Solanum tuberosumDedo, Jimma, Ethiopia220036IBC Pot 66Solanum tuberosumDedo, Jimma, Ethiopia220037IBC Pot 68Solanum tuberosumDedo, Jimma, Ethiopia220038IBC Pot 70Solanum tuberosumDedo, Jimma, Ethiopia220040IBC Pot 81Solanum tuberosumDedo, Jimma, Ethiopia220041IBC Pot 84Solanum tuberosumKombolcha, east Hararge, Ethiopia260042IBC Pot 91Solanum tuberosumKarafildicha, Shashemene, Ethiopia190044IBC Pot 92Solanum tuberosumKarafildicha, Shashemene, Ethiopia190045IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia190046IBC Pot 94Solanum tuberosumKarafildicha, Shashemene, Ethiopia190047IBC Tom 3Lycopersicon esculentumTseday, Holeta, Ethiopia240050IBC Tom 53Lycopersicon esculentumTseday, Holeta, Ethiopia200051IBC Tom 58Lycopersicon esculentumMaturulu, Guder, Ethiopia200053IBC Tom 58Lycopersicon esculentumMutulu, Guder, Ethiopia200054IBC Pep 7Capsicum annumMutulu, Guder, Ethiopia2000 <td>21</td> <td>IBC Pot 60</td> <td>Solanum tuberosum</td> <td>Karafildicha, Shashomono, Ethiopia</td> <td>1900</td>	21	IBC Pot 60	Solanum tuberosum	Karafildicha, Shashomono, Ethiopia	1900
34IBC Pot 61Solution InterosumAwassa, Ethiopia180035IBC Pot 62Solutium tuberosumDedo, Jimma, Ethiopia220036IBC Pot 66Solutum tuberosumDedo, Jimma, Ethiopia220037IBC Pot 68Solutum tuberosumDedo, Jimma, Ethiopia220038IBC Pot 70Solutum tuberosumDedo, Jimma, Ethiopia220039IBC Pot 71Solutum tuberosumDedo, Jimma, Ethiopia220040IBC Pot 81Solutum tuberosumMonsol, Ethiopia200041IBC Pot 84Solutum tuberosumKombolcha, east Hararge, Ethiopia200042IBC Pot 85Solutum tuberosumKarafildicha, Shashemene, Ethiopia165043IBC Pot 91Solutum tuberosumKarafildicha, Shashemene, Ethiopia190044IBC Pot 93Solutum tuberosumKarafildicha, Shashemene, Ethiopia190045IBC Pot 94Solutum tuberosumKarafildicha, Shashemene, Ethiopia190046IBC Tom 31Lycopersicon esculentumMutulu, Guder, Ethiopia240049IBC Tom 56Lycopersicon esculentumTseday, Holeta, Ethiopia200051IBC Tom 58Lycopersicon esculentumAdam Tulu, Ethiopia200052IBC Tom 88Lycopersicon esculentumAdam Tulu, Guder, Ethiopia200053IBC Tom 58Lycopersicon esculentumAdam Tulu, Guder, Ethiopia200054IBC Pep 77Capsicum annumMutulu, Guder, Ethiopia2000<	3 <u>4</u> 22	IBC Pot 61	Solanum tuberosum	Awassa Ethiopia	1900
1100 02Dotation intervisionProduct of the product of	34	IBC Pot 62	Solanum tuberosum	Awassa, Ethiopia	1800
BCInc. 100 C03Solanum tuberosumDedo, Jimma, Ethiopia220036IBC Pot 66Solanum tuberosumDedo, Jimma, Ethiopia220038IBC Pot 70Solanum tuberosumDedo, Jimma, Ethiopia220039IBC Pot 71Solanum tuberosumDedo, Jimma, Ethiopia220040IBC Pot 81Solanum tuberosumMobolcha, east Hararge, Ethiopia200041IBC Pot 84Solanum tuberosumAmbo, Ethiopia260042IBC Pot 86Solanum tuberosumKarafildicha, Shashemene, Ethiopia190044IBC Pot 92Solanum tuberosumKarafildicha, Shashemene, Ethiopia190045IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia192546IBC Pot 94Solanum tuberosumKarafildicha, Shashemene, Ethiopia190047IBC Tom 3Lycopersicon esculentumMtrulu, Guder, Ethiopia240048IBC Tom 51Lycopersicon esculentumTsedey, Holeta, Ethiopia240050IBC Tom 56Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190051IBC Tom 58Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia200053IBC Tom 56Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190054IBC Tom 58Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia200055IBC Pep 58Capsicum annumMutulu, Guder, Ethiopia200056IBC Pep 61Capsicum annum<	35	IBC Pot 65	Solanum tuberosum	Dedo Jimma Ethionia	2200
37IBC Pot 68Solanum tuberosumDedo, Jimma, Ethiopia220038IBC Pot 70Solanum tuberosumDedo, Jimma, Ethiopia220039IBC Pot 71Solanum tuberosumDedo, Jimma, Ethiopia220040IBC Pot 81Solanum tuberosumDedo, Jimma, Ethiopia200041IBC Pot 84Solanum tuberosumKombolcha, east Hararge, Ethiopia260042IBC Pot 86Solanum tuberosumKarafildicha, Shashemene, Ethiopia190043IBC Pot 92Solanum tuberosumKarafildicha, Shashemene, Ethiopia190044BC Pot 92Solanum tuberosumKarafildicha, Shashemene, Ethiopia190045IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia190046IBC Pot 94Solanum tuberosumKarafildicha, Shashemene, Ethiopia190047IBC Tom 1IILycopersicon esculentumTseday, Holeta, Ethiopia240048IBC Tom 6IILycopersicon esculentumKarafildicha, Shashemene, Ethiopia190050IBC Tom 58Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190051IBC Tom 58Lycopersicon esculentumAdam Tulu, Ethiopia200052IBC Tom 88Lycopersicon esculentumMutulu, Guder, Ethiopia185054IBC Pep 58Capsicum annumMutulu, Guder, Ethiopia200055IBC Pep 58Capsicum annumMutulu, Guder, Ethiopia200056IBC Pep 58Capsicum annumMutulu	36	IBC Pot 66	Solanum tuberosum	Dedo, Jimma, Ethiopia	2200
38IBC Pot 70Solanum tuberosum berosumDedo, Jimma, Ethiopia220039IBC Pot 71Solanum tuberosum Solanum tuberosumDedo, Jimma, Ethiopia220040IBC Pot 81Solanum tuberosumKombolcha, east Hararge, Ethiopia200041IBC Pot 84Solanum tuberosumAmbo, Ethiopia260042IBC Pot 86Solanum tuberosumKejo, Ethiopia165043IBC Pot 91Solanum tuberosumKarafildicha, Shashemene, Ethiopia190044IBC Pot 92Solanum tuberosumKarafildicha, Shashemene, Ethiopia192546IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia192047IBC Tom 3Lycopersicon esculentumMutulu, Guder, Ethiopia200048IBC Tom 111Lycopersicon esculentumTseday, Holeta, Ethiopia240049IBC Tom 53Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190051IBC Tom 56Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190052IBC Tom 58Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190053IBC Tom 58Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia200054IBC Pep 7Capsicum annumMutulu, Guder, Ethiopia200055IBC Pep 58Capsicum annumMutulu, Guder, Ethiopia200056IBC Pet 1076PPRC*Solanum tuberosumGoromt, Ambo, Ethiopia200057IBC Pot 1076PP	37	IBC Pot 68	Solanum tuberosum	Dedo, Jimma, Ethiopia	2200
39IBC Pot 71Solanum tuberosum bedo, Jimma, Ethiopia220040IBC Pot 81Solanum tuberosum solanum tuberosumDedo, Jimma, Ethiopia200041IBC Pot 84Solanum tuberosum solanum tuberosumKombolcha, east Hararge, Ethiopia260042IBC Pot 86Solanum tuberosum 	38	IBC Pot 70	Solanum tuberosum	Dedo, Jimma, Ethiopia	2200
40IBC Pot 81Solanum tuberosumKombolcha, east Hararge, Ethiopia200041IBC Pot 81Solanum tuberosumAmbo, Ethiopia260042IBC Pot 86Solanum tuberosumKarafildicha, Shashemene, Ethiopia165043IBC Pot 91Solanum tuberosumKarafildicha, Shashemene, Ethiopia190044IBC Pot 92Solanum tuberosumKarafildicha, Shashemene, Ethiopia190045IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia190046IBC Pot 94Solanum tuberosumKarafildicha, Shashemene, Ethiopia190047IBC Tom 3Lycopersicon esculentumMutulu, Guder, Ethiopia240048IBC Tom 611Lycopersicon esculentumTseday, Holeta, Ethiopia240050IBC Tom 53Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190051IBC Tom 56Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190052IBC Tom 88Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia200053IBC Tom 88Lycopersicon esculentumMutulu, Guder, Ethiopia200054IBC Pep 7Capsicum annumMutulu, Guder, Ethiopia200055IBC Pep 58Capsicum annumMutulu, Guder, Ethiopia200056IBC Pet 1076PPRC*Solanum tuberosumKombolcha, east Hararge, Ethiopia200057IBC Pot 1076PPRC*Solanum tuberosumGoromt, Ambo, Ethiopia200058IBC Pot	39	IBC Pot 71	Solanum tuberosum	Dedo, Jimma, Ethiopia	2200
A1IBC Pot 84Solanum tuberosumAmbo, Ethiopia260042IBC Pot 84Solanum tuberosumAmbo, Ethiopia165043IBC Pot 91Solanum tuberosumKarafildicha, Shashemene, Ethiopia190044IBC Pot 92Solanum tuberosumKarafildicha, Shashemene, Ethiopia190045IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia192546IBC Pot 94Solanum tuberosumKarafildicha, Shashemene, Ethiopia200047IBC Tom 3Lycopersicon esculentumMutulu, Guder, Ethiopia240048IBC Tom 6IILycopersicon esculentumTseday, Holeta, Ethiopia240050IBC Tom 53Lycopersicon esculentumTseday, Holeta, Ethiopia190051IBC Tom 56Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190052IBC Tom 88Lycopersicon esculentumAdam Tulu, Ethiopia160053IBC Pep 7Capsicum annumMutulu, Guder, Ethiopia200054IBC Pep 76Capsicum annumMutulu, Guder, Ethiopia200055IBC Pep 61Capsicum annumMutulu, Guder, Ethiopia200056IBC Pep 61Capsicum annumMutulu, Guder, Ethiopia200057IBC Pot 1076PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia200058IBC Pot 1076PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia260060IBC Pot 1080PPRC*Solanum tuberosumQarsa, east Hararge	40	IBC Pot 81	Solanum tuberosum	Kombolcha east Hararge Ethiopia	2000
11IntroductionIntroductionIntroductionIntroduction42IBC Pot 86Solanum tuberosumKejo, Ethiopia165043IBC Pot 91Solanum tuberosumKarafildicha, Shashemene, Ethiopia190044IBC Pot 92Solanum tuberosumKarafildicha, Shashemene, Ethiopia190045IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia192546IBC Pot 94Solanum tuberosumKarafildicha, Shashemene, Ethiopia200047IBC Tom 3Lycopersicon esculentumMutulu, Guder, Ethiopia240048IBC Tom 1IILycopersicon esculentumTseday, Holeta, Ethiopia240050IBC Tom 6IILycopersicon esculentumTsedey, Holeta, Ethiopia190051IBC Tom 56Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190052IBC Tom 58Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190053IBC Tom 58Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia200054IBC Pep 7Capsicum annumMutulu, Guder, Ethiopia200055IBC Pep 58Capsicum annumMutulu, Guder, Ethiopia200056IBC Pep 10Capsicum annumMutulu, Guder, Ethiopia200057IBC Pot 1076PPRC*Solanum tuberosumGoromt, Ambo, Ethiopia200058IBC Pot 1070PPRC*Solanum tuberosumGoromt, Ambo, Ethiopia260059IBC Pot 1080PPRC*Solanum tuberosum <td>41</td> <td>IBC Pot 84</td> <td>Solanum tuberosum</td> <td>Ambo Ethiopia</td> <td>2600</td>	41	IBC Pot 84	Solanum tuberosum	Ambo Ethiopia	2600
Har bereforeSolanum tuberosumRejor periodHar berefore190043IBC Pot 91Solanum tuberosumKarafildicha, Shashemene, Ethiopia190044IBC Pot 92Solanum tuberosumKarafildicha, Shashemene, Ethiopia190045IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia192546IBC Pot 94Solanum tuberosumKarafildicha, Shashemene, Ethiopia190047IBC Tom 3Lycopersicon esculentumMutulu, Guder, Ethiopia240048IBC Tom 1IILycopersicon esculentumTseday, Holeta, Ethiopia240050IBC Tom 6IILycopersicon esculentumTseday, Holeta, Ethiopia190051IBC Tom 56Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190052IBC Tom 58Lycopersicon esculentumAdam Tulu, Ethiopia160053IBC Tom 88Lycopersicon esculentumZiway, Ethiopia185054IBC Pep 7Capsicum annumMutulu, Guder, Ethiopia200055IBC Pep 61Capsicum annumMutulu, Guder, Ethiopia200056IBC Pot 1076PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia-59IBC Pot 1080PPRC*Solanum tuberosumGarsa, east Hararge, Ethiopia200060IBC Pot 1080PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia200061IBC Pot 1080PPRC*Solanum tuberosumGarsa, east Hararge, Ethiopia260062IBC Pot 768PPRC* <td< td=""><td>42</td><td>IBC Pot 86</td><td>Solanum tuberosum</td><td>Keio Ethiopia</td><td>1650</td></td<>	42	IBC Pot 86	Solanum tuberosum	Keio Ethiopia	1650
13135 For 1135 For 1135044IBC Pot 12Solanum tuberosumKarafildicha, Shashemene, Ethiopia190045IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia192546IBC Pot 94Solanum tuberosumKarafildicha, Shashemene, Ethiopia190047IBC Tom 3Lycopersicon esculentumMutulu, Guder, Ethiopia200048IBC Tom 1IILycopersicon esculentumTseday, Holeta, Ethiopia240049IBC Tom 6IILycopersicon esculentumTseday, Holeta, Ethiopia190050IBC Tom 56Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190051IBC Tom 56Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190053IBC Tom 58Lycopersicon esculentumMutulu, Guder, Ethiopia200054IBC Pep 7Capsicum annumMutulu, Guder, Ethiopia200055IBC Pep 61Capsicum annumMutulu, Guder, Ethiopia200058IBC Pot 1076PPRC*Solanum tuberosumKombolcha, east Hararge, Ethiopia200058IBC Pot 1079PPRC*Solanum tuberosumGoront, Ambo, Ethiopia260059IBC Pot 1080PPRC*Solanum tuberosumGoront, Ambo, Ethiopia260060IBC Pot 1080PPRC*Solanum tuberosumGoront, Ambo, Ethiopia260061IBC Pot 1080PPRC*Solanum tuberosumGoront, Ambo, Ethiopia260062IBC Tom 768PPRC*Lycopersicon esculentumAgaro	43	IBC Pot 91	Solanum tuberosum	Karafildicha Shashemene Ethiopia	1900
45IBC Pot 93Solanum tuberosumKarafildicha, Shashemene, Ethiopia192546IBC Pot 94Solanum tuberosumKarafildicha, Shashemene, Ethiopia190047IBC Tom 3Lycopersicon esculentumMutulu, Guder, Ethiopia200048IBC Tom 1IILycopersicon esculentumTseday, Holeta, Ethiopia240049IBC Tom 6IILycopersicon esculentumTsedey, Holeta, Ethiopia240050IBC Tom 53Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190051IBC Tom 56Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190052IBC Tom 58Lycopersicon esculentumMutulu, Guder, Ethiopia200053IBC Tom 88Lycopersicon esculentumZiway, Ethiopia185054IBC Pep 7Capsicum annumMutulu, Guder, Ethiopia200055IBC Pep 61Capsicum annumMutulu, Guder, Ethiopia200056IBC Pot 1076PPRC*Solanum tuberosumKombolcha, east Hararge, Ethiopia-59IBC Pot 10379PRC*Solanum tuberosumGoromt, Ambo, Ethiopia260060IBC Pot 1091PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia200061IBC Pot 1091PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia260062IBC Tom 768PPRC*Lycopersicon esculentumAgaro, Jimma, Ethiopia165062IBC Tom 768PPRC*Lycopersicon esculentumAgaro, Jimma, Ethiopia1650	44	IBC Pot 92	Solanum tuberosum	Karafildicha, Shashemene, Ethiopia	1900
46IBC Pot 94Solanum tuberosumKarafildicha, Shashemene, Ethiopia190047IBC Tom 3Lycopersicon esculentumMutulu, Guder, Ethiopia200048IBC Tom 1IILycopersicon esculentumTseday, Holeta, Ethiopia240049IBC Tom 6IILycopersicon esculentumTseday, Holeta, Ethiopia240050IBC Tom 53Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190051IBC Tom 56Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190052IBC Tom 58Lycopersicon esculentumAdam Tulu, Ethiopia160053IBC Tom 88Lycopersicon esculentumMutulu, Guder, Ethiopia200054IBC Pep 7Capsicum annumMutulu, Guder, Ethiopia200055IBC Pep 61Capsicum annumMutulu, Guder, Ethiopia200058IBC Pot 1076PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia200058IBC Pot 1080PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia260060IBC Pot 1091PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia260061IBC Pot 1091PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia260062IBC Tom 768PPRC*Lycopersicon esculentumArata Chaffa, Ziway, Ethiopia1650	45	IBC Pot 93	Solanum tuberosum	Karafildicha, Shashemene, Ethiopia	1925
47IBC Tom 3Lycopersicon esculentumMutulu, Guder, Ethiopia200048IBC Tom 1IILycopersicon esculentumTseday, Holeta, Ethiopia240049IBC Tom 6IILycopersicon esculentumTseday, Holeta, Ethiopia240050IBC Tom 53Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190051IBC Tom 56Lycopersicon esculentumAdam Tulu, Ethiopia160052IBC Tom 58Lycopersicon esculentumMutulu, Guder, Ethiopia200053IBC Tom 88Lycopersicon esculentumZiway, Ethiopia185054IBC Pep 7Capsicum annumMutulu, Guder, Ethiopia200055IBC Pep 58Capsicum annumMutulu, Guder, Ethiopia200056IBC Pep 61Capsicum annumMutulu, Guder, Ethiopia200057IBC Pot 1076PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia200058IBC Pot 1080PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia260060IBC Pot 1091PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia260061IBC Pot 1091PPRC*Solanum tuberosumAgaro, Jimma, Ethiopia165062IBC Tom 768PPRC*Lycopersicon esculentumArata Chaffa, Ziway, Ethiopia1850	46	IBC Pot 94	Solanum tuberosum	Karafildicha, Shashemene, Ethiopia	1900
48IBC Tom 1IILycopersicon esculentumTseday, Holeta, Ethiopia240049IBC Tom 6IILycopersicon esculentumTseday, Holeta, Ethiopia240050IBC Tom 53Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190051IBC Tom 56Lycopersicon esculentumAdam Tulu, Ethiopia160052IBC Tom 58Lycopersicon esculentumMutulu, Guder, Ethiopia200053IBC Tom 88Lycopersicon esculentumZiway, Ethiopia185054IBC Pep 7Capsicum annumMutulu, Guder, Ethiopia200055IBC Pep 58Capsicum annumMutulu, Guder, Ethiopia200056IBC Pep 61Capsicum annumMutulu, Guder, Ethiopia200057IBC Pot 1076PPRC*Solanum tuberosumKombolcha, east Hararge, Ethiopia200058IBC Pot 1079PPRC*Solanum tuberosumGoromt, Ambo, Ethiopia200060IBC Pot 1091PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia200061IBC Pot 1091PPRC*Solanum tuberosumAgaro, Jimma, Ethiopia165062IBC Tom 768PPRC*Lycopersicon esculentumArata Chaffa, Ziway, Ethiopia1650	47	IBC Tom 3	Lycopersicon esculentum	Mutulu, Guder, Ethiopia	2000
49IBC Tom 6IILycopersicon esculentumTsedey, Holeta, Ethiopia240050IBC Tom 53Lycopersicon esculentumKarafildicha, Shashemene, Ethiopia190051IBC Tom 56Lycopersicon esculentumAdam Tulu, Ethiopia160052IBC Tom 58Lycopersicon esculentumMutulu, Guder, Ethiopia200053IBC Tom 88Lycopersicon esculentumMutulu, Guder, Ethiopia200054IBC Pep 7Capsicum annumMutulu, Guder, Ethiopia200055IBC Pep 58Capsicum annumMutulu, Guder, Ethiopia200056IBC Pep 61Capsicum annumMutulu, Guder, Ethiopia200057IBC Pot 1076PPRC*Solanum tuberosumKombolcha, east Hararge, Ethiopia200058IBC Pot 1079PPRC*Solanum tuberosumGoromt, Ambo, Ethiopia260060IBC Pot 1080PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia200061IBC Pot 1091PPRC*Solanum tuberosumAgaro, Jimma, Ethiopia165062IBC Tom 768PPRC*Lycopersicon esculentumArata Chaffa, Ziway, Ethiopia1850	48	IBC Tom 1II	Lycopersicon esculentum	Tseday, Holeta, Ethiopia	2400
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53IBC Tom 88Lycopersicon esculentumZiway, Ethiopia185054IBC Pep 7Capsicum annumMutulu, Guder, Ethiopia200055IBC Pep 58Capsicum annumMutulu, Guder, Ethiopia200056IBC Pep 61Capsicum annumMutulu, Guder, Ethiopia200057IBC Pot 1076PPRC*Solanum tuberosumKombolcha, east Hararge, Ethiopia200058IBC Pot 1079PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia-59IBC Pot 262APPRC*Solanum tuberosumGoromt, Ambo, Ethiopia260060IBC Pot 1080PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia200061IBC Pot 1091PPRC*Solanum tuberosumAgaro, Jimma, Ethiopia165062IBC Tom 768PPRC*Lycopersicon esculentumArata Chaffa, Ziway, Ethiopia1850	52	IBC Tom 58	Lycopersicon esculentum	Mutulu, Guder, Ethiopia	2000
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56IBC Pep 61Capsicum annumMutulu, Guder, Ethiopia200057IBC Pot 1076PPRC*Solanum tuberosumKombolcha, east Hararge, Ethiopia200058IBC Pot 1079PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia-59IBC Pot 262APPRC*Solanum tuberosumGoromt, Ambo, Ethiopia260060IBC Pot 1080PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia200061IBC Pot 1091PPRC*Solanum tuberosumAgaro, Jimma, Ethiopia165062IBC Tom 768PPRC*Lycopersicon esculentumArata Chaffa, Ziway, Ethiopia1850	55	IBC Pep 58	Capsicum annum	Mutulu, Guder, Ethiopia	2000
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58IBC Pot 1079PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia–59IBC Pot 262APPRC*Solanum tuberosumGoromt, Ambo, Ethiopia260060IBC Pot 1080PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia200061IBC Pot 1091PPRC*Solanum tuberosumAgaro, Jimma, Ethiopia165062IBC Tom 768PPRC*Lycopersicon esculentumArata Chaffa, Ziway, Ethiopia1850	57	IBC Pot 1076PPRC*	Solanum tuberosum	Kombolcha, east Hararge, Ethiopia	2000
59IBC Pot 262APPRC*Solanum tuberosumGoromt, Ambo, Ethiopia260060IBC Pot 1080PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia200061IBC Pot 1091PPRC*Solanum tuberosumAgaro, Jimma, Ethiopia165062IBC Tom 768PPRC*Lycopersicon esculentumArata Chaffa, Ziway, Ethiopia1850	58	IBC Pot 1079PPRC*	Solanum tuberosum	Qarsa, east Hararge, Ethiopia	_
60IBC Pot 1080PPRC*Solanum tuberosumQarsa, east Hararge, Ethiopia200061IBC Pot 1091PPRC*Solanum tuberosumAgaro, Jimma, Ethiopia165062IBC Tom 768PPRC*Lycopersicon esculentumArata Chaffa, Ziway, Ethiopia1850	59	IBC Pot 262APPRC*	Solanum tuberosum	Goromt, Ambo, Ethiopia	2600
61IBC Pot 1091PPRC*Solanum tuberosumAgaro, Jimma, Ethiopia165062IBC Tom 768PPRC*Lycopersicon esculentumArata Chaffa, Ziway, Ethiopia1850	60	IBC Pot 1080PPRC*	Solanum tuberosum	Qarsa, east Hararge, Ethiopia	2000
62 IBC Tom 768PPRC* Lycopersicon esculentum Arata Chaffa, Ziway, Ethiopia 1850	61	IBC Pot 1091PPRC*	Solanum tuberosum	Agaro, Jimma, Ethiopia	1650
· ·	62	IBC Tom 768PPRC*	Lycopersicon esculentum	Arata Čhaffa, Ziway, Ethiopia	1850

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#### 44 F. Lemessa and W. Zeller

#### Table 1. continued.

Number	Strain designation	Origin	Country	Altitude (m)
63	GSPB 2690 <sup>T</sup>	Capsicum annum	Kenya	_
64	GSPB 2695 <sup>T</sup>	Lycopersicon esculentum	Kenya	_
65	GSPB 2709 <sup>T</sup>	Solanum tuberosum	Peru	2000
66	GSPB 2791 <sup>T</sup>	Solanum tuberosum	Peru	_
67	GSPB 2792 <sup>T</sup>	Solanum tuberosum	Cameroon	_

All the strains were collections of this study except those with \* which were obtained from Plant Protection Research Centre (PPRC), Ambo, Ethiopia, and the reference strains with <sup>T</sup> which were procured from Göttingen Collection of Phytopathogenic Bacteria (GCPB), Göttingen, Germany.



**Figure 1.** PCR-based confirmation of *Ralstonia solanacearum* isolates collected from Ethiopia. The 281 bp PCR product amplified is visible on the ethidium bromide stained agarose gel. M = DNA marker; + = positive control (an identified *R. solanacearum* strain from Göttingen Phytobacteriology Collection, Germany); - = negative control (reaction mixture without template DNA); Lanes 1–10, 11–20, 21–30, 31–40, 51–60 and 61–62 are strains from Ethiopia; Lanes 63–67 are strains obtained from Göttingen Phytobacteriology Collection (i.e., GSPB 2690, GSPB 2695, GSPB 2709, GSPB 2791 and GSPB 2792).

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Table 2. (	Comparison of	carbon sources	utilisation p	patterns of	Ethiopian	Ralstonia	solanacearum s	trains.
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Strain	Carbohydrate									Biovar
	Glucose	Fructose	Sucrose	Lactose	Maltose	Cellobiose	Dulcitol	Mannitol	Sorbitol	
IBC Pot 2JU, IBC Pot 4II, IBC Pot 8JU, IBC Pot 31JU, IBC Pot 42, IBC Pot 46, IBC Pot 48, IBC Pot 50, IBC Pot 55, IBC Pot 58, IBC Pot 59, IBC Pot 62, IBC Pot 91, IBC Pot 94, IBC Tom 6II, IBC Tom 53, IBC Pep 7, IBC Pep 58, IBC Pep 61,	+(1)	+(2)	+(1)	-	_	-	_	_	_	I
IBC Pot 1, IBC Pot 5, IBC Pot 34, IBC Pot 5II, IBC Pot 9II, IBC Pot 10II, IBC Pot 15II, IBC Pot 4JU, IBC Pot 6JU, IBC Pot 8JU, IBC Pot 9JU, IBC Pot 6III, IBC Pot 10III, IBC Pot 16III, IBC Pot 17III, IBC Pot 20III, IBC Pot 21III, IBC Pot 29JU, IBC Pot 40, IBC Pot 56, IBC Pot 57, IBC Pot 60, IBC Pot 61, IBC Pot 65, IBC Pot 66, IBC Pot 68, IBC Pot 70, IBC Pot 81, IBC Pot 84, IBC Pot 86, IBC Pot 93, IBC Tom 3, IBC Tom 1II, IBC Tom 56, IBC Pot 1079PPRC, IBC Pot 262APPRC, IBC Pot 1080PPRC, IBC Pot 1091PPRC, IBC Tom 768PPRC, GSPB 2695 <sup>T</sup> , GSPB 2791 <sup>T</sup>	+(1)	+(2)	+(1)	+(1-2)	+(1-2)	+(1)	_	_	_	Ш
GSPB 2690 <sup>T</sup> , GSPB 2709 <sup>T</sup> , GSPB 2792 <sup>T</sup>	+(1)	+(2)	+(1)	+(1)	+(1)	+(1)	+(1)	+(1)	+(1)	III

+(1) = positive reaction in 2-6 days; +(2) = positive reaction in 6-14 days; - = negative reaction; <sup>T</sup> reference strains.

strains from other regions of the world (He *et al.* 1983, Kelman 1954, Williamson *et al.* 2002). They produced fluidal colonies with a pink to red centre on TTC and a fluidal creamy colony on CPG which is typical of the pathogen (Hayward 1964, He *et al.* 1983). Yaynu (1989) also reported the same result on strains from Ethiopia on TTC. On King's B medium none of the strains produced a fluorescent pigment.

All of the Ethiopian 62 strains which were confirmed to be *R. solanacearum* and the GCPB reference strains invariably were Gram negative, oxidase and catalase positive, and hydrolysed Tween 80 (data not shown). None of the strains hydrolysed starch or gelatine. All strains produced  $H_2S$  from cysteine and reduced nitrate. As characteristical for *R. solanacearum*, none of the Ethiopian strains grew on 2% (wt/vol) NaCl. All strains grew at 37 °C and but not at 41 °C. The capacity to oxidize sucrose is a stable characteristic of *R. solanacearum* (Hayward 1964). Moreover, absence of growth at 2% NaCl is another characteristic of the pathogen (Ito *et al.* 1998). In our study, all the *R. solanacearum* strains were positive for sucrose oxidation and did not grow at 2% NaCl solution. We concluded that all the 62 strains from Ethiopia were *R. solanacearum*, which agrees with the results of the tomato bioassay and the specific PCR-based assays.

Some differences among strains from Ethiopia were observed in carbon source utilisation tests (Table 2). Based on Hayward's classification scheme (Hayward 1964), 19 of 62 strains were classified as biovar I and 43 as biovar II (Table 2). Biovar II strains produced acid from lactose, maltose and cellobiose but failed to utilise mannitol, sorbitol and dulcitol. Biovar I strains did not utilise disaccharides or sugar alcohols even after 5 weeks of incubation. Biovar III strains from GCPB utilised all of the sugar and alcohol carbohydrates.

In 1989 Yaynu reported the existence of only biovar II in Ethiopian *R. solanacearum* population. The phenotypic tests demonstrated that the Ethiopian strains of *R. solanacearum* belong to biovar I and biovar II. Strains in biovar I were obtained from potato, tomato, and pepper and were pathogenic to potato, tomato, eggplant, pepper and/or tobacco. Biovar II strains were obtained from potato and tomato, and pathogenic to

Temperature (°C)	Biovar								
	I	II	III						
22	0.311 B b	0.451 A a	0.280 B b						
27	0.462 A a	0.471 A a	0.607 A a						
32	0.564 A a	0.404 B a	0.617 A a						
37	0.566 A a	0.299 B b	0.620 A a						

Table 3. Growth of Ralstonia solanacearum biovar I, II, and III strains at different temperatures.

Means within a row and column followed by the same upper case and lower case letters, respectively, are not significantly different (Tukey,  $\alpha = 0.05$ ). Strains were grown in casamino acids-peptone-glucose (CPG) broth for 48 h under static conditions.

potato, tomato, and eggplant. In previous studies from Ethiopia, only biovar II was isolated from potato and tomato and those strains were pathogenic to potato, tomato, and eggplant (Yaynu 1989). This is the first report of biovar I of R. solanacearum in diseased plants in Ethiopia. Biovar I is the most widely distributed strain of R. solanacearum in the world (He et al. 1983). Hence, it is not surprising that biovar I was isolated among the strains collected from Ethiopia, as several thousands of potato genotypes have been introduced to the country (Berga et al. 1994) from the International Potato Centre (CIP), Peru, and other parts of the world to develop high yielding and adaptable cultivars with resistance to the major stresses. We suspect that strains of R. solanacearum may have been introduced through latently infected planting material. It has been demonstrated that, R. solanacearum can be widely disseminated through vegetative propagating material (tomato, Heliconia, banana, and potato) and contaminated irrigation water and latently infected planting materials play a major role in its local and international dissemination (Hayward 1991, Williamson et al. 2002).

The number of strains belonging to the new biovar in Ethiopia (biovar I) represented almost one third (19 out of 62) of the total number of strains collected. This may indicate that the introduction of the new strains to Ethiopia may not have occurred recently, rather occurred many years ago. One justification for this is that some of the strains in the new biovar were collected from areas distal to locations in Ethiopia (Holeta, Shashemene and Alemaya) where introduced potato genotypes are multiplied before distribution to farmers.

Growth tests under static conditions showed that temperature significantly (F = 20.97, P < 0.0001) affected growth of *R. solanacearum*. The two-way interaction between temperature and biovar was significant (F = 20.86, P < 0.0001) indicating that the effect of temperature on growth of *R. solanacearum* was associated with the biovar designation. Generally, the experiment showed that biovar II strains were able to grow preferentially at low temperature (22 °C). Biovar I and III strains (Table 3) grew at higher temperatures (32 and 37 °C). Thus, biovar II strains may be adapted to climates with relatively cooler temperatures than strains of biovars I and III, which grew well at higher temperatures. This is in agreement with previous reports that biovar II strains are adapted to cool tropical climates and biovars I and III strains are adapted to warm tropical climates (Horita *et al.* 2005, Swanson *et al.* 2005, Oepp/Eppo 2004, French *et al.* 1993, Marin and El-Nashaar 1993).

Isolates of biovar II in Ethiopia were collected from cool tropical regions with altitudes ranging from 1600 to 2600 meters above sea level. Likewise, biovar I strains from Ethiopia also were collected from areas ranging from 1630 to 2600 meters above sea level; in spite of its adaptation to warm tropical conditions. Moreover, of the three biovar III strains included as comparative controls in this study, one strain was isolated from 2000 meters above sea level in Peru (origin of the other two strains was not recorded); an environment not categorized as a warm tropical conditions. This may indicate that the strains can occur and cause disease in areas with environments to support optimal growth of the pathogen. There are reports that support that strains of R. solanacearum will cause disease in environments considered suboptimal for growth and survival (French et al. 1993). It is believed that the presence of these strains in these areas may be due to the distribution of infected potato tubers from one area to the other.

#### Pathogenicity

With the pathogenicity test, initial symptoms of wilting in susceptible hosts appeared 3 to 4 days after stem inoculation. Initial symptoms usually consisted of wilting of the inoculated leaf and stunting of growth. In potato, tomato, and eggplants, inoculation was fol-

Table 4.     Pathogenicity	of	Ralstonia	solanacearum	strains	from	Ethiopia	on	five	major	hosts	and	their	pathogenic	groups	and
respective biovars.															

Strains	Original host	Pathog	enicity o	Patho- genic group	Biovar			
		Potato	Tomato	Eggplant	Pepper	Tobacco		
IBC Pot 2JU, IBC Pot 4II, IBC Pot 8JU, IBC Pot 31JU, IBC Pot 46, IBC Pot 48, IBC Pot 50, IBC Pot 55, IBC Pot 58, IBC Pot 59, IBC Pot 94, IBC Tom 6II, IBC Tom 53, IBC Pep 58, IBC Pep 61	Potato, tomato, pepper	2.6-5 <sup>†</sup>	2.6-5	2.6-5	1.1-5	1.1-5	1	Ι
GSPB 2690 <sup>T</sup> , GSPB 2709 <sup>T</sup> , GSPB 2792 <sup>T</sup>	Potato, pepper	4.1-5	4.1-5	4.1-5	2.6-5	1.1-4	1	III
IBC Pot 42, IBC Pot 62, IBC Pot 91, IBC Pep 7	Potato, pepper	2.6-5	2.6-5	2.6-5	2.6-4	1	2	Ι
IBC Pot 1, IBC Pot 5, IBC Pot 34, IBC Pot 5II, IBC Pot 9II, IBC Pot 10II, IBC Pot 15II, IBC Pot 4JU, IBC Pot 6JU, IBC Pot 9JU, IBC Pot 6III, IBC Pot 10III, IBC Pot 16III, IBC Pot 17III, IBC Pot 20III, IBC Pot 21III, IBC Pot 29JU, IBC Pot 40, IBC Pot 56, IBC Pot 57, IBC Pot 60, IBC Pot 61, IBC Pot 65, IBC Pot 66, IBC Pot 68, IBC Pot 70, IBC Pot 71, IBC Pot 81, IBC Pot 84, IBC Pot 86, IBC Pot 92, IBC Pot 93, IBC Pot 1076PPRC <sup>*</sup> , IBC Pot 1079PPRC <sup>*</sup> , IBC Pot 262APPRC <sup>*</sup> , IBC Pot 1080PPRC <sup>*</sup> , IBC Pot 1091PPRC <sup>*</sup> , GSPB 2791 <sup>T</sup> , IBC Tom 3, IBC Tom 1II, IBC Tom 56, IBC Tom 58, IBC Tom 88, IBC Tom 768PPRC <sup>*</sup> , GSPB 2695 <sup>T</sup>	Potato, tomato	2.6-5	2.6-5	2.6-5	1	1	3	Π

<sup>†</sup> Disease severity score determined according to Horita and Tsuchiya (2001) where 1 is no symptom, and 5 is dead plant. All the strains were collections of this study except those with <sup>\*</sup> which were obtained from Plant Protection Research Centre (PPRC), Ambo, Ethiopia, and those with <sup>T</sup> which were procured from Göttingen Collection of Phytopathogenic Bacteria (GCPB), Göttingen, Germany.

lowed by considerable ooze and decay of the pith surrounding the point of inoculation; after which the plants wilted rapidly and died. All strains caused rapid wilting of eggplant, tomato and potato. Only 19 strains from Ethiopia and 3 strains from the Göttingen collection infected pepper and 15 strains from Ethiopia and 2 strains from Göttingen collection infected tobacco.

On the basis of host reaction, the strains studied could be categorized into three pathogenic groups (Table 4). Group 1 included strains that were virulent on all five host species; group 2 included a few strains that were virulent on all host species except tobacco; and group 3 included the majority of the strains that were virulent on potato, tomato, and eggplant but nonvirulent on pepper and tobacco. Biovar I strains fell in group 1 and 2 which showed that they have wide host range, whereas biovar II strains were placed in the narrow host range group 3; those that infect only potato, tomato, and eggplant. Strains of biovar III also infected all test plants.

Until 1989, only potato, eggplant, and tomato were infected by *R. solanacearum* in Ethiopia (Yaynu 1989).

Recently, however, pepper plants with symptoms of bacterial wilt were discovered (personal observation). The disease incidence on potato (Bekele 1996) and tomato (Earo 2002) has increased in Ethiopia. This increase in the intensity of the disease and host-range of the pathogen may be due to the introduction of biovar I strains although changes in cultural practices can also result in increased disease development.

In conclusion, the study demonstrated that there are two biovars (biovar I and II) of *R. solanacearum* in Ethiopia which differ in physiological and pathogenic characteristics. This indicates that a single control measure can not effectively work for both biovars of the pathogen.

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## References

- Bekele, K., 1996. Incidence and distribution of major potato diseases in 1993 and 1994 off-seasons in central Ethiopia (Abstract). In: The 4th Annual Conference of Crop Protection Society of Ethiopia, May 1996, Addis Ababa, Ethiopia: CPSE.
- Berga, L., Gebremedhin, W.G., Teresa, J., Bereke-Tsehai, T. and Yaynu, H., 1994. Potato improvement research. In: Proceedings of the 2<sup>nd</sup> National Horticultural Workshop of Ethiopia, pp. 75–86. Addis Ababa, Ethiopia: IAR and FAO.
- Elphinstone, J.G., Hennessy, J., Wilson, J.K. and Stead, D.E., 1996. Sensitivity of different methods for the detection methods for the detection of *Ralstonia solanacearum* in potato tuber extracts. OEPP/EPPO Bull., **26**, 255–262.
- Ethiopian Agricultural Research Organization (EARO), 2002. EARO Annual Report 2000. Addis Ababa, Ethiopia: EARO.
- Fahy, P.C. and Hayward, A.C., 1983. Media and methods for isolation and diagnostic tests. In: Methods in Phytobacteriology (Klement, Z., Rudolph, K. and Sands, D.C., Editors), pp. 134–142. Hungary, Budapest: Akademiai Kiado.
- French, E.R. and Sequeira, L., 1970. Strains of *Pseudomonas* solanacearum from Central and South America: A comparative study. Phytopathology, 60, 506–512.
- French, E.R., Aley, P., Torres, E. and Nydegger, U., 1993. Diversity of *Pseudomonas solanacearum* in Peru and Brazil. In: Bacterial Wilt (Hartman, G.L., Hayward, A.C., Editors), pp. 70–77. Canberra, Australia: ACIAR Proceedings No. 45.
- Gerhardt, P., Murray, R.G.E., Costilow, R.N., Nester, E.W., Wood, W.A., Krieg, N.R. and Phillips, G.B., 1981. Manual of Methods for General Bacteriology, p. 413. Washington DC: American Society for Microbiology.
- Hayward, A.C., 1964. Characteristics of Pseudomonas solanacearum. J. Appl. Bacteriol., 27(2), 265-77.
- Hayward, A.C, El-Nashaar, H.M, Nydegger, U. and De Lindo, L., 1990. Variation in nitrate metabolism in biovars of *Pseudo*monas solanacearum. J. Appl. Bacteriol., 69, 269–280.
- Hayward, A.C., 1991. Biology and epidemiology of bacterial wilt caused by *Pseudomonas solanacearum*. Annu. Rev. Phytopathol., 29, 65–87.
- Hayward, A. C., 1995. Systematics and phylogeny of *Pseudomonas solanacearum* and related bacteria. In: Genetic Diversity of Japanese Strains of *Ralstonia solanacearum* (Horita, M. and Tsuchiya, K., Editors), pp. 399–407. Phytopathology.
- He, L. Y., Sequeira, L. and Kelman, A., 1983. Characteristics of strains of *Pseudomonas solanacearum* from China. Plant Dis., 67, 1357–1361.
- Horita, M. and Tsuchiya, K., 2001. Genetic diversity of Japanese strains of *Ralstonia solanacearum*. Phytopathology, **91**, 399–407.
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- Horita, M., Tsuchiya, K. and Ooshiro, A., 2005. Characteristics of *Ralstonia solanacearum* biovar N2 strains in Asia. J. Phytopathol., **153**, 209–213.
- Ito, S., Ushijima, Y., Fujii, T., Tanaka, S., Kameya-Iwaki, M., Yoshiwara, S. and Kishi, F., 1998. Detection of viable cells of *Ralstonia solanacearum* in soil using a semiselective medium and a PCR technique. J. Phytopathol., 146, 379– 384.
- Janse, J.D., 1988. A detection method for *Pseudomonas solanacearum* in symptomless potato tubers and some data on its sensitivity and specificity. EPPO Bull., **18**, 343–351.
- Kelman, A., 1954. The relationship of pathogenicity in *Pseudo-monas solanacearum* to colony appearance on a tetrazolium medium. Phytopathology, **44**, 693–695.
- Kelman, A. and Person, L.H., 1961. Strains of *Pseudomonas* solanacearum differing in pathogenicity to tobacco and peanut. Phytopathology, **51**, 158–161.
- King, E.O., Ward, M.K. and Raney, D.E., 1954. Two simple media for the demonstration of pyocyanin and fluorescein. J. Lab. Clin. Med., 44, 301–307.
- Lozano, J.C. and Sequeira, L., 1970. Differentiation of races of *Pseudomonas solanacearum* by a leaf infiltration technique. Phytopathology, **60**, 833–838.
- Marin, J.E. and El-Nashaar, H.M., 1993. Pathogenicity and new phenotypes of *Pseudomonas solanacearum* from Peru. In: Bacterial Wilt (Hartman, G.L., Hayward, A.C., Editors), pp. 78– 84. Canberra, Australia: ACIAR
- OEPP/EPPO, 1990. Quarantine procedure no. 26: Pseudomonas solanacearum. OEPP/EPPO Bull., 20, 255–262.
- OEPP/EPPO, 2004. Diagnostic protocols for regulated pests: Ralstonia solanacearum. OEPP/EPPO Bull., 34, 173–178.
- Opina, N., Tavner, F., Holloway, G., Wang, J.F., Li, T.H., Maghirang, R., Fegan, M., Hayward, A.C., Krishnapillai, V., Hong, W.F., Holloway, B.W. and Timmis, J.N., 1997. A novel method for development of species and strain-specific DNA probes and PCR primers for identifying *Burkholderia solanacearum* (formerly *Pseudomonas solanacearum*). Ass. Pacif. J. Mol. Biol. Biotec., **5**, 19–33.
- Prior, P., Bart, S., Leclercq, S., Darrasse, A. and Anais, G., 1996. Resistance to bacterial wilt in tomato as discerned by spread of *Pseudomonas* (*Burkholderia*) solanacearum in the stem tissues. Plant Pathol., **45**, 720–726.
- Sands, D.C., 1990. Physiological criteria-Determinative tests. In: Methods in Phytobacteriology (Klement, Z., Rudolph, K., Sands, D.C., Editors), pp. 134–143. Budapest, Hungary: Akademiai Kiado.
- SAS Institute Inc., 1999. SAS Institute Inc., SAS OnlineDoc<sup>®</sup>, Version 8, Cary, NC, USA.
- Schaad, N.W., Jones, J.B. and Chun, W., 2001. Laboratory Guide for Identification of Plant Pathogenic Bacteria (3<sup>rd</sup> edition), pp. 4–10. American Phytopathological Society, St. Paul, MN.
- Smith, E.F., 1914. Bacteria in Relation to Plant Diseases, Vol. 2. Canegie Institute, Washington, USA.
- Smith, E.F., 1896. A bacterial disease of the tomato, eggplant, and Irish potato (*Bacillus solanacearum* nov. sp.). Bulletin, Division of Vegetable Physiology and Pathology, USDA, 12, 1-28.

Journal of Basic Microbiology 2007, 47, 40-49

- Smith, J.J, Offord, L.C., Holderness, M. and Saddler, G.S., 1995. Genetic diversity of Burkholderia solanacearum (synonym Pseudomonas solanacearum) race 3 in Kenya. Appl. Environ. Microbiol., 61, 4263-4268.
- Swanson, J.K., Yao, J., Tans-Kersten, J. and Allen, C., 2005. Behavior of *Ralstonia solanacearum* race 3 biovar 2 during latent and active infection of geranium. Phytopathology, 95, 136–143.
- Williamson, L., Nakaho, K., Hudelson, B. and Allen, C., 2002. Ralstonia solanacearum race 3, biovar 2 strains isolated from geranium are pathogenic to potato. Plant Dis., 86, 987–991.
- Winstead, N.N. and Kelman, A., 1952. Inoculation techniques for evaluating resistance to *Pseudomonas soslanacearum*. Phytopathology, **42**, 628–634.
- Wullings, B.A., Van Beuningen, A.R., Janse, J.D. and Akkermans, A.D.L., 1998. Detection of *Ralstonia solanacearum*,

which causes brown rot of potato, by Fluorescent in situ hyberdization with 23S rRNA-targeted probes. Appl. Environ. Microbiol., **64**, 4546–4554.

- Yabuuchi, E., Kosako, Y., Oyaizu, H., Yano, I., Hotta, H., Hashimoto, Y., Ezaki, T. and Arakawa, M., 1993. Validation of the publication of new names and new combinations previously effectively published out side the IJSB. International J. Sys. Bacteriol., 43, 398–399.
- Yaynu, H. and Korobko, A.P., 1986. Incidence of bacterial wilt in some potato growing areas of Ethiopia. In: Proceedings of the 15<sup>th</sup> Annual Meeting of the Ethiopian Phytopathological Committee (EPC), 13–14 March 1990. Addis Ababa, Ethiopia.
- Yaynu, H., 1989. Characteristics of isolates of *Pseudomonas* solanacearum in Ethiopia. Eth. J. Agric. Sci., **11**, 7–13.